ISSN: 3105-3262 | Quarterly Publication

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The Operating Room Global Journal (TORGJ)

VOLUME 2 ISSUE 1 MARCH 2026

Theme: "Optimizing Surgical Outcomes Through Innovation, Systems Improvement, and Patient-Centred Care."

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- Ruta Mehari Tafere
- Nykam Sankara Junior Ludwig
- Dimitri Tchinda
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- Ma-Fese Dorcas Akwo
- Nges Samuel
- Steve Kouam
- Fotio Theophile
- Ishaan Bakshi
- Danjuma Aliyu
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- Salihu Abdulrahman Kombo
- Hayat Gomma
- Sani Mohammad Sani
- Bashir Abdulmumini
- Madinat Shola Mohammed
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- Adebusola Adenike Owokole
- Parikshta Sookrah
- Hriday Singh Rawat
- Prashant Anand
- Sakshi Singh
- Saeed Ahmad
- Summyya Musharaf
- Nimra Rafique
- Shaistha Banu
- Jocelin Harriate D. Almeida
- Debshree Pattnaik
- Savant Choudhary
- Ahmed Orelope Ibrahim
- Emmanuel E. Anyebe
- Abdur-Rahman Olajide Lukman
- Ibrahim Opeyemi Abdulmumeen
- Silas Kolo
- Bukola Mary Fatukasi
- Yetunde Elizabeth Adeniyi
- Lateefat Ahmed
- Mufutau Dayo Ganiyu

Publication:
Volume 2 Issue 1 March 2026

Journal:
The Operating Room Global Journal (TORGJ)
ISSN: 3105-3262 (Online)
www.torgjournal.org

Editorial Office:
torgjournal@operatingroomissues.org
Editorial@torgjournal.org

Publisher:
The Operating Room Global Centre for Education, Research & Innovation.
+353-852079401
Co. Limerick, Ireland.
www.torgceri.org

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LETTER FROM OUR
EDITOR-IN CHIEF

It is my great pleasure to present Volume 2, Issue 1 March 2026 of The Operating Room Global Journal (TORGJ). As we enter a new publication year, this issue reflects the evolving landscape of surgical and perioperative care, where clinical excellence, systems efficiency, innovation, and compassionate practice converge to improve patient outcomes.

Surgical care today extends far beyond the operating theatre. It encompasses structured perioperative assessment, effective communication, evidence-based technique selection, technological integration, and multidisciplinary collaboration. The manuscripts featured in this issue collectively demonstrate how thoughtful system improvements and innovative practices can directly influence safety, recovery, and long-term outcomes.

Several studies highlight the vital role of perioperative nursing in reducing anxiety and postoperative complications, reinforcing the importance of structured patient engagement before surgery. Others examine technical and procedural determinants of outcomes, including wound closure techniques, predictors of keloid recurrence, and the clinical implications of operating room distractions and workflow inefficiencies. These investigations remind us that even seemingly small procedural or environmental factors can significantly shape surgical performance and patient recovery.

This issue also explores advances in anaesthesia and perioperative pain management, regenerative and interventional innovations, and the evolving therapeutic landscape in oncologic surgery. From imaging-guided regenerative techniques to the toxicity profile of high-dose immunotherapies, the research reflects a dynamic interface between innovation and patient safety. Case reports, including rare presentations in resource-limited settings, further emphasize the importance of clinical vigilance, diagnostic insight, and context-sensitive care.

Across all contributions, a unifying message emerges, optimizing surgical outcomes requires not only technical proficiency but also system-level awareness, patient- centered planning, and responsible innovation. The future of surgery depends on our ability to refine processes, reduce preventable risks, integrate emerging technologies responsibly, and maintain a steadfast commitment to ethical practice.

I extend my sincere appreciation to the authors, reviewers, and editorial team whose dedication and scholarship have made this issue possible. The diversity of contributors, spanning multiple regions and specialties continues to strengthen the global dialogue that TORGJ seeks to foster.

As we move forward in 2026, we remain committed to advancing safe, equitable, and innovative surgical care worldwide. May the research presented in this issue inspire continued reflection, collaboration, and progress within our global perioperative community.

With appreciation,

Dr. Zakir Hussain Parray
Editor-In-Chief, The Operating Room Global Journal (TORGJ)

Dr. Zakir Hussain Parray
(Editor-in-Chief, TORGJ)

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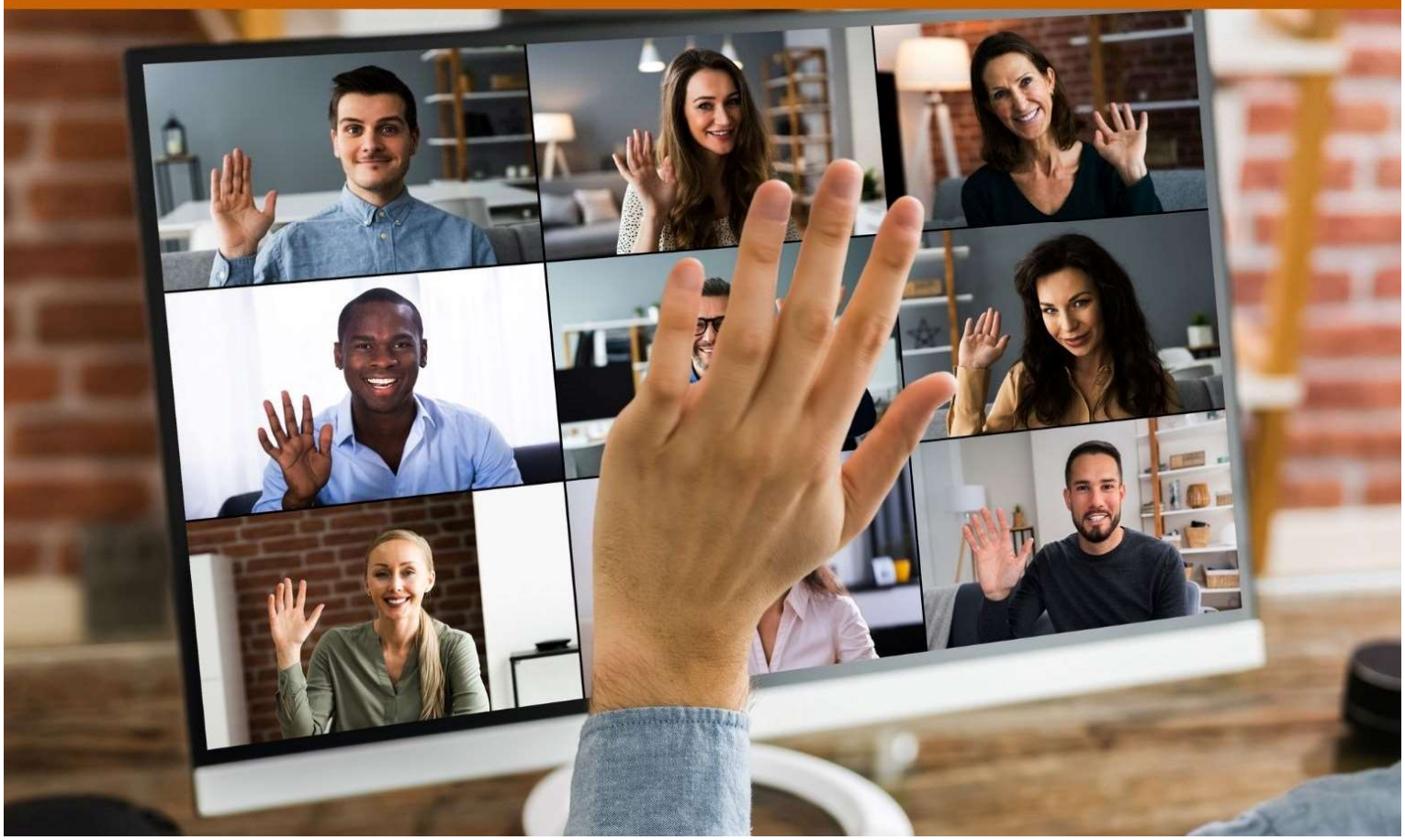

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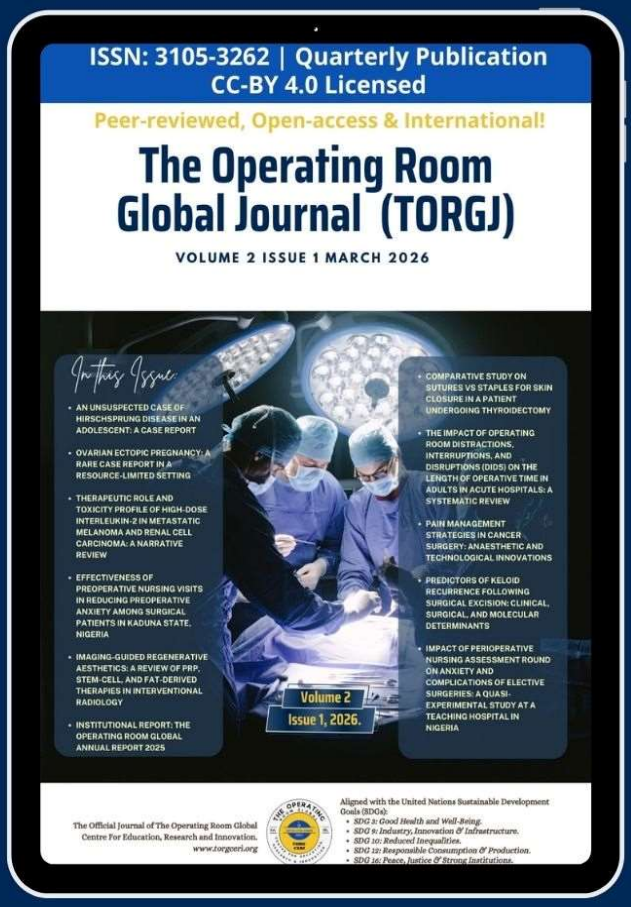

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An Unsuspected Case of Hirschsprung Disease in an Adolescent: A Case Report

Authors: Yirgalem Teklebirhan Gebreziher[1,4]*, Feven Mekonen Tadesse[1], Hadush Tesfay Negash[1], Berihu Tadishu Gebre[2], Seare Halefom Kahsay[1], Ruta Mehari Tafere[3]

[1]Department of Pediatric Surgery, Ayder Comprehensive Specialized Hospital, Mekelle University, Ethiopia.
[2]Department of Radiology, Ayder Comprehensive Specialized Hospital, Mekelle University, Ethiopia.
[3]Department of Internal Medicine, School of Medicine, College of Health Sciences, Aksum University, Tigray, Ethiopia.
[4]The Operating Room Global (TORG).
DOI: https://doi.org/10.64573/torgj2512007

*Corresponding Author:
Yirgalem Teklebirhan Gebreziher
yirgalemtek1@gmail.com
Declaration:
Authors' Contribution: Equal contributions.
Conflict of Interest: No conflict of interest.
Funding: No funding received by the authors.

Article History:
Received: 28-12-2025
Accepted: 11-01-2026
Available Online: 14-01-2026

QR access this Article

The Operating Room Global Journal (TORGJ) Volume 2 Issue 1 Mar 2026

ABSTRACT

Introduction: Hirschsprung's disease, a congenital disorder, is characterized by the absence of ganglion cells in the Meissner's plexus of the submucosa and Auerbach's plexus of the muscularis. Notably, late presentation is uncommon, with 95% of cases being diagnosed in infants younger than one year of age.

Case presentation: 15-year-old Black female patient presented to our hospital with the compliant of failure to pass feces of 5 days duration associated with abdominal distention. From an early age, she experienced persistent constipation and abdominal distention, leading to multiple admissions to local health centers for enema treatment. Oral laxatives were also prescribed, but they only provided temporary relief of her symptoms.

Clinical findings and investigations: Abdominal x-ray showed significantly dilated bowel loops with fecal loading. Barium enema showed a transition zone at the proximal one-third of the rectum with reversed rectosigmoid ratio.

Intervention and outcome: Rectal biopsy confirmed the diagnosis. Decompressive colostomy was done followed by soave pull through three months later. The patient is doing well during postoperative follow-up.

Conclusion: Adolescent patients with a history of childhood-onset constipation should be evaluated for the possibility of undiagnosed Hirschsprung's disease. Treating this condition can significantly enhance the patient's quality of life.

Keywords: Adult; Case report; Congenital; Constipation.

INTRODUCTION

Hirschsprung's disease is a congenital disorder characterized by the absence of ganglion cells in the Meissner's plexus of the submucosa and Auerbach's plexus of the muscularis (1). Hirschsprung's disease occurs in approximately 1 out of every 5,000 live births (2). The diagnosis is typically made before the age of 1 month in 65% of the total cases, and before the age of 1 year in 95% of the total cases. However, in rare cases, the condition may not be detected until the adolescent or adult years (3). This report presents a rare case of chronic constipation in an adolescent who was later diagnosed with Hirschsprung's disease and underwent a Soave pull-through procedure. This case report has been reported in line with the SCARE Criteria (4).

CASE PRESENTATION

15-year-old Black female patient presented to our hospital with the compliant of failure to pass feces of 5 days duration associated with abdominal distention. Since childhood, she had a history of constipation and abdominal distension, for which she was repeatedly admitted to local health centers and treated with enemas and oral laxatives. This provided only

temporary relief of her symptoms. The timing of her first passage of meconium was unknown. On physical examination, the patient appeared chronically ill, wasted, and had significant abdominal distension. Rectal exam revealed loose stool with normal sphincter tone.

Baseline investigations, such as a complete blood count, serum electrolytes, and thyroid function tests, were all within normal limits. An abdominal X-ray revealed significantly dilated bowel loops with fecal loading (Fig 1). The barium enema revealed a transition zone in the proximal one-third of the rectum, with a reversed rectosigmoid ratio, which was suggestive of Hirschsprung's disease (Fig 2).

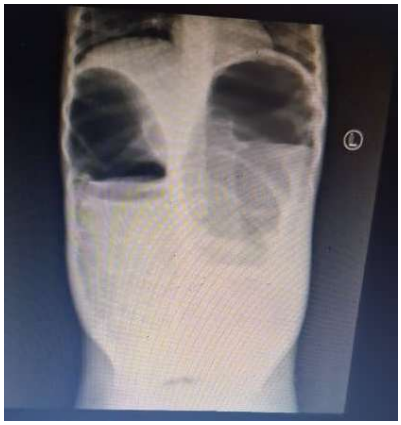

Figure 1: Abdominal x-ray showing significantly distended large bowel.

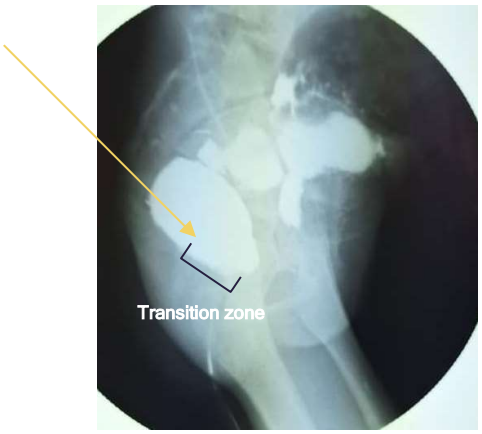

Figure 2: Contrast barium (oblique view).

The patient was prepared, and the abdomen was surgically explored through a left lower transverse incision, based on the clinical impression of large bowel obstruction secondary to an ultra-short segment of Hirschsprung's disease. Intraoperative findings revealed a transition zone at the rectosigmoid junction, accompanied by significant dilatation of the proximal colon (figure 3). A diverting decompressive sigmoid loop colostomy was performed, and tissue samples from the stoma and rectum were obtained and submitted for histopathological evaluation. The histopathological findings confirmed the presence of an aganglionic rectum and a ganglionated colostomy site.

Three months later, the patient underwent a Soave pull-through procedure. The postoperative course was uneventful. At the 6-month follow-up, she reported a dramatic improvement in her bowel function and experienced rapid weight gain.

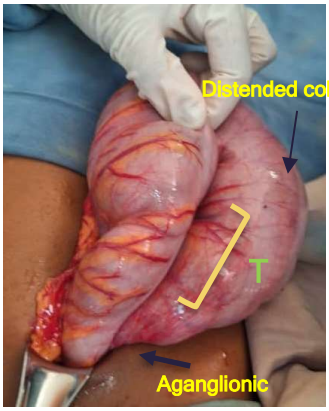

Figure 3: intraoperative

DISCUSSION

Hirschsprung's disease is characterized by the complete absence of ganglion cells within the colonic wall, resulting in an absent recto-anal inhibitory reflex (2). Hirschsprung's disease is a major cause of intestinal obstruction in infants. In over

90% of cases, diagnosis and treatment are carried out within the first 5 years of life. In contrast, Hirschsprung's disease in adults accounts for approximately 5% of cases and is often mistaken for chronic constipation (5).

Hirschsprung's disease is classified into four categories based on the length of the aganglionic segment: short (distal sigmoid colon and rectum), long (distal sigmoid colon and rectum to splenic flexure), total colonic aganglionosis (entire colon), and ultra-short (distal rectum and anal canal). Hirschsprung's disease in adults typically presents as the short or ultra-short form, with relatively mild symptoms, especially early in life (6).

When Hirschsprung's disease is clinically suspected, imaging studies, anal manometry, and full-thickness rectal biopsies are typically performed to confirm the diagnosis (2). A plain abdominal radiograph is typically the first diagnostic step. It may demonstrate a grossly distended large bowel, with a possible absence of stool in the distal colon or rectum. Additionally, a contrast enema can reveal a transition zone between the distal aganglionic bowel segment and the distended proximal ganglionated bowel, a finding considered the most accurate radiologic feature of Hirschsprung's disease (7). Definitive diagnosis of Hirschsprung's disease relies on a rectal biopsy, which reveals the absence of ganglion cells in the myenteric plexus and hypertrophy of the nerve endings (8).

The treatment of Hirschsprung disease is surgical. The principles of the operation are to remove the aganglionic colon and connect the normally innervated bowel just above the anus, at a level which prevents further functional obstruction, but at the same time preserves fecal continence. The definitive surgical intervention may be carried out in a single-stage or multi-stage approach. A stoma may still be the appropriate approach for children with severe enterocolitis, extensive dilatation of the proximal bowel, total colonic aganglionosis, or limited pathology support (9).

In cases of undiagnosed Hirschsprung's disease, patients often experience severe constipation from early childhood, and the colon proximal to the aganglionic bowel tends to be severely dilated. This can complicate surgical dissection and create incongruence during anastomosis, making a one-stage pull-through procedure less effective in older children compared to infants. Early postoperative complications, particularly anastomotic leakage, occur frequently in children with late-diagnosed HD. Therefore, a diverting stoma should be considered for these patients (10). In our case, given the unavailability of frozen section, the presence of malnutrition, and the massive bowel dilatation, we decided to perform a two-stage surgery with an initial diverting loop colostomy.

The surgical treatment of adult Hirschsprung's disease should account for the anatomical changes and the technical challenges of dissection encountered in adulthood. While numerous surgical approaches have been described for Hirschsprung's disease, four primary techniques - Swenson, Duhamel, Soave, and Lynn procedures - are most utilized (11). The Soave procedure involves stripping the rectal mucosa, while maintaining the muscular cuff of the rectum. A ganglionic segment of colon is then brought down, and a colo-anal anastomosis is performed (2). The Soave pull-through is the preferred surgical technique at our institution, favored by our experienced surgeons who have achieved excellent results with this approach.

CONCLUSION

Adolescent patients with a history of childhood-onset constipation should be evaluated for the possibility of undiagnosed Hirschsprung's disease. Treating this condition can significantly enhance the patient's quality of life.

ACKNOWLEDGEMENTS

Not applicable.

ETHICAL APPROVAL

This type of study does not require any ethical approval by our institution.

FUNDING

This case report was not funded by any person or institution.

DECLARATION OF COMPETING INTEREST

The authors have no conflicts of interest to disclose in relation to this work.

CONSENT

Written informed consent was obtained from the patient's mother for publication of this case report and accompanying images. A copy of the written consent is available on request.

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CITE THIS MANUSRIPT

- **APA (7th edition):** Gebreziher, Y. T., Tadesse, F. M., Negash, H. T., Gebre, B. T., Kahsay, S. H., & Tafere, R. M. (2026, January 14). *An unsuspected case of Hirschsprung disease in an adolescent: A case report. The Operating Room Global Journal (TORGJ), 2*(1). https://doi.org/10.64573/torgj2512007
- **Harvard**: Gebreziher, Y.T., Tadesse, F.M., Negash, H.T., Gebre, B.T., Kahsay, S.H. and Tafere, R.M., 2026. An unsuspected case of Hirschsprung disease in an adolescent: A case report. *The Operating Room Global Journal (TORGJ)*, **2**(1). Published 14 January. Available at: https://doi.org/10.64573/torgj2512007
- **Vancouver**: Gebreziher YT, Tadesse FM, Negash HT, Gebre BT, Kahsay SH, Tafere RM. An unsuspected case of Hirschsprung disease in an adolescent: A case report. *The Operating Room Global Journal (TORGJ).* 2026 Jan 14;2(1). https://doi.org/10.64573/torgj2512007

- **MLA (9th edition)**: Gebreziher, Yirgalem Teklebirhan, et al. "An Unsuspected Case of Hirschsprung Disease in an Adolescent: A Case Report." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 1, 14 Jan. 2026, https://doi.org/10.64573/torgj2512007
- **Chicago (Author-Date)**: Gebreziher, Yirgalem Teklebirhan, Feven Mekonen Tadesse, Hadush Tesfay Negash, Berihu Tadishu Gebre, Seare Halefom Kahsay, and Ruta Mehari Tafere. 2026. "An Unsuspected Case of Hirschsprung Disease in an Adolescent: A Case Report." *The Operating Room Global Journal (TORGJ)* 2 (1), January 14. https://doi.org/10.64573/torgj2512007

The Operating Room Global Journal (TORGJ) Volume 2 Issue 1 Mar 2026

Ovarian Ectopic Pregnancy: A Rare Case Report in a Resource-Limited Setting

Authors: Sankara Nykam[1,2,4*], Dimitri Tchinda[2,3], Tatapong Lily Funzeh[2,3], Ma-Fese Dorcas Akwo[3], Nges Samuel[1], Steve Kouam[1], Fotio Theophile[1]

[1] *Medicalised Health Center, Babadjou, Cameroon*
[2] *Faculty of Health Sciences, University of Bamenda, Bambili, Cameroon*
[3] *Faculty of Medicine and Biomedical Sciences, University of Yaoundé 1, Yaoundé , Cameroon*
[4] *The Operating Room Global (TORG).*
DOI: https://doi.org/10.64573/torgj2512003

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*Corresponding Author:
Nykam Sankara Junior Ludwig
nykamsankara@yahoo.com
Declaration:
Authors' Contribution: Sankara Nykam & Tchinda Dimitri: Conceptualization; Methodology; Writing, Original Draft; Fotio Theophile: Supervision & Methodology; Steve Kouam & Nges Samuel; Data Curation; Formal Analysis; Investigation; Tatapong Lily Funzeh & Ma-Fese Dorcas Akwo: Writing, Review & Editing.
Conflict of Interest: No conflict of interest.
Funding: No funding received by the authors.

Article History:
Received: 18-12-2025
Accepted: 11-01-2026
Available Online: 16-01-2026

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ABSTRACT

Background: Ovarian ectopic pregnancy (OEP) is a rare form of ectopic pregnancy which occurs when a fertilized ovum implants into the ovary. The most common risk factor is prior use of IUCD. Management of OEP can be conservative or surgical.

Case: We report a 32-year-old Gravida 2 Para 0010 with a history of right ectopic pregnancy successfully managed medically two years ago who came presenting with severe right lower abdominal pain and 08 weeks amenorrhea. Pregnancy test was positive, laparotomy revealed presence of an unruptured right fluid filled ovarian mass which was removed through wedge resection.

Conclusion: Ovarian ectopic pregnancy should be considered in all reproductive age women who present with severe acute abdominal pain and positive pregnancy test even if ultrasound findings are inconclusive especially in low resource setting were quantitative serum β HCG and laparoscopy are not available.

Keywords: Ovarian ectopic pregnancy, laparotomy, case report, low resource setting.

INTRODUCTION

Ectopic pregnancy is a form of pregnancy in which the embryo attaches itself outside of the uterus, most commonly (95% of cases) in the fallopian tubes [1]. Ovarian ectopic pregnancy (OEP) is a rare form of ectopic pregnancy which occurs when a fertilized ovum implants into the ovary [2]. It occurs in 0.5% to 3% of most ectopic cases. It's incidence ranges between 1 in 7,000 to 1 in 40,000 live births [3].

The most significant risk factor for OEP are intrauterine contraceptive devices (IUCD) which accounts for approximately 57% to 90% of patients with primary OEP [4,5]. Other risk factors include pelvic inflammatory disease (PID), sexually transmitted infections (STIs), endometriosis, previous ectopic pregnancy, use of assisted reproductive technologies, prior pelvic surgery, advanced maternal age, multiparity [2,6].

Diagnostic evaluation in OEP include serial quantification of serum beta HCG level measurement [7], Transvaginal ultrasound (TV-US) which reveals a wide echogenic ring with an internal echo lucent area on the ovarian surface ("ring of fire" sign) [6], laparoscopy remains the gold standard for the diagnosis of OEP [8]. MRI has also been used in some reported cases of OEP for localizing the implantation site when it is unclear on TV-US [9].

The management of OEP can be medical or surgical. Medical management can be done using a single dose of intramuscular methotrexate, though uncommon and controversial, there is limited evidence available regarding management of OEP with methotrexate even though some cases have reported successful results [4]. Surgical management with laparoscopy remains the gold standard due to its minimally invasive nature where a wedge resection, cystectomy or oophorectomy is performed depending on age, patients desire to conceive and others [8]. Laparatomy is done in hemodynamically instable patients. Histopathologic examination can be performed post operatively to confirm the diagnosis [8].

In low resource setting with third category hospitals, the diagnosis and management of OEP remains very challenging due to lack of adequate paraclinical such as quantitative beta HCG serum levels and laparoscopy. Surgical management in low resource setting is mostly done through laparotomy which has the inconvenience of being highly invasive and increases the risk of postoperative complications.

CASE PRESENTATION

This is a 32-year Gravida 2 Para 0010, with a contributive history of right ectopic pregnancy two years ago which was managed medically and last menstrual period (LMP) of 08 weeks prior to consultation who came presenting with severe right lower abdominal pain, burning in nature, continuous, non-radiating with no relieving or aggravating factor. There was no per vaginal bleeding, no vaginal discharges. Review of system was remarkable for one episode of vomiting. On physical examination the patient was seen in pains holding the right iliac fossa with BP: 105/66mmHg, pulse: 87 BPM, Temp0: 36.80C, the conjunctiva was pink, abdomen non distended, tenderness at the hypogastric and right iliac fossa, no rebound tenderness, tympanic abdomen with bowel sounds active.

On vaginal examination, the vulva was clean and the cervix was closed. Our initial diagnosis was a right ectopic pregnancy based on the severe right sided pain and LMP of 08 weeks. Our differential diagnosis was a ruptured right hemorrhagic cyst and appendicitis. Laboratory investigation revealed a positive urine pregnancy test (Qualitative βHCG), quantitative β HCG was unavailable in our setting, full blood count was normal. For the radiologic investigation, a pelvic ultrasound was done which revealed an empty uterus (Figure 1), an unruptured tubal (ampullary) ectopic pregnancy of 09 weeks 03 days (Figure 2), free fluid in the pouch of Douglas and an unruptured right ovarian cyst of approximately 30 ml (Figure 3). A transvaginal ultrasound and laparoscopy were not available in our setting.
Due to the severe right lower abdominal pain the patient experienced, associated with the diagnostic uncertainty between the unruptured ectopic pregnancy and the unruptured ovarian cyst, we opted for a surgical management in first intention. An emergency laparotomy was done under general anesthesia, intraoperative findings revealed a non-gravid uterus, fallopian tubes were free with normal size, presence of a right fluid filled ovarian mass (figure 3, 4, 5) which was resected. Upon sectioning of the ovarian cyst, an encapsulated non-living fetus of approximately 09 weeks was seen with a surrounding clear amniotic fluid (figure 6, 7, 8).

In post operative management, the patient was hospitalized for a total of 05 days where she received intravenous antibiotics (ceftriaxone and metronidazole), analgesics (ketoprofen and paracetamol) with no post operative complications. One month after discharge from the hospital, the patient was asked to do STI related laboratory investigations to rule out pelvic inflammatory disease as one of the etiologies of the OEP and the treatment was done accordingly (see table 1). The patient was later referred to a gynecologist in town for better follow up and preparation for the next pregnancy.

DISCUSSION

Ovarian ectopic pregnancy (OEP) is a rare form of ectopic pregnancy which occurs when a fertilized ovum implants into the ovary [2]. It occurs in 0.5% to 3% of most ectopic cases. It's incidence ranges between 1 in 7,000 to 1 in 40,000 live births [3]. The first documented case of ovarian pregnancy was described in 1682 [10]. This is a case of a 32-year-old Gravida 2 Para 0010 who was successfully managed for ovarian ectopic pregnancy.

The most established and well recognized risk factor for OEP is prior use of the intrauterine device which ranges from 57% to 90% of patients with primary OEP [4,5]. IUD impairs tubal mobility, hence facilitating ovarian implantation. Other causes include pelvic inflammatory disease (PID), sexually transmitted infections (STIs), endometriosis, prior pelvic surgery and others. In our case, our patient had a history of ectopic pregnancy which was successfully managed medically [2,6]. In recent years, invitro fertilization has become a rising risk factor for OEP which can be explained by the application of ovulation stimulation drugs which increase sex hormone by the ovaries, hence affecting the contractile sensitivity of the uterine smooth muscle and interfering with the functioning of the uterus. After embryo transfer, the zygote moves back into the fallopian tube and implants itself in the ovary [11–13]. endometriosis and pelvic adhesions can block ovulation, forcing the egg cell to stay in the ruptured follicle and fertilization occurring directly in the ovary [14].

Although the exact pathophysiology of OEP is unknown, reflux of the fertilized egg back into the ovary is the most frequently known mechanism. Other methods that have been suggested including interfering with the release of the ovum from the broken follicle, fallopian tube dysfunction and inflammatory thickening of the ovarian tunica albuginea. Pathogenesis may also include fertilization out of the fallopian tube then implantation inside the ovarian stoma. The tunica albuginea is a structure that covers the ovary, lacking muscle fibers and filled with blood vessels and loose connective tissue. The tendency for early rupture may be exacerbated by this lack of muscle support. When the trophoblastic tissue invades the ovarian stroma, it damages nearby blood vessels, which causes intra-abdominal blood to quickly build up and rupture. This explains why hemoperitoneum and, occasionally hemodynamic instability are commonly found in ovarian pregnancies. Furthermore, the ovary's lack of decidualized endometrium may restrict the tissue's ability to support implantation, which would further increase the risk of early rupture [15].

The clinical manifestations of OEP are very similar to that of tubal ectopic pregnancy which include amenorrhea, abdominal pain and per vaginal bleeding. This shared symptomatology between OEP and tubal ectopic pregnancy makes it extremely hard to differentiate them preoperatively [16]. In our case, the patient had amenorrhea and pelvic pain only. When the ovarian pregnancy ruptures, the patient experiences severe abdominal pain due to large intra-abdominal hemorrhage begins which can be manifested clinically with hemorrhagic shock and anemia. The differential diagnosis of OEP include tubal ectopic pregnancy, hemorrhagic ovarian cyst, ovarian torsion, tubo-ovarian abscess, acute appendicitis [2].

An elevated serum β HCG indicates the patient is pregnant even in other forms of ectopic pregnancy. Serum HCG continues to rise if treatment is started early enough but the value rarely doubles above 48 hours [20]. In low resource setting, quantitative serum HCG is hardly available as in our case were we mainly relied on qualitative β HCG, making follow up and therapeutic decisions very complicated. Laparoscopy remains a very good alternative for the diagnosis of OEP [21] however because most OEP are emergency consultations due to severe abdominal pain and hemodynamic instability, transvaginal ultrasound has become the main diagnostic modality because of its high availability and affordability especially in low resource settings. In our case a pelvic ultrasound was done due to the unavailability of the transvaginal probe. Recommended ultrasound finding for the diagnosis of ovarian pregnancy include 1) the presence of a wide echogenic ring with an internal echo lucent area on the ovarian surface, 2) the presence of an ovarian cortex, including a corpus luteum or follicles around the mass, and 3) the echogenicity of the ring being greater than that of the ovary itself [22–24].

Other imaging modalities include MRI which is mostly used when transvaginal ultrasound findings are insufficient. It visualizes the presence of extra uterine gestation structures that typically appear as a high-intensity mass containing distinct, low-intensity foci on T2-weighted imaging, which indicate hemorrhage [25]. CT scan is not routinely used in diagnosing OEP however it is important in the diagnosis of ectopic pregnancy at specific sites such as retroperitoneal [26], hepatic [27] and omental pregnancies [28]. Its use in diagnosing ovarian pregnancy remains limited.

The management of ovarian ectopic pregnancy can be conservative or surgical. Conservative treatment includes systemic methotrexate using either single dose [29] or multiple dose [30] regimens . Successful treatment of OEP with laparoscopic or intravaginal injection of methotrexate directly in the ovarian ectopic pregnancy has already been reported [31,32]. Conservative management is mainly done in patients who are hemodynamically stable and requires close monitoring and serial quantification of serum β HCG level to evaluate treatment progression. In our case, conservative management could not be done because we were able to quantify serum β HCG level for close monitoring and the patient experienced severe lower abdominal pain. Surgical management is done mainly through laparoscopy as gold standard because of its minimally invasive nature and less complications, but this requires the patient to be hemodynamically stable [33].

The German gynaecologist, Spiegelberg in 1878 proposed a criterion for the diagnosis of ovarian ectopic pregnancy. 1) The ipsilateral tube must be intact, 2) the gestational sac must occupy a position in the ovary, 3) the ovary must be attached to the uterus through the utero-ovarian ligament, and 4) there must be ovarian tissue attached to the pregnancy in the specimen [17]. OEP can be classified as intrafollicular or extrafollicular OEP based on the etiology [18]; In the intrafollicular OEP, the oocyte is not discharged from the follicle during ovulation. Subsequently, the sperm enters through the ruptured opening and initiates fertilization in the follicle [19]. Extrafollicular OEP occurs when an oocyte has been released from the follicle but becomes implanted on the ovarian surface after fertilization.

It mostly involves an ovarian wedge resection to remove as little normal ovarian tissue as possible [34]. In patients with hemodynamic instability due to massive abdominal bleeding an emergency laparotomy is a suitable option. In our case, conservative management could not be done because we were unable to quantify serum β HCG level for close monitoring and the patient experienced severe lower abdominal pain. Laparoscopy could not be done due to the lack of the laparoscopic machine as well as technical expertise to use it, we therefore went for a laparotomy where we did an ovarian wedge resection leaving the ovaries intact.

CONCLUSION

Ovarian ectopic pregnancy is rare but poses significant diagnostic and management challenges due to similar clinical symptomatology with tubal ectopic pregnancy and other differential diagnosis such as ovarian cyst, ovarian torsion and appendicitis. It is potentially life threatening when not diagnosed early and clinical recognition is necessary to reduce mortality and morbidity. Ovarian ectopic pregnancy should be considered in all reproductive age women who present with severe acute abdominal pain and positive pregnancy test even if ultrasound findings are inconclusive especially in low resource setting were quantitative serum β HCG and laparoscopy are not available.

PATIENT'S CONSENT STATEMENT

A clear and well drafted patient consent form has been attached on a separate word document highlighting the patient's signature and agreement to this case report.

AUTHOR CONTRIBUTIONS (CRediT)

Concept and Design: Sankara Nykam, Tchinda Dimitri, Fotio Theophile
Acquisition and Interpretation of Data: Steve Kouam, Nges Samuel
Drafting of Manuscript: Sankara Nykam, Tchinda Dimitri
Manuscript Review : Tatapong Lily Funzeh , Ma-Fese Dorcas Akwo
Supervision: Fotio Theophile
All the authors approve the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING STATEMENT

All authors have declared that no financial support was received from any organization for the submitted work.

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CITE THIS MANUSCRIPT:

- **APA (7th edition):** Nykam, S., Tchinda, D., Funzeh, T. L., Akwo, M.-F. D., Samuel, N., Kouam, S., & Theophile, F. (2026, January 16). *Ovarian ectopic pregnancy: A rare case report in a resource-limited setting. The Operating Room Global Journal (TORGJ), 2*(1). https://doi.org/10.64573/torgj2512003
- **Harvard**: Nykam, S., Tchinda, D., Funzeh, T.L., Akwo, M.-F.D., Samuel, N., Kouam, S. and Theophile, F., 2026. Ovarian ectopic pregnancy: A rare case report in a resource-limited setting. *The Operating Room Global Journal (TORGJ)*, **2**(1). Published 16 January. Available at: https://doi.org/10.64573/torgj2512003
- **Vancouver**: Nykam S, Tchinda D, Funzeh TL, Akwo MFD, Samuel N, Kouam S, Theophile F. Ovarian ectopic pregnancy: A rare case report in a resource-limited setting. *The Operating Room Global Journal (TORGJ).* 2026 Jan 16;2(1). https://doi.org/10.64573/torgj2512003
- **MLA (9th edition)**: Nykam, Sankara, et al. "Ovarian Ectopic Pregnancy: A Rare Case Report in a Resource-Limited Setting." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 1, 16 Jan. 2026, https://doi.org/10.64573/torgj2512003
- **Chicago (Author-Date)**: Nykam, Sankara, Dimitri Tchinda, Tatapong Lily Funzeh, Ma-Fese Dorcas Akwo, Nges Samuel, Steve Kouam, and Fotio Theophile. 2026. "Ovarian Ectopic Pregnancy: A Rare Case Report in a Resource-Limited Setting." *The Operating Room Global Journal (TORGJ)* 2 (1), January 16. https://doi.org/10.64573/torgj2512003

TABLES

Table 1: STI related exams with their results.

STI exams	Results
Chlamydia serology	IgM: Negative, IgG: Negative
TPHA/VDRL	Negative
Herpes I and II	Negative
Vaginal smear culture	Bacteria isolated: Escherichia coli Sensitivity: ofloxacin, doxycycline, ciprofloxacin
Mycoplasma culture	Sterile

Figures

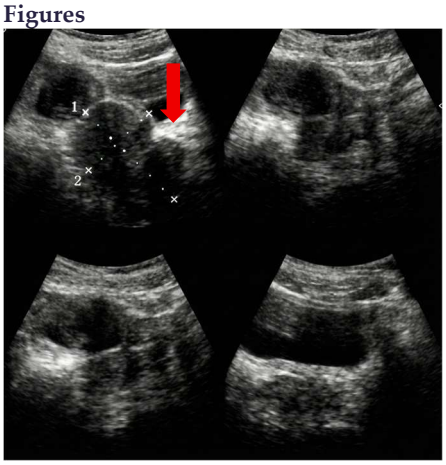


Figure 1: Pelvic ultrasound showing an empty uterus (red arrow).

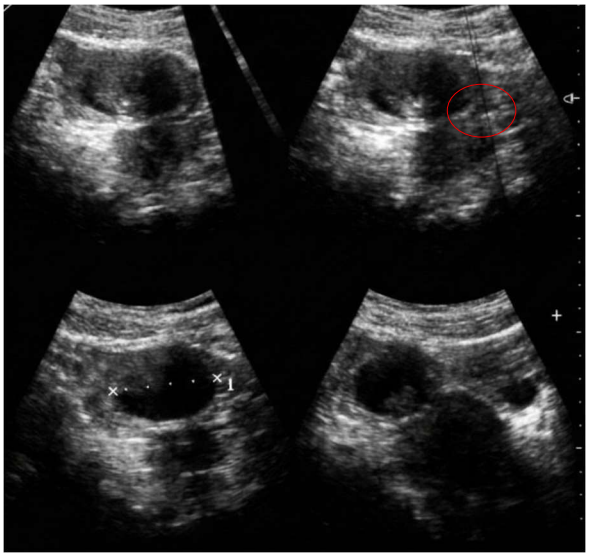
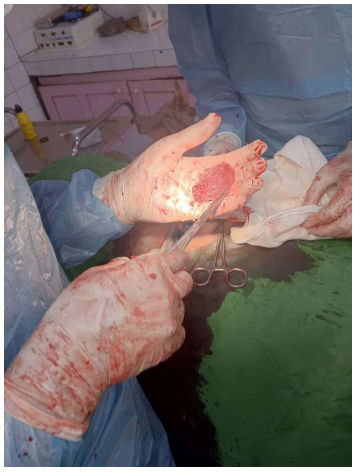
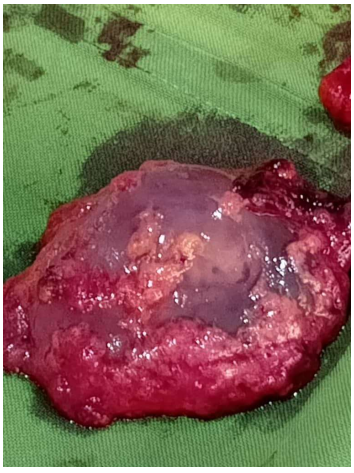


Figure 2: Pelvic ultrasound showing an annexial ectopic pregnancy of 09 weeks 03 days (red circle).





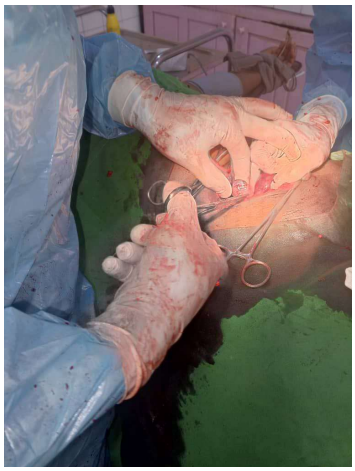
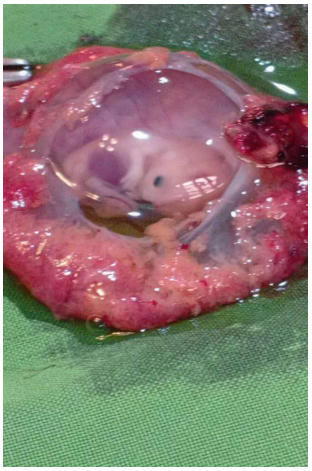
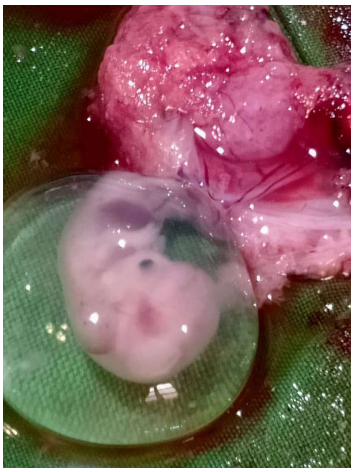


Figure 3, 4, 5: presence of a right fluid filled ovarian mass which was removed, with the ovary still intact.





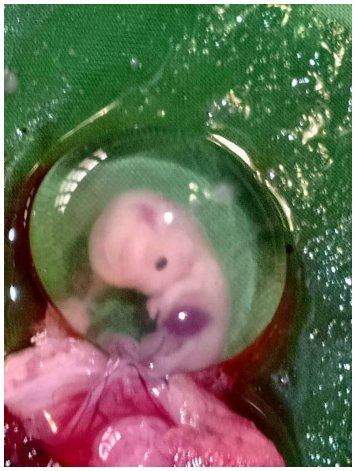
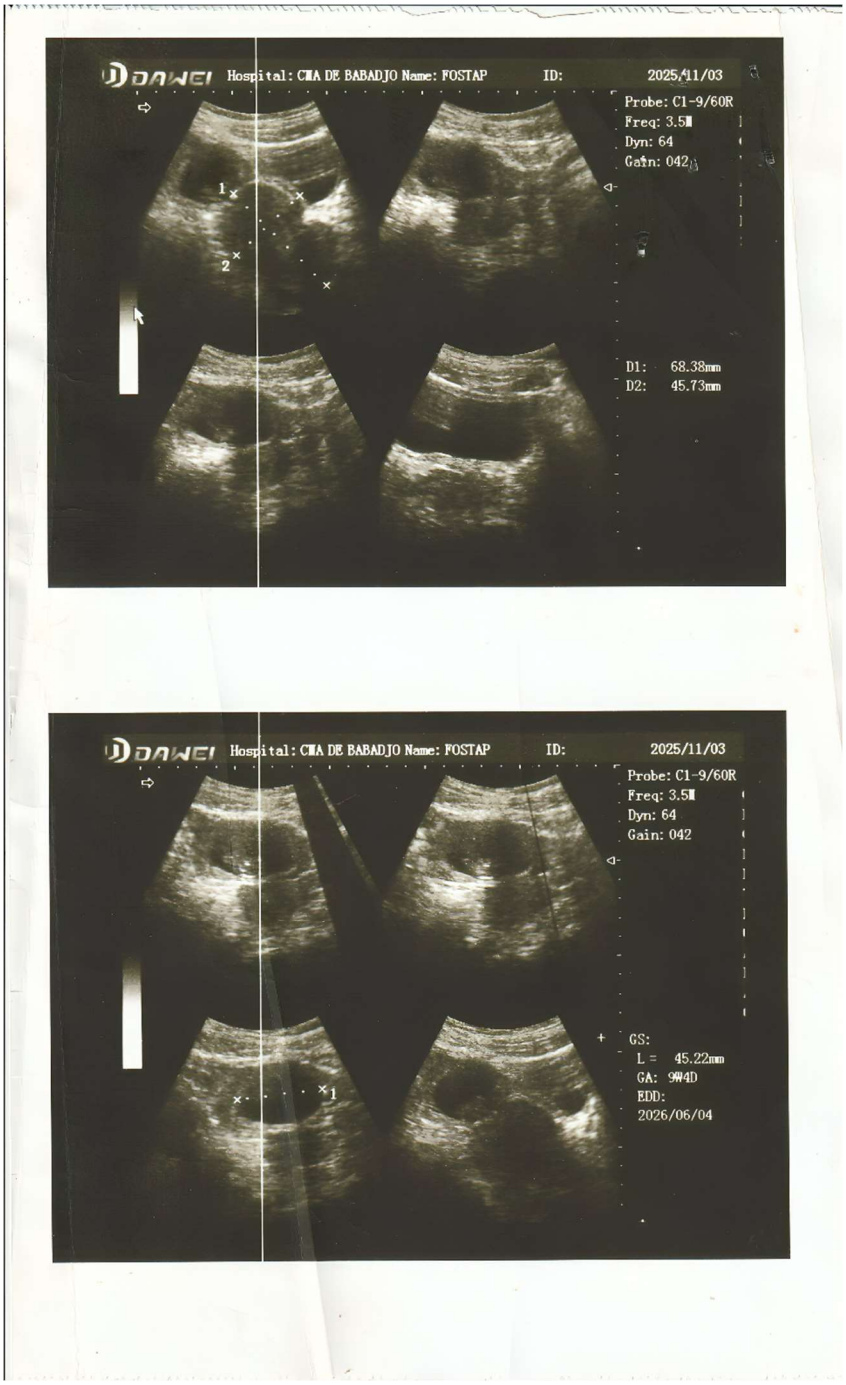


Figure 6, 7, 8: An encapsulated non-living fetus of approximately 09 weeks with a surrounding clear amniotic fluid.

Disclaimer

The ultrasound images used in this case report were color graded and enhanced using Google's Nano banana pro for removal of artifacts and high format resolution PNG format. The original echography file is shown below as proof of originality.



Therapeutic Role and Toxicity Profile of High-Dose Interleukin-2 in Metastatic Melanoma and Renal Cell Carcinoma: A Narrative Review

Authors: Ishaan Bakshi[1,2,3*]

[1] *MBA (Healthcare), Dr. DY Patil University, Pune, India.*
[2] *R-ITI Trainee, Royal College of Radiologists.*
[3] *The Operating Room Global (TORG).*

DOI: https://doi.org/10.64573/torgj2512004

The Operating Room Global Journal (TORGJ) Volume 2 Issue 1 Mar 2026

***Corresponding Author:**
Ishaan Bakshi
ishaan_bakshi@yahoo.com

Declaration:
Author's Contribution: Dr. Ishaan Bakshi conceived, wrote, revised, and approved the final manuscript.
Conflict of Interest: No conflict of interest.
Funding: No funding received by the author.

Article History:
Received: 20-12-2025
Accepted: 17-01-2026
Available Online: 19-01-2026

QR access this Article

ABSTRACT

Background: High-dose interleukin-2 (HD IL-2) is one of the earliest clinically proven immunotherapy approaches for solid tumors. In a select subset of patients with stage III or IV metastatic melanoma and renal cell carcinoma, HD IL-2 has demonstrated the ability to induce significant and long-lasting therapeutic benefits, including durable remissions achieved without the need for further systemic treatment.

Biological Rationale: For HD IL-2 to produce durable therapeutic benefit, it must elicit a robust immune response through marked proliferation and functional activation of immune effector cells, particularly cytotoxic T lymphocytes and natural killer cells. These immune mechanisms underpin the immune-mediated tumor regression observed in responsive patients.

Clinical Efficacy: Experience from early National Cancer Institute clinical trials, as well as subsequent multi-institutional and registry-based studies, has established objective response rates of approximately 15–20% in metastatic melanoma and 20–25% in metastatic renal cell carcinoma. A small but clinically significant minority of patients achieved durable complete remissions. Those attaining complete responses have demonstrated prolonged progression-free and overall survival extending many years beyond completion of HD IL-2 therapy, often without additional treatment.

Toxicity and Limitations: The clinical use of HD IL-2 is constrained by its narrow therapeutic window and significant toxicity profile. Major adverse effects include capillary leak syndrome, cardiovascular instability, renal impairment, and neuropsychiatric toxicity. These risks necessitate inpatient administration, intensive monitoring, and restriction of therapy to highly specialized centers with appropriate expertise.

Conclusion: This narrative review evaluates the biological rationale, therapeutic efficacy, toxicity profile, and current clinical relevance of HD IL-2. Its role is contextualized within contemporary treatment paradigms dominated by immune checkpoint inhibitors and emerging engineered IL-2 variants, highlighting HD IL-2's enduring significance as a therapy capable of inducing durable, treatment-free remissions in carefully selected patients.

Keywords: *High-dose interleukin-2; Immunotherapy; Metastatic melanoma; Renal cell carcinoma; Cytokine therapy; Immune-mediated tumor response; Capillary leak syndrome; Durable remission; Immune checkpoint inhibitors; Engineered IL-2 variants.*

INTRODUCTION

Interleukin 2 (IL-2), a cytokine that serves many different functions, plays a central role in regulating adaptive immune processes such as proliferation and survival of T lymphocytes upon activation by antigens, as well as their functional maturation. CD4+ helper T cells produce IL-2 after an antigenic stimulus, which stimulates the proliferation of CD8+ T lymphocytes and NK (natural killer) cells and works to establish immunological memory. Because of these biologic activities,

IL-2 was one of the first immune mediators to be utilized for systemic cancer treatment long before the advent of immune checkpoint blockade.

High dose IL-2 entered clinical development because of a series of seminal studies performed at the National Cancer Institute demonstrating reproducible immune-mediated tumor regression through the use of systemic IL-2 in a subset of patients with metastatic cancer. The consistent objective responses seen during this time along with the observation of prolonged survival among complete responders provided the rationale for the first immunotherapeutic agent to receive a formal approval from the US Food and Drug Administration, when it was approved for the treatment of metastatic renal cell carcinoma in 1992, followed by the second approval for the treatment of metastatic melanoma in 1998. This represented a pivotal moment in the history of cancer therapy, as it established that modulation of the immune system could serve as an effective therapeutic technique for solid tumors when other viable options for durable systemic treatment were non-existent.

The early identification of metastatic melanoma and renal cell carcinoma (RCC) as particularly responsive to immunotherapy with IL-2 is a product of their intrinsic properties related to tumor immunogenicity. In the case of melanoma, the tumor has a high somatic mutational burden, which translates into the generation of numerous neoantigens that will ultimately lead to the immune recognition of the tumor. Conversely, RCC has a highly vascularized and cytokine dependent local microenvironment. The existence of this type of environment would theoretically support the infiltration and activation of effector immune cells into the RCC microenvironment. As such, the above-described biological characteristics of melanoma and RCC provide a mechanistic explanation for their relative sensitivity to cytokine-based methods of enhancing the immune response.

While high-dose IL-2 has been a major contributor to the development of cancer immunotherapy, it has always been limited by its toxicity. The systemic exposure to the cytokine results in predictable but potentially life-threatening toxicities, including capillary leak syndrome, cardiovascular instability, renal impairment and neuropsychiatric effects. To safely administer this type of therapy, patients must be hospitalized in specialized centers, and the selection of eligible patients must be restricted to those who have adequate cardiopulmonary and metabolic reserves. Thus, in the current era of oncology, the dilemma between the potential for durable and treatment-free remission and the potential for life-threatening toxicities continues to be the primary consideration affecting the clinical utilization of high-dose IL-2.

METHODOLOGY

To identify studies contributing to this review, databases of academic and clinical literature were searched using PubMed, Embase and the Cochrane Library as the major sources of information due to their extensive indexing of oncology and immunotherapy literature and their validity as a source of key literature regarding the clinical development of high-dose Interleukin-2 from 1990 - December 2025.

The following categories of literature were evaluated for eligibility for inclusion in this study; clinical trials (Phase I - III), large prospective and retrospective cohorts, both national and international registries, landmark translational studies evaluating high-dose IL-2 for metastatic melanoma and renal cell carcinoma, including efficacy, durability of response, survival outcomes and toxicities related to the use of IL-2. Case reports, small series from single institutions and non-peer reviewed sources were excluded unless they offered valuable historical or novel insight into the use of IL-2. Greater importance was placed on the interpretation of the results from primary clinical trials, while contemporary consensus reviews were used selectively to round out findings and to provide context for clinical and therapeutic developments regarding the use of IL-2.

Unlike a systematic review, this paper presents information in a narrative format and therefore is subject to selection bias. However, this narrative approach provides the opportunity to combine mechanistic, clinical, and historical elements that contribute to an overall understanding of how IL-2–based immunotherapy will continue to be seen and utilized clinically.

Ethical AI Use Disclosure Statement

The author declares that he used AI-Assisted tools in the writing and editing of this manuscript. However, the author takes full responsibility for all scientific content, including assessment of the literature, interpretation of findings, as well as providing editorial input to the paper. The author did not use AI Systems to produce original scientific conclusions, to interpret clinical data or to analyze scientific data.

IMMUNOLOGICAL BASIS OF IL-2 THERAPY

IL-2 Biology

Interleukin-2 or IL-2 mediates its effects on the immune system through a complex of proteins that are called the IL-2 receptor. This receptor consists of three different proteins - CD25 (the IL-2R alpha chain), CD122 (the IL-2R beta chain) and CD132 (the common gamma chain). Each of these chains is present on a different type of immune cell and is involved in the growth and development of that specific cell type. Activated effector T lymphocyte cells will express the high-affinity form of the receptor complex, while NK cells and memory T cells will typically express the intermediate affinity form of the receptor. Because of this heterogeneity in the receptor molecules, IL-2 has different effects at different dosages and on different types of immune cells.

Binding of the ligand to the receptor triggers intracellular signal transduction events through the actions of Janus Kinases 1 and 3 (JAK1 and JAK3), leading to phosphorylation and translocating STAT5 to the nucleus of the cell. Once the STAT pathway has been activated, the process of gene transcription begins within the nucleus and is responsible for the signals that regulate the progression of the cell cycle, cell survival, and effector cell differentiation. Simultaneously, through activation of the PI3k-AKT pathway, enhanced metabolic function and resistance to apoptosis is achieved, while through the MAPK pathway, further proliferation of effector cell expansion occurs. These multiple signal transduction pathways work collectively to produce large numbers of effector immune cells capable of producing cytotoxic effects against potentially harmful tumors.

The ability for IL-2 to stimulate not only the effector cells but also regulatory T cells, which express a high-affinity receptor for IL-2, shows that regulatory T cells can expand at the expense of effector activation, or vice versa, due in part, to the fact that regulatory T cells also express the high-affinity receptor. This explains some of the limitations in therapy with IL-2 and helps provide the rationale for designing engineered IL-2 variants that selectively stimulate effector cells and have the potential to limit the expansion of regulatory T-cells.

Mechanisms of Antitumor Activity

High-dose IL-2 helps to keep cytotoxic CD8 T cells growing and building their capabilities. Cytotoxic CD8 T cells that are growing and building their capabilities have an increased capability to recognize and kill tumors, and they produce larger amounts of pro-inflammatory cytokines that modify the tumor microenvironment and enhance the ability for the immune system to eliminate tumors.

In addition to benefiting adaptive immunity, IL-2 also enhances innate immunity by promoting the growth and activation of natural killer (NK) T cells. NK T cells do not rely solely on specific antigens to exert destruction. Natural killer T cells assist in providing additional immune surveillance in the presence of heterogeneous tumor cells. The combined activation of both adaptive and innate immune systems creates a broader opportunity for IL-2 to restore immune responses and reduce or eliminate the ability of cells to escape the immune cells based on continued loss of antigens.

A clinical finding of high-dose IL-2 treatment is that patients may attain long-term, durable complete remissions. For patients who achieve long-term disease control, the continued immune response is believed to create a stable population of tumor-specific memory T cells that can be reactivated when the patient is again exposed to tumor antigens. Therefore, the potential continued long-term overall survival associated with the use of IL-2 results from the immunologic memory created by administration of IL-2 compared to most modern-day systemic agents and provides a rationale for its continued clinical use.

HIGH-DOSE IL-2: THERAPEUTIC PROTOCOLS

Definition and Dosing Strategy

High-dose IL-2 (interleukin-2) therapy includes the administration of high enough levels of IL-2 to stimulate a strong response from the entire immune system. In terms of modern-day clinical practice, the typical method used today is to give high doses of IL-2 through intermittent intravenous bolus doses rather than giving a continuous infusion of low-dose IL-2. Standard dosing regimens typically include a dose range of 600,000 to 720,000 international units of IL-2 per kilogram body weight every eight hours, with a maximum of fourteen doses permitted during each inactive treatment cycle, depending on the patient's individual tolerance. Typically, patients receive two inactive treatment cycles with a short break in between to allow the patient to recover from acute adverse effects of the therapy.

Because of the intense physiological changes caused by the administration of IL-2, physicians will only administer this therapy to patients who are hospitalized and will require constant monitoring of hemodynamic parameters, fluid balance, cardiopulmonary function, and serial blood and urinalysis laboratory-test evaluations of renal and liver-function tests, electrolytes, and blood counts throughout their treatment. Patients receiving IL-2 therapy will be given a dose of IL-2 based on close dynamic evaluations of the patient, rather than just completing a previously established dosing schedule; in addition, any patient experiencing significant toxicity will have their IL-2 therapy interrupted early.

Patient Selection and Eligibility Criteria

The safe administration of high-dose IL-2 depends heavily on thorough patient selection. Typically, patients must have a baseline performance status of 0 or 1 (ECOG) that indicates excellent functional capacity, which represents all of the cardiopulmonary and metabolic requirements of high-dose IL-2 therapy and requires sufficient physiological reserve for tolerating transient multi-organ stress due to therapy.

All patients will go through an extensive pretreatment work-up. Cardiovascular integrity needs to be thoroughly assessed because IL-2 induces hypotension, tachyarrhythmias, and transient myocardial dysfunction in a large percentage of patients. Consequently, any patient with underlying ischemic heart disease, an impaired cardiac reserve, or significant arrhythmias will not qualify.

In addition, both adequate renal and hepatic functions are required prior to initiating therapy because the cytokine-induced capillary leak syndrome, which occurs in most patients receiving cytokines and results in multiple organ failures due to cytokine-related hypoperfusion, can lead to significant morbidity when these organs are not able to adequately respond to treatment. Pulmonary reserve is also evaluated to minimize the potential for respiratory problems associated with fluid shifts.

Individuals with active infections, poorly controlled autoimmune diseases, symptomatic CNS metastases, and significant baseline organ impairment are not candidates for high-dose IL-2 therapy. While these eligibility criteria greatly limit the number of patients eligible for treatment, they are essential to ensuring treatment-related morbidities are minimized and that the risks and benefits remain favorable for long-term responders.

CLINICAL EFFICACY

Metastatic Melanoma

High-dose interleukin-2 (IL-2) was originally investigated for the treatment of metastatic melanoma by the NCI (National Cancer Institute) and has been further developed through multiple clinical trials with additional centers. In these pivotal trials, as well as in registry trials, the rate of objective response rates has been reported to fall between 15% and 20%, indicating that IL-2 can induce an immune response to stone blasting tumor cells, even when those tumors are advanced or resistant to standard treatments. While complete responses are generally uncommon, they can present the most significant clinical change because of using IL-2.

The percentage of patients who have complete responses is approximately 5% to 8% following treatment with IL-2. In fact, studies have demonstrated that long-term follow-up in complete responders may result in lasting complete remission even years after administration of a dose of IL-2 has been stopped. The experience gained from the use of cytotoxic chemotherapy indicates that most patients experience only a short-term period of disease stabilisation before the remittance of disease re-occurs; therefore, IL-2 possesses the potential to provoke a long-term immune-mediated cure for some patients who have received it.

Data gathered from several landmark studies indicate that among complete responders, there may be a plateau effect regarding survival because of being treated with IL-2, suggesting that for a small but meaningful percentage of patients who achieve complete remission following the administration of IL-2, a functional cure may be achievable.

Metastatic Renal Cell Carcinoma

The product of the cytokine interleukin-2 has demonstrated the clinically significant activity in the treatment of advanced carcinoma associated with the kidney (metastatic renal cell carcinoma (mRCC)). Specifically, the use of IL-2 in the treatment of mRCC has been associated with improved overall response rates (20% to 25%), a significant number of patients achieving a complete response (5% to 10%).

Non-clear-cell renal cell carcinoma (NCC-RCC) has been shown to be relatively more resistant to IL-2 treatment compared to clear-cell renal cell carcinoma (CC-RCC). Histological subtype is critical when predicting IL-2 therapeutic efficacy. When comparing IL-2 treatment to other systemic therapies for mRCC and melanoma, both melanoma and RCC patients have shown a high degree of durable complete response (DCR) following IL-2 treatment; Long-term DCR is common among RCC patients who achieve a complete response after treatment with IL-2.

Additionally, these Long-term DCR demonstrate the immune-mediated response to treatment with IL-2 compared to most current systemic therapeutic agents to treat mRCC. Therefore, treatments with IL-2 should continue to be selectively incorporated within clinical practice when considering the possibilities of immune-response treatment of RCC.

Predictors of Response

Researchers attempting to identify which patients are most likely to respond favorably to high-dose IL-2 have evaluated both clinical and immunologic factors. Favorable clinical factors include patients with less tumor burden overall, better functional capabilities, and no large volume number of visceral metastases. It is believed that these factors may represent a less immunosuppressive tumor microenvironment as well as being more amenable to amplification of the immune response. Investigational studies examining biomarkers indicate that patients who have higher lymphocyte counts prior to starting therapy, as well as having a higher density of immune cells that are infiltrating into their tumors and have evidence of having an immune response to their cancer prior to treatment, may have improved response rates. Despite some promise for these findings, none of these associations is universally established from patient study to patient study, and thus no clinically validated predictive method for selecting appropriate patients has been created. Thus far, patient selection primarily depends upon the clinical judgment of the investigator regarding the performance status of the patient, the organs involved, and their overall distribution of disease.

TOXICITY PROFILE OF HIGH-DOSE IL-2

The use of high-dose interleukin-2 (IL-2) can be associated with an acute toxicity syndrome characterized by the activation of the immune system, and that endothelial cell dysfunction, due to cytokine-induced endothelial cell activation; the toxic effect of this syndrome is markedly dose-dependent. There will be some reversibility of most effects with adequate supportive care; however, due to the severity of the effects, the administration of high-dose IL-2 requires administration and monitoring in a specialized inpatient setting for constant monitoring and rapid practice of intervention.

Capillary Leak Syndrome

Capillary Leak Syndrome is the defining toxicity and primary toxicity associated with high-dose IL-2 treatment. Cytokines cause activation of endothelial cells, which results in increased permeability of the blood vessels, leading to the passage of fluid and protein from the vascular space to the extravascular space. Patients experience the following clinical signs: dehydration; accumulation of fluid in the body compartments; decreased urine volume; and increased hematocrit and hemoglobin concentration in the blood. The severity of Capillary Leak Syndrome typically increases with the cumulative dose of high-dose IL-2 within each treatment cycle and is managed by closely monitoring hemodynamics; judicious use of intravenous fluids; and the timely initiation of vasopressors when indicated. The management of Capillary Leak Syndrome may lead to interruptions or discontinuations in the delivery of high-dose IL-2 based on clinical severity rather than on where the patient is on a pre-designed dosing schedule.

Cardiopulmonary Toxicity

A common complication of IL-2 therapy is hemodynamic instability, which is also a major limiting factor for dosing. Hypotension is often seen requiring medication assistance to maintain blood pressure, and patients may experience temporary heart rhythm irregularities (both supraventricular and ventricular arrhythmias), necessitating continuous monitoring with an electrocardiogram.

The primary cause of pulmonary toxicity is the presence of interstitial and alveolar fluid as a result of capillary leak syndrome. Patients presenting with pulmonary congestion will often have trouble breathing, low oxygen saturation in the blood, and may show changes on chest radiographs. In addition to initiating supplemental oxygen therapy, other management strategies include careful fluid administration, a temporary pause in IL-2 therapy until the patient's respiratory function stabilizes, and the use of appropriate medications.

Renal, Hepatic, and Neurological Effects

Renal dysfunction seen with IL-2 therapy is often attributed to reduced blood flow to the kidneys related to the effects of cytokines rather than from direct damage caused by IL-2. Acute kidney injury may result in oliguria and increasing serum creatinine levels, and it is generally reversible once hemodynamic stability is restored, and the administration of IL-2 is ceased. A common effect of therapy resulting from IL-2 is temporary elevation of hepatic transaminases and bilirubin levels, due to an inflammatory response in the liver. Normally, these laboratory abnormal findings will resolve spontaneously once treatment is completed.

Lastly, an array of neurological effects can occur while receiving IL-2; these include mild cognitive slowing and mood changes to more severe presentations of agitation, confusion, or hallucinations. Neurological complications are believed to result from the systemic immunity response to IL-2 therapy as well as metabolic changes associated with the treatment that can alter blood flow to the brain. A prompt neurological evaluation should be performed on any patient experiencing severe neurotoxicity from therapy.

Treatment-Related Mortality and Risk Mitigation

Historically, high-dose IL-2 (interleukin-2) was associated with significant mortality due to treatment-related complications. However, the development of more defined patient eligibility criteria, standardization of toxicity management clinical pathways, and the implementation of multidisciplinary teams providing supportive care have led to a decreased incidence of fatal complications related to treatment with IL-2. Current practice involves using only experienced medical centers with direct access to intensive medical support services when administering high-dose IL-2 for cancer therapy. Therefore, strict eligibility criteria must be adhered to, as well as continuous monitoring and interventions early on that are supportive of patients to decrease the risk of treatment-related complications.

COMPARISON WITH MODERN IMMUNOTHERAPIES

Conceptual and Mechanistic Distinctions

The unique immunological treatment paradigms offered through high-dose IL-2 and immune checkpoint inhibitors have many differences in their mechanisms of action as well as the effects they produce through those mechanisms. The action of IL-2 is to directly increase the number of immune effector cells by rapidly expanding the number of lymphocytes and natural killer cells. More specifically, these immune effector cells (NK) are rapidly produced, resulting in rapid proliferation and activation of the immune effector cell (NK) population. In turn, this rapid proliferation and activation results in widespread systemic immune stimulation over short periods of time. Conversely, checkpoint inhibitors indirectly enhance the ability of the immune response to fight cancer by removing the inhibitory signals associated with the immune response.

Those mechanistic differences lead to markedly different clinical profiles. Checkpoint inhibitors have significantly higher overall response rates in diverse patient populations, and they have become standard of care for patients with metastatic melanoma and renal cell carcinoma. However, durable disease control with checkpoint inhibitors generally requires continued treatment. Although there is a lower overall frequency of response to high-dose IL-2, it is still unique in that the subset of patients who are selected for treatment with this modality are likely to have long-lasting durable remissions that do not require continued treatment following the initiation of therapy.

Balancing Therapeutic Benefit and Toxicity

Compared to current checkpoint-based therapies, the high-dose IL-2 risk-to-reward ratio is extremely different. The risks associated with use of high-dose IL-2 include intense, predictable, and primarily reversible side effects which must be treated in the hospital and should be limited to patients who have good physiologic reserves to endure them. Conversely, patients receiving checkpoint inhibitor therapies are usually given treatment outside of a hospital setting. Therefore, checkpoint inhibitors are generally much more acceptable and broader in the number of patients able to use them, although, like IL-2, may have life-threatening immune-related reactions that may occur unpredictably.

Checkpoint inhibitor therapy's high tolerability and wide-spread acceptability when compared to IL-2 has promoted more frequent use in day-to-day medical practices. However, the fact that CTLA-4 and anti-PD1 monoclonal antibodies induce durable complete remissions is yet another distinction that sets high-dose IL-2 apart both biologically and clinically from most of the contemporary agents currently being used.

Combination and Sequential Strategies

A growing body of research suggests that combining or sequencing the use of IL-2 and immune checkpoint inhibitors may be a useful strategy to improve clinical outcomes. Checkpoint inhibitors are thought to increase the size of the pool of lymphocytes that respond to tumors, while IL-2 enhances the activity of those same lymphocytes through its stimulating effect. In contrast, IL-2 can also enhance the duration of responses initially induced by checkpoint inhibitors.

Although researchers have been somewhat cautious about examining how different combinations of the two therapies might impact the risk of added toxicity, recent studies indicate that new engineered IL-2 variants that preferentially stimulate lymphocytes preferred for the immune response while minimizing systemic toxicity may provide an effective approach to limit potential adverse events. Furthermore, combining therapies using a sequence in which an IL-2 injection is given after initial node involvement with checkpoint inhibitors shows that responses remain active when these therapies are combined and may remain viable as newer medicines are developed.

CURRENT ROLE AND CLINICAL RELEVANCE

Enduring Clinical Significance

Immune checkpoint inhibitors and targeted therapies are the dominant treatment in the current treatment algorithms for metastatic melanoma and renal cell carcinoma; however, high-dose interleukin-2 (IL-2) is still a unique clinical entity. The long-term clinical significance of IL-2 is its ability to induce long-term complete responses in a small group of patients without the need for further treatment, a happening that is rare for even the newest immunotherapy drugs. As the only immunotherapy drug with this biologic difference, IL-2 provides both conceptual and clinical value, even though the everyday use of IL-2 is decreasing.

In addition to providing clinical value, the long-term follow-up of patients treated with IL-2 gives clinicians unique insight into the natural history of responsive immune-mediated tumor eradication; therefore, the data from long-term follow-up have provided the foundation of developing and evaluating new immunotherapeutic approaches to achieve durable anticancer immunity.

Selective Use and Niche Applications

Currently, clinicians utilize high doses of Interleukin-2 (IL-2) only for those patients whose organ function is intact, whose overall condition is G (good), and where IL-2 has been found to be potentially curative due to the type of cancer(s) involved (e.g. clear cell renal cell carcinoma and specific subtypes of melanoma).

However, due to the need for specialized infrastructure within the institutions administering IL-2 as well as experienced multidisciplinary teams to support its safe delivery, the use of IL-2 is limited to only a few specialized centers across the United States (U.S.). At these specialized treatment facilities, patients with tumors that potentially respond to IL-2 are offered this treatment on the basis that they are willing to accept the risks associated with the use of IL-2 for the potential of longer-term tumor control.

Economic and Resource Considerations

High doses of IL-2 lead to many upfront resource expenditures for hospitalization, intensive monitoring, and supportive care. However, patients who achieve durable remission will not need systemic therapy for the duration of the life of that patient, thus leading to long-term economic savings versus treating patients with drug regimens of chronic nature. These financial aspects clearly provide a rationale for using IL-2 selectively in patients who have a high probability of receiving a substantial benefit.

FUTURE DIRECTIONS

Development of Modified IL-2 Therapeutics

The very high levels of toxicity associated with IL-2 administered at high doses has led to the development of engineered IL-2 molecules specifically designed to allow for an increased therapeutic window. The altered IL-2 drugs are made to preferentially stimulate antitumor effectors and provide less stimulation of regulatory T-cells and endothelial cells (i.e., increasing the risk of capillary toxicity and systemic effects associated with vascular endothelium) than the conventional IL-2. The methods of engineering these IL-2 variants include, but are not limited to, altering the receptor binding profile of IL-2, pegylation of IL-2, fusion protein constructs of IL-2, and targeted delivery platforms for IL-2.

Initial investigations of these engineered IL-2 variants suggest that it may be possible to take advantage of the positive effects of immune amplification generated by IL-2, with reduced systemic toxicities and side effects than would have been experienced through conventional IL-2 administration. If the initial studies can be further validated in larger clinical trials, it is expected that engineered IL-2 variants will become broadly used for the treatment of patients and be used in conjunction with other Immunotherapeutics in practice today.

Combined and Sequential Immunotherapy Strategies

Combining IL-2-based therapy with immune checkpoint inhibitors is an active area of clinical investigation, as these agents may enhance the antitumor response to checkpoint blockade in patients who have responded partially or transiently to the latter therapy by enhancing the proliferation of lymphocytes and their functional capacity. On the other hand, by preparing the immune environment for the actions of IL-2, checkpoint blockade may create more effective conditions under which IL-2 can expand and enhance the proliferation of T cells.

Currently, many clinical trials are being conducted to find out how best to sequence IL-2 treatment and immune checkpoint blockade, determine appropriate dosages of both treatments, and mitigate the risk of increased immune-related adverse events (irAE) due to excessive immune stimulation by both treatments. These clinical trials demonstrate the shift to a comprehensive approach toward rationally designed combination Immunotherapeutics based on the mechanistic complementarity of these two therapeutic classes.

Toward Personalized Immune-Based Therapy

With advances made in immune profiling and biomarker development, we will be able to better personalize IL-2 treatments. By looking at the immune environment around the tumor, specifically the balance between effector and regulatory lymphocytes, patterns of cytokine signaling, and expression levels of immune checkpoints, we will be able to identify the best candidates for long-term benefit from IL-2-induced immune amplification.

Using molecular and immunologic biomarkers will allow us to better select patients who would benefit from treatment while minimizing unnecessary treatment of low probability candidates and maximizing the benefit of treatments through better selection processes. As the field of precision oncology continues to grow and evolve, we may see a resurgence of IL-2 therapies that are more sophisticated and targeted than previously used.

LIMITATIONS OF EXISTING EVIDENCE

Absence of Contemporary Comparative Trials

Evaluating the use of high-dose interleukin-2 has a significant drawback because there are no randomized clinical trials conducted in the current era of immunotherapy. The efficacy and safety data for the product have been developed before the development of immune checkpoint inhibitors and targeted therapies became widely used, thereby precluding a direct comparison with current standard of care therapies. As a result, relative assessments of the therapeutic value of IL-2 are based largely on historical data rather than current head-to-head comparative clinical evidence.

Impact of Selective Patient Enrollment

The unique and very structured recruitment process used in clinical trials of IL-2 has a substantial impact on the outcome for each patient. In addition to safety for those who receive study treatment, this type of recruitment creates a bias in the way that potential patients are chosen. As a result, the likely success of IL-2 may not be representative of what can be achieved in the general oncology patient population; rather, this selective enrollment creates an inflated view of the likely success rate of IL-2 and a diminished representation of the potential risks of IL-2 treatment in a more expansive oncology population.

Constraints on External Validity

High-dose IL-2 is prescribed in institutional settings that have been developed specifically to employ high-dose IL-2. Each institution may create its own unique protocols, toxicity management plans, and patient follow-up procedures, thereby providing a very different experience than what would occur if the same treatment were to be provided to an individual patient outside of an institutional setting. Because of this variability, the results of existing clinical trials may not necessarily be applicable to routine oncology clinical practice.

CONCLUSION

High-dose IL-2 is a unique milestone in the history of developing cancer immunotherapies. It was among the very first systemic therapies to illustrate the potential of immune modulation to elicit durable, treatment-free remissions in patients with metastatic melanoma and renal cell carcinoma. High-dose IL-2 has a low overall response rate but produces profound and lasting benefits in a subset of patients, making it one of the most dramatic and unprecedented drugs from both a clinical and biological standpoint.

Due to the limited therapeutic window and high toxicity associated with high-dose IL-2, only carefully selected patients can receive this treatment, and it must be administered in specialized treatment settings. The emergence of immune checkpoint inhibitors has largely replaced IL-2 in the first-line treatment setting as they can be used more broadly, are better tolerated, and are therefore increasingly used in today's cancer patients. Nevertheless, due to the inherent ability of high-dose IL-2 to create long-lasting complete remissions without continuous treatment, it is still in a unique position compared to most of the other drugs currently available.

In today's environment of utilizing immunotherapy to treat cancer, high-dose IL-2 has transitioned from a commonly applied treatment to one that is increasingly being used more selectively and as a niche treatment for a selected population of patients. However, the fact that high-dose IL-2 is still being utilized is relevant to the development of other new immunotherapies based on the knowledge gained from high-dose IL-2. As the field continues to advance, it is likely that therapies that utilize IL-2 will once again find their way to the clinic in forms that are consistent with the concept of precision oncology.

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CITE THIS MANUSCRIPT:

APA (7th edition): Bakshi, I. (2026, January 19). Therapeutic role and toxicity profile of high-dose interleukin-2 in metastatic melanoma and renal cell carcinoma: A narrative review. The Operating Room Global Journal (TORGJ), 2(1). https://doi.org/10.64573/torgj2512004

Harvard: Bakshi, I., 2026. Therapeutic role and toxicity profile of high-dose interleukin-2 in metastatic melanoma and renal cell carcinoma: A narrative review. The Operating Room Global Journal (TORGJ), 2(1). Published 19 January. Available at: https://doi.org/10.64573/torgj2512004

Vancouver: Bakshi I. Therapeutic role and toxicity profile of high-dose interleukin-2 in metastatic melanoma and renal cell carcinoma: A narrative review. The Operating Room Global Journal (TORGJ). 2026 Jan 19;2(1). https://doi.org/10.64573/torgj2512004

MLA (9th edition): Bakshi, Ishaan. "Therapeutic Role and Toxicity Profile of High-Dose Interleukin-2 in Metastatic Melanoma and Renal Cell Carcinoma: A Narrative Review." The Operating Room Global Journal (TORGJ), vol. 2, no. 1, 19 Jan. 2026, https://doi.org/10.64573/torgj2512004

Chicago (Author-Date): Bakshi, Ishaan. 2026. "Therapeutic Role and Toxicity Profile of High-Dose Interleukin-2 in Metastatic Melanoma and Renal Cell Carcinoma: A Narrative Review." The Operating Room Global Journal (TORGJ) 2 (1), January 19. https://doi.org/10.64573/torgj2512004

The Operating Room Global Journal (TORGJ) Volume 2 Issue 1 Mar 2026

Effectiveness of Preoperative Nursing Visits in Reducing Preoperative Anxiety Among Surgical Patients in Kaduna State, Nigeria

Authors: Danjuma Aliyu[1, 2, 6*], Dalhat Khalid Sani[2], Salihu Abdulrahman Kombo[2], Hayat Gomma[2], Sani Mohammad Sani[3], Bashir Abdulmumini[3], Madinat Shola Mohammed[4], Funke Sulyman[5]

[1,2,6]Department of Perioperative Nursing, College of Nursing Sciences, Ahmadu Bello University Teaching Hospital Zaria, Kaduna State, Nigeria.

[2]Department of Nursing Science, Ahmadu Bello University, Zaria.

[3]Nursing Science Programme, Distance Learning Centre, Ahmadu Bello University, Zaria.

[4]Department of Nursing Services, Tudun Wada, Ahmadu Bello University Teaching Hospital, Zaria, Kaduna State, Nigeria.

[5]School of Nursing, Babcock University, Ilishan Remo, Ogun State, Nigeria.

[6]The Operating Room Global (TORG).

DOI: https://doi.org/10.64573/torgj2512006

***Corresponding Author:**
Danjuma Aliyu
aliyudanjuma19@gmail.com

Declaration:

Authors' Contribution: Equal contributions.

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History:
Received: 21-12-2025
Accepted: 19-01-2026
Available Online: 22-01-2026

QR access this Article

ABSTRACT

Background: Preoperative anxiety (PA) is a prevalent challenge among surgical patients and is linked to poorer perioperative outcomes. Preoperative nursing visits (PNVs) were significantly associated in reducing PA, but evidence from Nigerian tertiary hospitals particularly in northern states remains limited.

Methods: A post-test only non-equivalent control group quasi-experimental design was used to recruit 204 patients scheduled for elective surgeries in two tertiary hospitals in Kaduna State. Participants were divided into intervention (n = 102) and control (n = 102) groups. Anxiety levels were categorized as mild, moderate, or severe. Chi-square and independent t-tests were used to determine associations between PNVs and preoperative anxiety.

Results: Most respondents were young and in their middle age with relatively high educational attainment. Patients who received the intervention reported considerable low mean in anxiety scores as against those in the control group (Mean = 2.82 as against 3.11; t = -2.90883, p = 0.00981). Chi-square analysis confirmed a significant association between PNVs and anxiety levels ($\chi^2 = 12.026$, df = 2, p = 0.002). Patients who received PNVs expressed less worries about anaesthesia and surgery but demonstrated stronger informational needs, particularly regarding anaesthesia and surgical procedures.

Conclusion: Our findings show that patients who received PNVs reported lower anxiety scores compared to those receiving routine nursing care. While the design does not allow causal conclusions, the results suggest that PNVs may play a useful role in reducing patient anxiety in Nigerian tertiary hospitals. Integrating PNVs into routine perioperative practice may strengthen patient-centred care, reduce surgical anxiety, and improve outcomes.

Keywords: Preoperative anxiety; preoperative nursing visit; perioperative nursing; perioperative outcomes; surgical patients.

BACKGROUND

Preoperative anxiety (PA) affects eight in every ten surgical patients (SPs) and is related to high postoperative pain, delay in recovery, prolonged hospitalization, and reduced patient satisfaction with surgical care(1–3). Anxiety is mostly triggered by fear of anaesthesia, uncertainty about surgical outcomes, fear of postoperative pain and surgical complications. Non-pharmacological intervention on educational and psychological support carryout by nurses was associated with lowering PA and enhancing perioperative outcomes[4,5].

Preoperative nursing visits (PNVs) offer SPs individualised information, reassurance, emotional support, and anticipatory guidance. Evidence from a high-income country indicates that PNVs significantly lower anxiety and contribute to better postoperative outcomes, including reduced pain, fewer complications, and improved postoperative recovery and outcomes[6–9]. The use of emerging techniques such as enhanced preoperative education and virtual reality based preoperative patients' preparation further demonstrate anxiety-reducing potential[10,11].

In Nigeria, studies from Osun and Borno States report that preoperative counselling and education reduce anxiety and postoperative pain, supporting the relevance of nursing-led interventions in resource-constrained environments[12,13]. With limited pharmacological options and high surgical caseloads in many tertiary hospitals, structured PNVs remain a feasible and cost-effective strategy[13].

Despite evidence from Southern Nigeria and high-income countries, there are limited empirical evidence on structured PNVs in Northern Nigeria's tertiary hospitals and challenges of implementing PNVs in Nigerian tertiary hospitals, cultural factors influencing patient anxiety. Thus, this study provides evidence on PNVs in Kaduna State by assessing whether PNVs is associated with reducing PA among SPs in tertiary hospitals.

METHODS

Study Design, Setting and Participants

To evaluate the effect of PNVs, we carried out a posttest only non-equivalent group quasi-experimental study on SPs in two tertiary teaching hospitals in Kaduna State, Nigeria. This design was used due to the impracticality of randomization and within-hospital controls. The two hospitals were selected to prevent treatment contamination and preserve routine nursing care practices, and both institutions are comparable public tertiary referral teaching hospitals within the same state, making the design appropriate and consistent with real world nursing intervention studies. Surgical patients scheduled for elective procedures at Ahmadu Bello University Teaching Hospital (ABUTH) Zaria who received structured PNVs (intervention group), while those at Barau Dikko Teaching Hospital (BDTH), Kaduna, received routine nursing care (control group). Adults undergoing elective surgery between the ages of 18 and 60 were eligible to participate and patients with diabetes, autoimmune disorders, mental illness, cognitive/hearing impairments, emergency surgeries, previous surgeries, day-case procedures, or post-traumatic stress disorder were excluded.

Sample Size Determination and Sampling Technique

The Cochran-Armitage formula for comparing two proportions was used to determine the sample size, with 70% of the intervention group and 50% of the control group predicted to have positive outcomes. At 80% power and 95% confidence. A total of 204 patients in all were calculated and for each group, 102 patients were recruited after accounting for 10% attrition. A convenience sampling was employed, and every participant gave their informed consent.

Intervention: Preoperative Nursing Visit

The PNV consisted of a structured 20–30-minute session conducted at least 24 hours prior to surgery by trained perioperative nurses using a validated checklist. The components included explanations of the surgical procedure, anaesthesia, expected recovery, pain management strategies, and postoperative care instructions. Perioperative Nurses also provided emotional reassurance and encouraged patients to ask questions. This standardized approach ensured uniform delivery of information and minimized variability in patient experience.

Tools for Data Collection

A semi-structured questionnaire given by the interviewer was used to collate the data and Amsterdam Preoperative Anxiety and Information Scale (APAIS) was adapted for this study by merging the original Likert-scale responses into three clinically meaningful categories: mild, moderate, and severe anxiety. This collapsing was performed to enhance interpretability, facilitate categorical analysis, and align anxiety levels with clinical decision-making. The modification did not alter the original items and the scoring structure of the tool but involved post-scoring categorization and the reliability of the modified tool for the study was supported by its good internal consistency (Cronbach's $\alpha = 0.84$).

Study Variables

The independent variable was the structured PNVs. Dependent variables included preoperative anxiety. Confounders such as age, sex, type of surgery, and comorbidities were considered during analysis.

Data Analysis

SPSS version 27.0 was used to analyse the data. Clinical and socio-demographic traits were presented using descriptive statistics. Chi-square and independent t-tests were used to evaluate correlations between continuous and categorical data. Statistical significance was defined at $p \leq 0.05$, and the APAIS tool was modified by collapsing response options into three levels: mild, moderate, and severe categories based on threshold reported in previous study14 even though, the original item scoring was preserved, only categories were collapsed post-scoring. Future studies should employ multivariate analyses to adjust for demographic differences such as education and ethnicity to provide stronger evidence about the relationship between PNVs and reduced PA.

Ethical Considerations

Approvals for the study was obtained from the Ministry of Health Kaduna State (NHRE/17/03/2018), and ABUTH Zaria (NHREC/ABUTH-HREC/29/08/23) Research and Ethics Committees. Confidentiality and anonymity were guaranteed, and written informed consent was obtained. Participants were free to leave at any moment.

RESULTS

There were 204 patients in all, 102 of whom were recruited from the intervention facility and 102 in the control hospital. Many SPs were aged 28–32 years (34.3% as against 37.3%). Occupationally, most participants were civil servants or engaged in business/trade, accounting for nearly two-thirds of both groups. Ethnic distribution showed that the treatment group was predominantly Hausa/Fulani (53.9%), whereas the control group was more diverse, with Hausa/Fulani (41.2%) and other ethnicities (31.4%) being most common. In terms of marital status, 65.7% of both groups were married. With 56.9% of the treatment group and 74.5% of the control group reporting tertiary education, this level of education was the highest. A smaller proportion reported Islamic education (17.6% vs. 4.9%). Religiously, most participants were Muslim (67.6% treatment; 58.8% control), followed by Christians (32.4% as against 38.2%). Notable demographic differences were observed between groups, particularly in education and ethnicity, which may have influenced anxiety outcomes (See Table 1).

The PA levels of patients in the intervention and control groups are compared in Table 2. The intervention group's mean anxiety score (Mean = 2.82) was considerably lower than the control group's (Mean = 3.11), and the difference reached statistical significance ($t = -2.90883$, $p = 0.0098$). Patients in the intervention group reported more worries about anaesthesia and surgery, but a higher proportion expressed moderate to severe concern about the outcome of the operation. Importantly, these patients also demonstrated a stronger desire for information about both anaesthesia and the surgical procedure, with 81.4% moderately and 36.3% severely interested in additional information about the operation. In contrast, SPs in the control group may likely to have mild or moderate anxiety and showed less demand for detailed information. Although patients in the intervention group expressed moderate concern about surgical outcomes, their overall anxiety scores were low, suggesting that PNVs shifted anxiety toward information seeking behaviour rather than more worry.

Table 3 presents the comparison of PA levels between SPs who received PNVs and those who received routine nursing care. The findings show a clear difference in PA distribution between the two groups. In the intervention group, most patients (63%) reported mild anxiety, compared to only 41% in the control group. Conversely, moderate anxiety was observed among SP in the control group (48%) as compared to the intervention group (26%). Severe anxiety was uncommon in both groups, with similar proportions reported. The intervention group demonstrated a more favourable anxiety level, with a greater proportion of patients falling within the mild anxiety category. The association between PNVs and anxiety category was statistically significant ($\chi^2 = 12.026$, $df = 2$, $p = 0.002$), confirming that PNVs was associated with PA levels.

DISCUSSION

The findings of this study suggest that patients who received PNVs reported mild mean anxiety scores and were more likely to fall within the mild anxiety level compared to those who received routine care. These findings are consistent with global evidence that reported the value of nurse-led preoperative education and psychological support in reducing patient apprehension and improving surgical readiness[14,15,16,17,18,19]. These findings align with studies from Osun and Borno States in Nigeria, which demonstrated that structured counselling and education reduced anxiety and postoperative pain[12, 14]. This result also supported evidence that states, informed SPs experienced reduced PA(20). The effect of PNVs experienced by SPs is likely attributed to improved knowledge, clarification of misconceptions, enhanced patient–nurse communication, and emotional reassurance.

An interesting observation was the increased information-seeking behaviour among patients in the intervention group. This is not indicative of anxiety but rather reflects the heightened engagement and preparedness of patients. These outcomes were also documented in previous studies[5, 21, .22, 23, 24]. In addition, PNVs may reduce the intensity of preoperative anxiety by channelling it into proactive information-seeking[25].

The demographic patterns suggest that young to middle-aged adults with higher educational attainment SPs may influence the association with PNVs, although this requires further exploration. Prior studies have shown that health literacy and support are significant factors in postoperative recovery[26]. These findings suggest that tailoring PNVs to diverse patient profiles, including those with low literacy or limited support, could benefit from it effect in resource-constrained settings strengthens the relevance of PNVs in Nigeria. Contrary findings reported among surgical patients found no significant effect of PA on postoperative outcomes (27) this may relate to differences in complexity, severity and patient expectations. This disparity may reflect differences on the surgery type, patient population, ethnicity or the quality and duration of PNVs as supported by[28,29], who argued that family support or patient knowledge alone may not significantly reduce PA.

The study's strengths include standardised intervention delivery, adequate sample size, and use of a validated instrument. However, one of the limitations of this study is the non-equivalent control group design, with the intervention group drawn from ABUTH and the control group from BDTH. Differences in hospital culture, routine nursing practices, patient demographics and surgical teams may independently influence anxiety levels. This study also employed a post-test only design, baseline anxiety levels were not measured. It is therefore not possible to confirm equivalence between groups at the outset. The observed differences in post-intervention scores may partly reflect pre-existing differences between patients at ABUTH and BDTH, which limits the internal validity of the findings. Therefore, while the findings suggest that PNVs are associated with reduced anxiety, the possibility that hospital-level differences contributed to the observed effects cannot be excluded. A randomized controlled trial within the same hospital would provide stronger causal evidence. Due to patient flow, bed space arrangement and the possibility of contamination, we are unable to evaluate the baseline PA and verify it impact between groups before intervention. Furthermore, differences in education and ethnicity between the two facilities may have influenced anxiety outcomes. Despite these limitations, the findings provide promising evidence supporting the integration of PNVs into routine preoperative care pathways in Nigeria.

CONCLUSION

In this study, SPs who received PNVs reported lower anxiety scores compared to those receiving routine nursing care. While the design does not permit causal conclusions, the findings suggest that nursing visits may be a useful approach to reducing preoperative anxiety and enhancing patient preparedness in Nigerian tertiary hospitals. Future research using randomized control designs and multivariate adjustment is needed to confirm these associations.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING STATEMENT

All authors have declared that no financial support was received from any organization for the submitted work.

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CITE THIS MANUSCRIPT

- APA (7th edition): Aliyu, D., Sani, D. K., Kombo, S. A., Gomma, H., Sani, S. M., Abdulmumini, B., Mohammed, M. S., & Sulyman, F. (2026, January 22). *Effectiveness of preoperative nursing visits in reducing preoperative anxiety among surgical patients in Kaduna State, Nigeria. The Operating Room Global Journal (TORGJ), 2*(1). https://doi.org/10.64573/torgj2512006
- Harvard: Aliyu, D., Sani, D.K., Kombo, S.A., Gomma, H., Sani, S.M., Abdulmumini, B., Mohammed, M.S. and Sulyman, F., 2026. Effectiveness of preoperative nursing visits in reducing preoperative anxiety among surgical patients in Kaduna State, Nigeria. *The Operating Room Global Journal (TORGJ)*, 2(1). Published 22 January. Available at: https://doi.org/10.64573/torgj2512006
- Vancouver: Aliyu D, Sani DK, Kombo SA, Gomma H, Sani SM, Abdulmumini B, Mohammed MS, Sulyman F. Effectiveness of preoperative nursing visits in reducing preoperative anxiety among surgical patients in Kaduna State, Nigeria. *The Operating Room Global Journal (TORGJ).* 2026 Jan 22;2(1). https://doi.org/10.64573/torgj2512006
- MLA (9th edition): Aliyu, Danjuma, et al. "Effectiveness of Preoperative Nursing Visits in Reducing Preoperative Anxiety Among Surgical Patients in Kaduna State, Nigeria." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 1, 22 Jan. 2026, https://doi.org/10.64573/torgj2512006
- Chicago (Author-Date): Aliyu, Danjuma, Dalhat Khalid Sani, Salihu Abdulrahman Kombo, Hayat Gomma, Sani Mohammad Sani, Bashir Abdulmumini, Madinat Shola Mohammed, and Funke Sulyman. 2026. "Effectiveness of Preoperative Nursing Visits in Reducing Preoperative Anxiety Among Surgical Patients in Kaduna State, Nigeria." *The Operating Room Global Journal (TORGJ)* 2 (1), January 22. https://doi.org/10.64573/torgj2512006

Table 1: Demographic Characteristics of Patients (n = 204)

Variables	Study (n = 102)		Control (n = 102)	
Age group	**F**	**%**	**F**	**%**
18–22	11	10.8	9	8.8
23–27	31	30.4	22	21.6
28–32	35	34.3	38	37.3
33–37	13	12.7	20	19.6
38–42	6	5.9	6	6.9
≥43	6	5.9	7	6.9
Occupation				
Civil servant	37	36.3	34	33.3
Business/trade	34	33.3	28	27.5
Unemployed	14	13.7	12	11.8
Student	10	9.8	13	12.7
Retired	7	6.9	8	7.8
Others	0	0.0	7	6.9
Ethnicity				
Hausa/Fulani	55	53.9	42	41.2
Igbo	13	12.7	12	11.8
Yoruba	15	14.7	16	15.7
Others	19	18.6	32	31.4
Marital status				
Single	26	25.5	15	14.7
Married	67	65.7	67	65.7
Divorced	5	4.9	12	11.8
Widow	4	3.9	8	7.8
Education				
Primary	1	1.0	0	0.0

Secondary	21	20.6	21	20.6
Tertiary	58	56.9	76	74.5
Islamic	18	17.6	5	4.9
None	4	3.9	0	0.0
Religion				
Muslim	69	67.6	60	58.8
Christian	33	32.4	39	38.2
Others	0	0.0	3	2.9

Table 2: Distribution of Preoperative Anxiety Levels among Patients

Anxiety	Intervention (n = 102)						Control (n = 102)					
	Mild		Moderate		Severe		Mild		Moderate		Severe	
	F	%	F	%	F	%	F	%	F	%	F	%
Worried about anaesthesia	51	50.0	51	50.0	0	0.0	47	46.1	48	47.1	7	6.9
Worried about operation	32	31.4	28	27.5	42	41.2	41	40.2	44	43.1	17	16.7
Worried about operation outcome	34	33.3	22	21.6	46	45.1	38	37.3	55	53.9	9	8.8
Require more information about anaesthesia	16	15.7	83	81.4	3	2.9	30	29.4	56	54.9	16	15.7
Require more information about operation	21	20.6	40	39.2	40	39.2	26	25.5	53	52.0	17	16.7
Aggregate mean %	31	30.4	45	44.1	26	25.5	19	18.6	51	50.0	12	11.8
Aggregate mean score	**2.82**						**3.11**					
t = -2.90883, p = 0.0098												

Table 3: Effect of Perioperative Nurse Visits on Preoperative Anxiety Levels

	Anxiety Level				
Perioperative Nurse Visits	**Mild**	**Moderate**	**Severe**	**X^2 (df)**	**p-value**
Intervention	64 (62.7)	26 (25.5)	12 (11.8)	**12.026 (2)**	**0.002**
Control	42 (41.2)	49 (48.0)	11 (10.8)		
Total	**106 (51.9)**	**75 (36.8)**	**23 (11.3)**		

Imaging-Guided Regenerative Aesthetics: A Review of PRP, Stem-Cell, and Fat-Derived Therapies in Interventional Radiology

Authors: Ishaan Bakshi[1,4], Parikshta Sookrah[2], Hriday Singh Rawat[3,4], Prashant Anand[3], Sakshi Singh[3]

[1]Dr. DY Patil University; Royal College of Radiologists
[2]Elevé Aesthetic Clinic, Mauritius
[3]Anna Medical College, University of Technology, Mauritius
[4]The Operating Room Global (TORG).

DOI: https://doi.org/10.64573/torgj2601001

***Corresponding Author:**
Ishaan Bakshi
ishaan_bakshi@yahoo.com

Declaration:
Authors' Contribution: Equal contributions
Conflict of Interest: No conflict of interest.
Funding: No funding received by the authors.

Article History:
Received: 11-01-2026
Accepted: 24-01-2026
Available Online: 28-01-2026

QR access this Article

ABSTRACT

Background: The regenerative field of aesthetic medicine has placed a growing emphasis on using biologically derived, minimally invasive techniques through which tissue function and quality can be restored. Autologous (patient's own) therapies such as platelet-rich plasma (PRP), stem-cell-derived products, and fat-derived grafts have become common treatments for a variety of indications including facial rejuvenation, scar treatment, and hair restoration. Most of these treatments are currently performed with the aid of landmark-based methods for injecting, which can lead to inconsistent results and increased risks during procedures.

Rationale and Purpose: Interventional radiology offers the opportunity to use a more precise image-guided technique with the use of real-time imaging (i.e., ultrasound) to view vascular structures and soft-tissue planes as they are placed within the body. This allows for better needle placement and allows for the accurate delivery of biologic agents with significantly less risk of intravascular injections. The purpose of this narrative review is to describe the current body of literature regarding the use of imaging guidance to aid in the delivery of regenerative aesthetic medical procedures. It will address the following components: clinical efficacy, safety, regulatory aspects, and standardization of the imaging technique.

Methods and Results: A structured search of the literature was completed using PubMed, Embase, and the Cochrane Database from 2020 to July 2025.Based on the available studies, image-guided delivery of biologic medications does demonstrate an increase in procedural accuracy, improves the distribution of grafts within tissues, and leads to improved patient-reported outcomes when compared to traditional methods of injection. However, much variation exists in the methods of biologic preparation, methods to assess the outcomes, and length of time patients are followed the procedure.

Conclusion: Recent evidence has shown that imaging guidance can help increase both safety and reproducibility in various areas of the patient care continuum. However, there continues to be a lack of high-quality randomized trials demonstrating the benefits associated with imaging guidance and comprehensive standardized protocols for the utilisation of imaging guidance, which ultimately hampers the development of clinically significant evidence-based treatment algorithms. A need for additional multi-disciplinary studies is present to create valid and scientifically based guidelines for incorporating the use of interventional radiology within regenerative aesthetic practices.

Keywords: *Platelet-rich plasma; stem-cell therapy; fat grafting; regenerative aesthetics; interventional radiology; ultrasound-guided injection; imaging guidance.*

The Operating Room Global Journal (TORGJ) Volume 2 Issue 1 Mar 2026

INTRODUCTION

Over the last decade, regenerative and interdisciplinary approaches to aesthetics have garnered significant interest from an expanding patient population seeking to return to a youthful, healthy state with less invasive techniques and with more permanent enhancement of their appearance. As opposed to traditional aesthetic medicine techniques that primarily employ synthetic fillers, neurotoxins, or surgical procedures, regenerative techniques in aesthetic medicine continue to promote and/or augment natural tissue quality and stimulate the body's own ability to regenerate damaged tissue and replace it with new, improving the appearance of the skin through enhanced collagen production, increased blood flow and healing, and improved structural support through improved skin texture, elasticity, and volume by the use of their own tissue through the use of autologous biomaterials such as PRP, stem cell-derived products, and adipose tissue-derived grafts.

Although regenerative aesthetic procedures are becoming increasingly prevalent, most are still being performed using the traditional landmark-based injection methods (surface anatomy & practitioner experience) which can vary significantly based on the individual (i.e. patient's vascular and soft tissue anatomy). As such, biologic materials that are placed inconsistently may result in inconsistent outcomes (i.e. not able to achieve desired effects), loss of durability of the outcome(s), and increased risk of developing complications (Risks include tissue ischemia; necrosis and/or, in rare cases, permanent blindness). In addition, it is critical that clinicians utilize image guided interventions to enhance procedural accuracy, thereby improving clinical outcomes.

Interventional Radiology now provides the framework for enhancing procedural accuracy by using real-time imaging guidance. The different modalities (i.e. Ultrasound, CT, Fluoroscopy) provide clinicians with direct vision of the vascular structures & the soft tissue plane and allow for accurate needle placement in relation to the injection of biologic material. Ultrasound is the most practical modality for use in aesthetic practice because the technology is readily available and does not involve exposure to ionizing radiation and provides the clinician with real-time, dynamic assessment capability. Providing clinicians with accurate tissue planes avoids injecting into critical vessels, thus ensuring uniform distribution of biologic materials throughout the defined treatment area.

In the present day, there is relatively little scientific evidence and there is considerable heterogeneity among studies pertaining to the use of imaging to provide guidance during regenerative medicine processes (i.e., platelet-rich plasma [PRP], stem cells, and fat transfer). The differences among these biologics with respect to preparation protocols, imaging modality types, outcome measures, and follow-up durations hinder the ability to make reasonable comparisons of efficacy between studies and create standards of practice. Therefore, to define the potential applications of interventional radiology for regenerative aesthetics, an assessment of all available scientific literature is warranted.

The present narrative review article serves to provide insights into how imaging is used to support the administration of PRP, stem cells, and fat to improve aesthetic outcomes. Consideration will be given to biological mechanisms, clinical efficacy, safety issues, and regulatory concerns as well as gaps in knowledge that require investigation to enhance both future research and practice in this area.

METHODOLOGY

The purpose of this narrative review is to synthesize and critically analyze the current literature regarding Imaging-Assisted Rejuvenation. This review was intended to consolidate current clinical practices, identify the evidence supporting these practices, and highlight possible weaknesses within the field as opposed to being an exhaustive systematic review.

Literature Search Strategy

A systematic search of the bibliographic databases of PubMed, Embase, and the Cochrane Library was conducted on the complete range from database inception through July 2025. The databases used were chosen because of the extensive content they have included from all areas of biomedical/clinical/surgical research. Search terms used were a mixture of keyword and Medical Subject Heading (MeSH) terms including all of the following: regenerative aesthetics; platelet-rich plasma; PRP; stem cells; adipose-derived stem cells; fat grafting; stromal vascular fraction; ultrasound guided injections; CT-guided; interventional radiology. Boolean operators (AND and OR) were used as needed to narrow the searches.
Manual review of the reference sections in reviewed publications were also performed to obtain additional publications of significance.

Study Selection

The eligibility criteria for study inclusion are as follows:
(1) subjects included in the study had to be human.
(2) the study had to be written in English.
(3) the study had to evaluate the application of platelet-rich plasma, stem-cell therapy, or adipose derived products delivered under imaging guidance.
4) the study had to report on aesthetic/reconstructive applications, i.e., facial rejuvenation, scar management, treatment of alopecia, or soft tissue volumization.
The following were included as exclusionary criteria for study: non-human subjects, non-aesthetic applications, conference abstracts without the full article, and regenerative procedures without imaging guidance

Screening and Data Extraction
Two individuals completed title and abstract screening to establish relevance. Eligible studies for which it could not be determined based upon title and abstract were screened by reviewing the full paper. The authors achieved consensus when there was a difference of opinion about whether to include a study.
Relevant data from all studies included study design and patient population, method of biologic preparation, imaging modality, injection technique, clinical indication for treatment, outcome measurements, length of follow-up, and complications.

Assessment of Evidence Quality
Overall quality of evidence was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework. Each of the three major types of therapies (platelet-rich plasma, stem-cell-based therapy, and fat grafting) was evaluated according to the following criteria for quality of evidence: Study design, risk of bias, consistency of study results, directness of the evidence, and precision with which outcome estimates are made. Results of this evaluation provided data to support comparative analyses between different types of therapies and to identify the current need for additional high-quality studies.

Ethical Use of Artificial Intelligence
Artificial intelligence–based tools were used only in the early stages of manuscript preparation for limited language checking and formatting support. All scientific content, literature selection, data interpretation, and critical analysis were performed by the authors. The final version of the manuscript was comprehensively rewritten, reviewed, and approved by the authors to ensure originality, accuracy, and full academic accountability. No AI tools were used to generate scientific arguments, fabricate data, or replace author judgment.

REGENERATIVE AESTHETICS: BIOLOGICAL BASIS

Regenerative Aesthetic Medicine is becoming increasingly popular because it addresses more than just the surface of the skin. Instead of just covering up the cosmetic effects of aging, it restores the structural integrity and biological function of the skin. While traditional approaches usually treat the visible effects of aging, such as wrinkles and sagging skin, now these techniques buff the skin and promote the growth of new skin cells and healthy connective tissue. Therefore, regenerative procedures are more physiologically based compared to traditional cosmetic procedures and therefore may provide longer-term aesthetic benefits.

As more people have sought non-surgical options for treating signs of aging, the trend has broadened to all ages. Many physicians now offer preventive and maintenance regimens (also referred to as prejuvenation) that provide patients with the opportunity to act prior to experiencing the negative effects of aging, such as wrinkle formation. Patients are choosing regenerative procedures because they prefer more natural-looking results that do not add excessive volume to the face or create unnatural contours.

The regenerative aesthetic approach includes the use of biological materials obtained from the individual patient that could repair tissue through the inclusion of cellular and molecular repair factors. Platelet-rich plasma contains the highest concentration of growth factor for stimulating fibroblast production, angiogenesis, and collagen production. Mesenchymal stem cells could support regenerative processes through both differentiation and the release of bioactive substances for regulating inflammation, increasing vascular connection, and enhancing the remodelling of the extracellular matrix. The

material derived from adipose tissue contains a very large number of stromal cells, contains an extensive number of extracellular vesicles, and serves as a very durable support for tissue growth and healing.

These biological materials interact in the microenvironment where they are placed and stimulate the formation of new blood vessels, increase the dermal thickness, and improve the vitality of the cells. Growth factors produced by the platelets, including (but not limited to) platelet-derived growth factor (PDGF), vascular endothelial growth factor (VEGF) and transforming growth factor beta (TGFβ), are important for coordinating all of these processes. In addition to the production of growth factors by the platelets, the interactions of extracellular vesicles and cytokines also influence the immune response and support the dynamic process of wound healing. Therefore, the combined effect of these pathways results in an improvement of the quality of the tissue for a longer time than just the short-term volumetric effects.

Regenerative therapies are an alternative to traditional aesthetics because they focus not only on how the cell works (function) but also on how the cell is held up (structure). After treatment using biological methods, many studies have documented improved hydration, elasticity, and mechanical strength of the tissues, which correlates with improved organization of the extracellular matrix and increased blood flow to the tissues being treated. The biological basis of regenerative therapies is therefore the ideal foundation for precision delivery systems because accurate placement of a substance during the treatment will utilize the full capacity of the regenerative therapy with minimal dispersion and depletion.

IMAGING MODALITIES IN AESTHETIC INTERVENTIONS

Using imaging has become more helpful in the field of Aesthetics when using biological injectables and grafts. Imaging gives practitioners access to a true 3-dimensional look at the soft tissue layers, blood vessels, and the position of the needle relative to the skin and blood vessels as opposed to the practice of using surrounding anatomical structures, such as the nose, as a guide. Consequently, imaging provides a more accurate method of performing aesthetic procedures that ultimately improve on the safety, consistency, and clinical reproducibility of how practitioners perform the procedures.
Ultrasound imaging is currently the most popular imaging device used in the field of Aesthetic Medicine. Linear transducers with high-frequency transducers facilitate a clear visual look at the soft tissues under the skin at the face-level, particularly the arteries, veins, and connective tissue planes. An ultrasound can provide images of the needle being advanced through the skin so that practitioners have a chance to verify the depth of their injections. Practitioners also have an ability to change the position of the needle while they are injecting materials. This is exceptionally helpful in the peri-orbital, bridge between the eyebrows(glabellar), and temples because if the needle accidentally punctures a blood vessel, it may produce serious repercussions. In addition, Doppler technology also provides clinicians with the ability to see blood flow through blood vessels. This allows for the prevention of inadvertent accidents due to a lack of blood flow to the area.

In addition to helping clinicians prevent complications, ultrasound provides the practitioner with a greater ability to ensure that materials are placed uniformly and accurately within the tissues they are injected into, leading to predictable outcomes. The accurate selection of the plane for injection can also lead to less migration of the biological materials and support for the proper integration and therapeutic activity of the grafted materials.

For procedures that require working with deeper structures or more complicated anatomical defects, advanced imaging modalities can be used as a supplementary resource. CT scanning not only gives the ability to assess osseous landmarks and deep soft tissues with high resolution but is also useful in some reconstructive or volumetric applications. MRI has advantages in soft tissue contrast and will help define a procedure plan for patients who have had prior surgery, trauma, or have developed fibrosis. However, for aesthetic procedures, both CT and MRI have limited use due to cost and availability, and with regards to CT, the risk of ionizing radiation when using CT scans.

Fluoroscopy is rarely used in aesthetic interventions but may be appropriate for use in select cases where there is a need for continuous visualization of deep tissue planes or for large-volume graft placement. Fluoroscopy is mainly limited to specialized reconstructive cases and not to routine cosmetic practices.

New imaging technologies are developing, thus increasing the capabilities of image-guided aesthetics. For example, ultrasound elastography provides a means for quantitative measurement of tissue stiffness and could help in determining the best injection planes and evaluating the degree of response associated with treatment. Furthermore, there are new imaging systems being developed based on artificial intelligence to provide automated vascular mapping and procedural

planning, thereby decreasing operator variability. While these new technologies are still in the early stages of clinical integration, they are promising future tools for helping in standardizing aesthetic outcomes.

Integrating different types of imaging modalities provides a way to use a precision-based approach to improve the safety of procedures performed using these techniques, ensure consistency of delivering biologicals, and support research-based methods in the use of regenerative aesthetic medicine

PRP UNDER IMAGE GUIDANCE

Platelet Rich Plasma (PRP) is among the most frequently used biological therapies within the practice of regenerative aesthetic medicine because of its excellent safety profile, ease of preparation, availability from the individual patient (autologous), and the relatively simple process of preparation. PRP is obtained from centrifuging the peripheral blood to separate the solid components of the blood (the red blood cells and white blood cells) from the liquid component (plasma) to create a concentrated preparation of platelets, which contains a high concentration of growth factors, cytokines, and bioactive proteins. After PRP is injected into a patient, the biologically active component will be released slowly and will aid in the repair and remodelling of tissue.

The biological properties of PRP are mainly interactive with the following four types of biological mediators: Platelet-Derived Growth Factor, Vascular Endothelial Growth Factor, Transforming Growth Factor β, and Insulin-Like Growth Factor. These biological mediators stimulate fibroblast proliferation, increase the formation of new blood vessels (angiogenesis), increase the synthesis of collagen, and mediate the inflammatory reaction. As a result, improving the texture, elasticity, and healing ability of the skin.

The conventional technique for PRP injections employs various anatomic landmarks on the skin's surface to help the physician determine where to place the needle. However, since there is no standard way to use these landmarks, the placement of PRP into the target tissues can vary and may not produce desired results. Furthermore, incorrect placement of PRP increases the chance that a blood vessel or nerve will be damaged during the procedure. One solution to these problems is utilizing imaging technology, such as ultrasound, to visualize the tissue layers and blood vessels surrounding the needle in real time. With the use of ultrasound, PRP can be accurately deposited into the appropriate tissue surface, and therefore its clinical benefits become more evident.

The use of ultrasound guidance helps to ensure that the distribution of PRP is more consistent throughout the area of injection and that there is reduced risk of injecting PRP into blood vessels. The use of Doppler imaging also allows the physician to identify the blood vessels surrounding the injection site, thus allowing for safe placement of PRP in anatomically sensitive areas. Occasionally, fluoroscopy is used to help guide PRP injection into areas that are deeper or anatomically complex; however, the routine use of fluoroscopy in an aesthetic practice is uncommon.

The clinical applications of image-guided PRP are widespread across many aesthetic practices. For example, when used for facial rejuvenation, multi-layering of intradermal and subdermal PRP has been shown to enhance skin tonality, hydration, and reduced fine line formation. In the case of androgenetic alopecia, consistent perifollicular application of PRP has been demonstrated to improve hair density and to decrease hair shedding. Additionally, the use of PRP has also been effective for the treatment of scarring, burn rehabilitation, and postoperative recovery, where PRP helps to remodel collagen and speeds up the healing process.

While numerous studies report successful outcomes with PRP therapy, there is considerable variation in protocols for preparing PRP, including differences in platelet concentration, activation, and treatment intervals. These differences preclude making direct comparisons across these studies and complicate the synthesis of evidence. Use of imaging guidance helps to lessen the impact of these limitations, as it enables a more consistent delivery method; however, further standardisation of preparation and administration procedures are still required to achieve the best clinical outcomes.

STEM-CELL THERAPIES UNDER IMAGING GUIDANCE

The use of stem cell treatments for Regenerative Aesthetics has grown in popularity because of the ability to restore biological function and structural integrity of the tissues. The two most common cellular sources for stem cell treatments include bone marrow aspirate concentrate and adipose-derived mesenchymal stem cells. Bone marrow aspirate concentrate contains

mixed populations of hematopoietic and mesenchymal progenitor cells. Adipose-derived mesenchymal stem cells (ADMSCs) are accessible, plentiful, and capable of differentiating into more than one lineage. In addition to their ability to undergo differentiation, these cells also exert a significant regenerative effect by means of paracrine signalling through secretion of biologically active cytokines, growth factors, and extracellular vesicles that regulate inflammation, induce angiogenesis, and enhance the remodelling of the extracellular matrix. These mechanisms of action through paracrine signalling are believed to be the primary reasons for the therapeutic activity of stem cells in aesthetic applications. By altering the local microenvironment, stem cells are believed to improve the thickness, elasticity, and hydration of the dermis.

The accurate delivery method of cellular suspensions is crucial to the best possible achievement of effective therapeutic treatment with minimal procedural risk for patients. Traditionally, cellular suspensions have been injected into a patient based on the established landmark technique. Unfortunately, these techniques are often associated with less-than-optimal distribution of cellular suspension with a higher frequency of injury to surrounding blood vessels. Image guidance technology has changed the ways in which cellular suspensions can be injected into a patient. Imaging techniques, most notably, ultrasound, allow for real-time observation of the injection plane and direction of the needle and nearby blood vessels, making it easier to exactly target intradermal, subcutaneous, and/or deep fascial compartments when injecting cellular suspensions and tissue.

Computed tomography is useful for supporting both deep or reconstructive applications in the case of complex or traumatic anatomical defects. In addition to offering a greater degree of procedural reproducibility, image-guided stem cell delivery may improve stem-cell survival because the appropriate tissue and blood supply are being targeted. The expected physical results of uniform distribution of the cellular suspension throughout its intended injection site include reduced localized cell aggregation and a reproducible regenerative effect. These advantages are particularly true concerning facial rejuvenation, scar remodelling, and contour restoration.

The literature on clinical outcomes of stem-cell-based aesthetic treatments is limited and of poor methodological quality. Almost all published studies are small case series, pilot trials, or observational studies that have described improved outcomes with skin texture, pigmentation, scar flexibility, and volume preservation; however, variations between the methods of isolation of the stem cells, the preparation of the stem cells, the amount of stem cells injected, and the injection technique have resulted in difficulty interpreting study results.

In addition to clinical considerations, there are also significant safety and regulatory issues associated with the use of stem cells. Reported theoretical risks are aberrant differentiation, immunodynamic responses, and potential tumor formation associated with allo-generated or heavily manipulated products. Although very few aesthetic procedures have had serious outcomes reported, there is currently insufficient data on the long-term safety of this type of treatment. Thus, a key component of proper clinical practice will include thorough screening of qualified patients for treatment, compliance with regulatory guidelines regarding stem cell use, and thoughtful communication with patients regarding the use and risks of stem cell treatments.

Overall, the use of imaging technology is vital in the goal of standardizing the delivery of stem cells for Regenerative Aesthetics. Improvements in safety and accuracy can support the development of more dependable clinical protocols for the use of stem cells and can also serve as a foundation for future, high-quality clinical studies in stem cell-based therapies.

FAT-DERIVED THERAPIES UNDER IMAGING GUIDANCE

Fat-derived therapy is at the core of the practice of Regenerative Aesthetics by allowing for the ability to restore both structural and biologically active volume back to a patient. Adipose tissue obtained from an individual has viable adipose tissue as well as stromal cells, endothelial or progenitor cells, and growth factors that will sustain tissue regeneration and integration of the graft for an extended period. Thus, fat grafting has become an acceptable method for enhancing and improving the contour, rejuvenation, and/or treatment of scarring in the face.

Low-pressure liposuction techniques and small-diameter cannulas are most used to harvest microfat (adipose tissue) while maintaining adipocyte viability and minimizing mechanical trauma. Typical donor sites for microfat harvest include the abdomen, flanks, and thighs. The harvested adipose tissue is usually harvested using decantation, filtration, or low-speed centrifugation to decrease fluid, blood, and oil content. The purified graft of adipose tissue contains a high concentration of

viable adipocytes along with other extracellular matrix components and is utilized primarily to provide volume restoration to the recipient site.

Nanofat (adipose tissue): Mechanically emulsified microfat using methodically repeated transfer of microfat from one syringe to another using a filter or screen until all of the adipocytes are destroyed; maintaining the stromal cells, growth factors and extracellular matrix fragments intact. Nanofat does not provide volume and is therefore primarily used as a dermal rejuvenator, for scar modulation, and to improve skin texture and pigment. The stromal vascular fraction (SVF) is isolated from nanofat through mechanical or enzymatic methods to isolate the regenerative cell populations (adipose derived stem cells, pericytes, endothelial cells, and immune cells). The SVF is utilized as a stand-alone product or can be used in conjunction with microfat to enhance the regenerative and volumetric effects.

The use of imaging guidance is integral to improving the outcomes achieved during both the harvest phase and injection phase of fat-related procedures. Ultrasound evaluation prior to the start of the procedure allows identification of appropriate harvest sites while avoiding damage to major vascular structures, thus decreasing complications associated with harvesting. The use of ultrasound during the injection process improves the accuracy of placement within the desired tissue layer and increases the evenness of fat distribution.

When using ultrasound guidance to view the location of the cannula and the effect of injecting on the tissue, the injector can modify their technique during the injection process and avoid applying excess pressure on the fat injected, thus decreasing the likelihood of compromising the viability of the fat being injected. The use of ultrasound reduces the chance of an intra-arterial injection of the fat; although this is infrequently seen in practice, this complication can be catastrophic, particularly in high-risk areas of the face such as the glabella, nose and temples.

From a clinical point of view, fat-derived products are commonly used to replace volume lost due to aging in the midface, peri-oral areas, jawline, and back of the hands. Nanofat and stromal vascular fraction are often used in periorbital rejuvenation, resulting in increased dermal thickness, increased dermal elasticity, and a reduction of fine lines and wrinkles. In scar management, fat-derived therapies have demonstrated increased fibroblast activity, increased collagen production, and improved tissue pliability, resulting in improved cosmetic outcomes.

While many clinical studies have demonstrated the efficacy of fat grafting, the retention of grafts can be inconsistent based on the method of fat harvesting, how fat is processed and injected, and how well the area receiving the graft has blood flow. By using imaging as guidance when grafting fat, one can achieve better reproducibility and potentially increase the survival of the graft because tissue will grow into and integrate with the grafted tissue better. However, standardised protocols and long-term clinical outcome evaluations will help clarify the best practice for using fat grafts in the clinical setting.

COMPARATIVE ANALYSIS

Three main types of biological therapies are available in regenerative aesthetic medicine: Platelet Rich Plasma (PRP), stem cell treatments and fat grafts (called adipose grafts). While these three methods have the same purpose of improving the regeneration of tissue and the aesthetic appearance of the client, each one has its own unique mechanisms of action, uses, amount of scientific support for use and level of safety. Therefore, a direct comparison of all three forms of therapy is necessary for informed decision making by clinicians and responsible advice to clients about the option best suited to their needs.

PRP has its greatest regenerative effect through the delivery of various growth factors that initiate angiogenesis, stimulate fibroblast production, facilitate the maturation of scar tissue through the production of extracellular matrix (ECM) components, and stimulate the production of collagen. Because PRP is harvested from the client's own body, with minimal processing needed prior to use, it has a much lower risk for side effects, making it an attractive option for many aesthetic professionals. PRP has demonstrated efficacy in facial rejuvenation, treating male-pattern baldness, reducing the appearance of scars and increasing the longevity of fat grafts. However, the effects of PRP therapy are variable and may require multiple sessions to maintain optimal results.

Stem cell treatments, on the other hand, support the regeneration of tissue through two mechanisms: differentiation of mesenchymal cells into specialized connective tissue cells (so-called "untargeted metabolism") and cell-signalling pathways ("paracrine signalling"). Adipose-derived stem cells (ASCs) and bone marrow-derived MSCs (MSCs) modulate the

inflammatory response, promote angiogenesis (formation of new blood vessels), and support tissue remodelling. Positive results for using stem cells in the areas of facial rejuvenation and scar remodelling have been reported in the literature; however, most of the literature supporting the use of stem cells comes from small observational trials. In addition, the lack of regulatory approval for most stem-cell-based treatments and the uncertainty of long-term safety may limit the use of these therapies in clinical practice at this time.

Autologous fat grafting produces both immediacy of volume and durability of regenerative benefits through the introduction of both stromal cells and growth factors. It is commonly used for facial contouring, rejuvenation of the hands, and correction of scars; however, while there is a large clinical experience to support the use of fat grafting, the retention of fat is difficult to predict and complications such as fat necrosis and the formation of oil cysts can happen. Studies have demonstrated that using imaging technology for guidance improves accuracy in placement and reduces the risks of vascular events, making fat grafting safer than it was previously thought to be. When considering the available evidence for PRP, levels of confidence are based on a low to moderate quality of evidence, especially in association with evidence-based applications such as alopecia and skin rejuvenation. Evidence of the efficacy of stem-cell therapy is of low to very low quality, due to the limited number of clinical trials and the wide range of methodology and approaches to carrying out trials. In general, fat grafting has a moderate amount of observational evidence in support of its use; however, very few high-quality randomised trials exist. For all modalities of treatment examined, the delivery of tissue in an image-guided manner produces increased consistency in terms of technical success and decreased overall rates of complications compared to non-image guided delivery methods.

Table 1. Comparative Characteristics of Regenerative Aesthetic Modalities

Parameter	Platelet-Rich Plasma	Stem-Cell Therapy	Fat-Derived Therapy
Primary mechanism	Growth factor–mediated tissue repair	Cellular differentiation and paracrine signaling	Volumetric support and stromal regeneration
Common indications	Facial rejuvenation, alopecia, scars	Rejuvenation, scar remodeling, reconstruction	Volumization, contouring, scars
Biologic source	Autologous blood	Bone marrow or adipose tissue	Autologous adipose tissue
Evidence quality (GRADE)	Low to moderate	Low to very low	Moderate
Durability	Variable: repeat sessions needed	Uncertain; limited long-term data	Variable; dependent on graft survival
Main risks	Bruising, edema, limited response	Regulatory, theoretical tumor risk	Fat necrosis, embolism (rare)
Regulatory status	Generally permissive	Highly restricted	Moderate regulation
Role of imaging	Improves precision and safety	Enhances placement and viability	Reduces vascular risk, improves retention

SAFETY AND COMPLICATIONS

Regenerative aesthetic procedures involve placing materials that are biologically active into parts of the body that are complicated in both anatomic structure and have numerous blood vessels. When a procedure is performed using anatomical landmarks and without real-time monitoring, there is a risk that a substance will not be put in the correct location, that the substance will not be dispersed evenly in the tissue, and that there will be damage to blood vessels. These limitations could impair the effectiveness of the treatment and increase the risk of developing an adverse event.

A serious potential complication associated with facial injectables is that they could inadvertently enter a blood vessel (inadvertent intravascular injection). Vascular occlusion from injection of a filler material into a high-risk area (periorbital, glabellar, nasal, and temporal regions) can cause tissue to Ischemic (lack of oxygen) and/or necrotic (dead), resulting in irreversible loss of vision. Grafting fat without a means of guided imaging also has been implicated in fat embolism and

central retinal artery occlusion. Although these events are infrequent, their potential for serious consequences emphasizes the need for accuracy-based delivery.

Platelet-Rich Plasma (PRP) is thought to have a safe profile because it is derived from the patient's own blood and, therefore, is minimally manipulated. Common complications reported with the use of PRP are mild and of short duration, i.e., local pain, edema, redness, and bruising. Serious complications have been reported infrequently and are usually associated with technical errors rather than the biological properties of PRP itself.

The use of stem cell therapy adds an additional level of concern from a safety standpoint. As the use of stem cells is relatively new, safety needs to be carefully considered, and there are numerous theoretical risks regarding the implementation of stem cells, including the ability of stem cells to differentiate inappropriately, cause immunologic reactions and potentially lead to the development of tumors or cancer, especially when there is extensive manipulation of stem cells or if stem cells are obtained from other individuals (i.e. Allogeneic). There has been a limited number of reported adverse events related to aesthetic applications, and as such, the lack of large-scale and long-term safety data also creates a significant concern. It is therefore important to follow the regulations related to the use of stem cells strictly and to perform appropriate patient selection.

With the application of fat-derived therapies, there is the potential for local and systemic complications. The most common complications associated with fat-derived therapies include fat necrosis, oil cysts, contour irregularities, and infection. There is also the potential for graft resorption and Volume Asymmetry followed by secondary procedures. Although these are rare, there are serious complications associated with the use of fat-derived therapies, including the possibility of fat embolism and vascular occlusion, which are typically associated with high-pressure injection or intravenous placement of a cannula.

The use of imaging to guide the procedure significantly reduces procedural risk by allowing the clinician to visualize the anatomy of the vascular system, the trajectory of the needle, and the tissue response in real-time. The use of ultrasound imaging allows the clinician to avoid important blood vessels, confirm the correct injection plane, and confirm an even distribution of the graft. In addition, Doppler imaging allows the clinician to see the areas where blood is actively flowing and increases safety. With the use of imaging, the clinician can also identify early on complications such as hematoma formation, fluid collections, and fluid displacement, allowing for early intervention.

Clinical studies and procedural audits suggest that ultrasound-guided regenerative interventions are associated with lower complication rates and improved outcome predictability compared with blind techniques. Although imaging guidance does not eliminate risk entirely, it represents a critical component of modern safety protocols in regenerative aesthetic practice.

REGULATORY AND ETHICAL CONSIDERATIONS

The clinical application of regenerative biologic therapies in aesthetic medicine is governed by complex and evolving regulatory frameworks that vary considerably across jurisdictions. These regulations are designed to balance innovation with patient safety, scientific integrity, and ethical responsibility. Understanding and complying with these frameworks is essential for clinicians practicing imaging-guided regenerative aesthetics.

Because PRP is usually minimally manipulated autologous product under the definition established for regulation by the FDA, PRP is therefore subject to relatively little or limited regulatory restrictions in many jurisdictions. PRP can be used by physicians in the U.S. and in many European countries for homologous purposes when manufactured with approved preparation devices and within an approved clinical governance structure.

In many parts of South Asia, clinicians direct the use of PRP; however, there is a recommendation that any new or testing application of PRP receive institutional ethical approval. On the contrary, stem cell therapy is highly regulated with strict oversight because the long-term safety, immunogenicity and tumorigenicity of stem cell therapies are currently uncertain. Under 21CFR 1271, most stem cell products are classified as human cells, tissues and cellular products, therefore requiring the sponsoring organization to obtain FDA authorization before the implementation of substantially manipulated, or non-homologous, stem cell products in clinical trials. In Europe, stem cell therapies are classified as Advanced Therapy Medicinal Products and require a centralized regulatory approval process. According to the Indian regulatory framework, there is also

a regulation restricting the use of stem cells for non-homologous aesthetic purposes, and these therapies require oversight by an institutional ethics committee before being approved for human use.

The extent of manipulation of the tissue is the primary determining factor for the regulation of fat-derived therapies. Most regions allow autologous fat grafting with minimal mechanical processing for aesthetic purposes; however, the enzymatically isolated stromal vascular fraction is classified as more than minimally manipulated tissue and, as such, is subject to stricter regulations. Within India specifically, utilization of stromal vascular fraction can only occur under investigational purview after receiving ethics committee approval and notifying the regulatory body.

Regenerative aesthetics holds itself to the ethical principles surrounding ethical practice, which are autonomy, beneficence, non-maleficence and justice. Clinicians involved in regenerative aesthetics have an obligation to inform patients thoroughly and accurately in regard to the appropriate indications for treatment, the expected therapeutic outcomes, the risk of adverse effects associated with the various procedures, as well as informing them of the limitations present in their scientific knowledge at the time they receive treatment, specifically noting that it may be investigational in nature for the stem cell-based therapies.

Regenerative aesthetics: Ethical oversight of marketing and promotional practices. Inaccurate/exaggerated marketing claims, selective reporting of treatment outcome data, and/or misrepresentation of independent peer-reviewed published scientific studies all negatively impact patient confidence in the clinician and the integrity of the practitioner.

Clinicians have an obligation to address the financial burden of regenerative aesthetic procedures through price equity and responsible resource utilization. To support patient safety, facilitate outcome monitoring, and develop high quality clinical evidence, institutional ethics reviews, standardised documentation, and structured long-term follow up must be part of the ethics governance processes. As regenerative aesthetic medicine continues to develop; ongoing collaboration between clinicians, regulators, and bioethicists must be found to ensure responsible and transparent clinical practice.

FUTURE DIRECTIONS

Regenerative aesthetic medicine has made significant progress in recent years, however there are still many scientific, technical, and regulatory challenges to address prior to mainstreaming these therapies into standardized clinical practice. A major concern is that there is currently no harmonized global regulatory framework. Differences in approval process and oversight have resulted in a proliferation of unregulated and/or inadequately monitored practices, such as "stem-cell tourism" which pose serious clinical and ethical risks to patients.

Thus, for regenerative aesthetics to progress in the future, it will be necessary to develop combined regulatory processes which promote patient safety while encouraging responsible innovation. Collaboration between international regulatory agencies, professional societies, and academic institutions may help create common standards for the processing of biologics, the application of biologics to patients, and the reporting of patient outcomes.

Technological innovations are expected to become an increasingly important factor in regenerative aesthetics. New techniques such as ultrasound, three-dimensional imaging, and AI assistance for pre-procedural planning will likely enable greater accuracy in parameters such as vascular mapping, injection techniques, and operator variability. As robotic-assisted techniques are developed in the future, it is likely that they will also allow for increased procedural accuracy in specific situations. Nonetheless, when integrating these new technologies, it is critical that robust governance frameworks addressing issues such as data security, algorithmic transparency, and accountability for professionals are in place.

A major gap in research is the current lack of multicenter randomized controlled trials (RCTs) with sufficient patient numbers and long-term follow-up that provide a high level of evidence. The need for standardization across biologically based treatments (e.g., biotherapeutics) through uniform imaging procedures, dosing regimens, and assessment tools is crucial for minimizing variability across studies and improving the quality of research quality assessments. Creating and validating patient-reported outcome measures (PROMs) for regenerative aesthetics is a means to enhance the clinical evaluation of patients treated with regenerative therapies.

The future of this area of medicine relies heavily upon and will continue to benefit from developing inter-professional teams (IPTs). Establishing IPTs that incorporate all of the involved specialties; interventional radiology, dermatology, plastic surgery, regenerative medicine, and bioethics will ease the pathway to developing standard treatment guidelines and structured training programs. Their existence may facilitate the establishment of accredited centers of excellence that provide a consistent standard of care.

Although it is unclear which existing IPT will emerge with similar scientific credibility as the developing regenerative aesthetic field, scientific rigor, technological advances, and ethical oversight will assure that regenerative aesthetic medicine is constructed as a sound, evidence-based discipline. Long-term investments in clinical research, education, and regulatory harmonization will be critical for promoting sustainable and highly responsible progress within regenerative aesthetic medicine.

CONCLUSION

Regenerative aesthetics stands as a primary development in aesthetic medicine where practices have moved from temporary cosmetic enhancement to biologically based restoration of tissue and long-term rejuvenation. The use of autologous biologics (the patient's own body), such as platelet-rich plasma (PRP), stem cell-based therapies, and fat grafting, illustrates the shift in focus from short term cosmetic improvement to the restoration of tissue quality, integrity (structure), and function (physiological performance).
The incorporation of interventional radiology has helped to resolve one of the major limitations of most conventional aesthetic procedures, the reliance on operator-dependent landmark-based injection techniques. By using real-time imaging guidance (especially with ultrasound), physicians can visualize the blood vessels and tissue structures they are injecting in real-time, which increases the accuracy and reproducibility of their procedures, and helps to decrease the incidence of serious complications. Accurate selection of tissue plane, in combination with accurate delivery, also enhances the survival of grafts and increases the potential for more consistent clinical results.

Presently available information indicates that the delivery of active ingredients using imaging guidance (e.g., ultrasound) provides safety and technical advantages in all areas of regenerative medicine. Platelet-rich plasma is considered to have good tolerability and provides moderate clinical benefits when used in certain indications. Stem cell therapies have shown promise, although the limitations of the studies conducted so far have resulted in insufficient high-quality evidence to support long-term safety and efficacy. Fat-derived therapies produce volume increase and regeneration but have not consistently demonstrated sufficient graft retention durability across various practices. Each type of therapy should implement imaging guidance to help maximize its therapeutic potential while minimizing risk during the procedure.

However, the heterogeneity in the methods used to produce biologics, administer them, and evaluate the outcomes remains a significant barrier to the widespread adoption of regenerative aesthetic practices. This, combined with the lack of large-scale randomized controlled trials and tools that standardize the evaluation of outcomes, has limited our capability to definitively assess the long-term efficacy of these products. Regulatory variances and ethical issues emphasize the necessity for transparent regulatory structures and responsible clinical application.

Combining techniques from both regenerative medicine and interventional radiology will create an avenue to provide more precise treatments with less risk, more predictability and better biological outcomes in aesthetics. Collaboration between different specialties, clinical trials, and standardized education will help in establishing the standard of care for regenerative aesthetic imaging-guided procedures so they can continue to be offered and grow sustainably over time.

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CITE THIS MANUSCRIPT

- **APA (7th edition):** Bakshi, I., Sookrah, P., Rawat, H. S., Anand, P., & Singh, S. (2026, January 28). *Imaging-guided regenerative aesthetics: A review of PRP, stem-cell, and fat-derived therapies in interventional radiology*. *The Operating Room Global Journal (TORGJ)*, 2(1). https://doi.org/10.64573/torgj2601001
- **Harvard**: Bakshi, I., Sookrah, P., Rawat, H.S., Anand, P. and Singh, S., 2026. *Imaging-guided regenerative aesthetics: A review of PRP, stem-cell, and fat-derived therapies in interventional radiology*. *The Operating Room Global Journal (TORGJ)*, 2(1). Published 28 January. Available at: https://doi.org/10.64573/torgj2601001
- **Vancouver**: Bakshi I, Sookrah P, Rawat HS, Anand P, Singh S. Imaging-guided regenerative aesthetics: A review of PRP, stem-cell, and fat-derived therapies in interventional radiology. *The Operating Room Global Journal (TORGJ)*. 2026 Jan 28;2(1). https://doi.org/10.64573/torgj2601001
- **MLA (9th edition)**: Bakshi, Ishaan, et al. "Imaging-Guided Regenerative Aesthetics: A Review of PRP, Stem-Cell, and Fat-Derived Therapies in Interventional Radiology." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 1, 28 Jan. 2026, https://doi.org/10.64573/torgj2601001
- **Chicago (Author-Date)**: Bakshi, Ishaan, Parikshta Sookrah, Hriday Singh Rawat, Prashant Anand, and Sakshi Singh. 2026. "Imaging-Guided Regenerative Aesthetics: A Review of PRP, Stem-Cell, and Fat-Derived Therapies in Interventional Radiology." *The Operating Room Global Journal (TORGJ)* 2 (1), January 28. https://doi.org/10.64573/torgj2601001

Comparative Study on Sutures vs Staples for Skin Closure in a Patient Undergoing Thyroidectomy

Authors: Saeed Ahmad[1,2]*, Summyya Musharaf[1], Nimra Rafique[1]

[1] University of Health Sciences (UHS), Lahore, Pakistan.
[2]The Operating Room Global (TORG).

DOI: https://doi.org/10.64573/torgj2601004

The Operating Room Global Journal (TORGJ) Volume 2 Issue 1 Mar 2026

***Corresponding Author:**
Saeed Ahmad
saeedmalik0470@gmail.com

Declaration:
Authors' Contribution: Equal contributions
Conflict of Interest: No conflict of interest.
Funding: No funding received by the authors.

Article History:
Received: 27-01-2026
Accepted: 02-02-2026
Available Online: 04-02-2026

QR access this Article

ABSTRACT

Background: Thyroidectomy is a commonly performed surgical procedure and appropriate skin closure technique plays a crucial role in postoperative recovery, cosmetic outcomes, and patient comfort. Sutures and staples are widely used for skin closure however their comparative effectiveness remains debated.

Objective: To compare postoperative outcomes of sutures versus staples for skin closure following thyroidectomy in terms of pain intensity, wound complications, patient comfort, and cosmetic appearance.

Methodology: This prospective observational study was conducted at Shalamar Hospital, Lahore, Pakistan. A total of 101 patients undergoing thyroidectomy were included. Patients were divided into two groups based on the skin closure technique used: sutures (n=53) and staples (n=48). Postoperative pain was assessed using the Visual Analog Scale (VAS), while wound outcomes were evaluated using the Modified Southampton Wound Scoring System. Data were analyzed using SPSS version 25.

Results: Staples demonstrated better wound appearance and lower rates of inflammation and serous discharge compared to sutures. However, patients in the staple group experienced significantly higher postoperative pain scores (p=0.016). No statistically significant differences were observed between the two groups regarding seroma formation, drain comfort, or ICU stay.

Conclusion: Staples provide superior cosmetic outcomes and reduced wound complications but are associated with increased postoperative pain, which can be effectively managed with analgesics. Selection of skin closure techniques should be individualized based on patient needs and surgeon preference.

***Keywords**: Thyroidectomy; Sutures; Staples*

INTRODUCTION

Thyroidectomy is a surgical operation to remove all or parts of the thyroid gland. The thyroid gland is a ductless, butterfly-shaped endocrine gland located in the anterior neck, just below the larynx. It weighs about 15-20 grams. It consists of two lobes present on either side of windpipe trachea. Thyroid glands produce Thyroid hormones responsible for metabolic health, growth and development. Thyroid hormones referred as major metabolic hormones named as triiodothyronine (T3) and thyroxin (T4). It has many functions including controlling heart, muscle and digestive function, brain development and bone maintenance. Approximately 90-100 µg of T4 is produce from thyroid gland and 30-35 µg of T3 daily. Under-reactive

hormones typically result in bradycardia, cold intolerance, constipation, exhaustion, and weight gain. In contrast, weight loss, heat sensitivity, diarrhea, fine tremors, and muscle weakness are signs of hyperthyroidism brought on by increased thyroid gland activity. Its release should be balanced otherwise it cause many serious issues (Neerav 2018).

Thyroid diseases are widely prevalent across the world. It affects due to multiple factors like malnutrition, iodine deficiency, radiation exposure and congenital thyroid diseases. The prevalence of thyroidectomies is more common in women than in man which is in between 1-2% for hypothyroidism and 0.5-2% for hyperthyroidism. According to epidemiological studies 1% of men and 5% of women diagnosed with thyroid nodules clinically in iodine- deficient populations. Congenital hypothyroidism is also common among the newborns in 3500– 4000 births in iron-depleted areas (Vanderpump, cham & springer 2019).16-31% adults are having thyroidectomies for multiple thyroid diseases due to radiations. (Maja Sulejmanovic et al. 2019) Estimated 20 million Americans have thyroid diseases. Approximately, 93,000 thyroidectomies are performed each year in the United States. Increasingly, these procedures are performed on an ambulatory basis. Global prevalence of thyroidectomies is 5%-10% and in Pakistan, Ratio of thyroid diseases especially hyperthyroidism is 5.1% (Compton 2020).

There are multiple reasons to perform thyroidectomy such as thyroid cancer, malignancy, symptomatic goiter, hyperthyroidism, or primary hyperparathyroidism and multi-nodular goiter. Differentiated thyroid cancers such as papillary and follicular and poorly differentiated and anaplastic carcinomas. Patients who experience compressive symptoms from a big goiter, such as dysphagia, dyspnea, shortness of breath and hoarseness should have a thyroidectomy. The first symptom to manifest is typically dysphagia to solids. Goiter-related aesthetic issues may warrant a thyroidectomy (Neerav 2018).

Part of the thyroid gland is removed in thyroidectomy depends upon the indication of the surgery. Thyroidectomy can be of two type total thyroidectomy and partial thyroidectomy. Total thyroidectomy involves the surgical removal of all or most of the thyroid gland. Partial thyroidectomy involves the removal of a part of the thyroid gland. Partial thyroidectomy has further four subcategories thyroid lobectomy involves the removal of one lobe of the thyroid gland, thyroid lobectomy with isthmectomy removal of tumors in the thyroid tissue between the two lobes of the thyroid gland (thyroid isthmus), partial thyroid lobectomy, and subtotal thyroidectomy (Andrew 2023).

An anterior cervical, Kocher and collar crease incision at 2-3cm above suprasternal notch is frequently used in the surgical approach to thyroid glands. Approximation of surgical incision is a critical issue and it plays a significant role in the affected person's recovery. For skin closure, there are 2 methods in practice, sutures closure, and staples. Sutures are the traditional technique, requiring a skilled doctor to tie the knots securely. A doctor uses a special needle and thread to put in stitches. Sutures are used to approximate the tissue and seal the skin. There are two types of surgical sutures which are absorbable and non-absorbable. Out of which non-absorbable sutures are more commonly used in the approximation of incision. Non-absorbable sutures include nylon, polypropylene, surgical steel and polyester. Subcuticular sutures, which can be either absorbable or non-absorbable and are often intradermal stitches put right beneath the epidermis to tighten it, are thought to be more appropriate since they induce minimal tissue reactivity (Byrne 2019).
Skin staplers are more sophisticated and advanced tools that are effective for wound closure techniques. Skin staples are used in place of sutures to increase the efficiency of fixation. Surgical skin staples are made of titanium and stainless steel. Staples (or metal clips), which are put to the external epidermis and pull the dermal edges of the wound together (Byrne 2019).

Using sutures and staples to close the thyroidectomy incision might result in several issues related to the amount of time needed for wound healing, the accuracy of the method, and the type of material being utilized and patients' overall satisfaction. Patients are affected differently by both procedures in terms of postoperative pain, allergic reaction or surgical site infection. Moreover, common complications of thyroidectomy are hypocalcemia, recurrent laryngeal nerve paralysis, hemorrhage and infection are encountered after thyroidectomy and a benign granulomatous inflammatory foreign body reaction (Neerav 2018).

Pain intensity post-operatively has a great impact after a surgical procedure it can also lead to hypertension which can increase the risk of bleeding at surgical site and cause wound drainage. Surgical site infections are rare in thyroidectomy however multiple complications related to closure techniques can occur. Surgical site complications usually arose before discharge including the following: blood transfusion, hematoma formation, pneumonia, and cardiac arrest, etc (Chai et al., 2016).

Stures and staples for closing the thyroidectomy incision have many effects on results. They vary in pain intensity, wound drainage and patient's overall satisfaction. So, a study to determine the best closure method with minimum effects after thyroidectomy was conducted to find the most appropriate method (Păduraru et al., 2019).

The findings of this study hold significant implications for the field of thyroid surgery and wound closure techniques. By providing evidence-based data on the outcomes of sutures versus staples, this research can guide surgeons in making informed decisions that maximize patient safety, improve wound healing, and enhance cosmetic results. Moreover, as thyroidectomy is a common surgical procedure, the results of this study have the potential to impact many patients worldwide. By advancing our knowledge on skin closure techniques in thyroidectomy, this research contributes to the improvement of surgical practices, ultimately benefiting patients and enhancing their overall surgical experience.

OBJECTIVE

To compare postoperative outcomes of sutures and staples used for skin closure following thyroidectomy, including pain intensity, wound complications, patient comfort, and cosmetic appearance.

METHODOLOGY

Study Design
This was prospective observational study. Patients were allocated to suture or staple closure based on surgeon preference.

Study Setting
This study was conducted in the E.N.T (Ear, Nose, and Throat) Department of Surgery, Shalamar Hospital, Lahore.

Study Duration
This study was completed within the duration of 6 months after the approval of synopsis.

Sample Size/ Statistically Power
The sample size was calculated by using the following formulae Two Proportions
n(?(Z?_(1-a/2)^2+Z_(1-ß)^2)(P_1 (1-P_1)+P_2 (1-P_2)))/(P_1-P_2)^2 Z1-a/2 95.0%
Z1-ß 80.0%

P1 Proportion of sutures closure is 7.1% P2 Proportion of staples closure is 14.3%
In this comparative prospective study, 101 patients were included therefore two groups, i.e., 101 patients, 53 patients in group A with sutures and 48 patients in group B with staples, will be enrolled for this study.

Sampling Technique
Non-probability purposive sampling technique was used.

Inclusion Criteria
- Patients with a confirmed diagnosis of thyroid disease necessitating thyroidectomy, such as thyroid cancer, multinodular goiter, or hyperthyroidism.
- Patients of age 18 years to 65 years with any skin type undergoing thyroid surgery.

Exclusion Criteria
- Patients with a previous history of open wound neck surgery.
- Patients who are diabetic and have ongoing skin or other infections.
- Pregnant patients are excluded.

Data Collection Procedure
After SSAHS–IRB (Ref No: SIHS/IRB/2023/017) was approved, data was collected from the patients of (Ear, Nose and Throat) ENT surgical department of Shalamar hospital, Lahore Pakistan. After explaining the objectives of the study, to the postoperative team and patients they were requested for their voluntary participation in this study. For those who volunteered to be study participants, written consents were taken from them along with the study questionnaire. The

consent was taken from them by giving them brief information about the research program. Two groups A and B were formed. Group A belong to those patients who undergo suture closure after thyroidectomy and group B belong to those patients who undergo staple closure. To check the postoperative pain, seroma, hematoma, infection, and hospital stay for patients who were treated by thyroidectomy, the assessments were performed. For postoperative pain assessment using a visual analog scale (VAS) to rate pain intensity from 0-10. Physical examination of the surgical site was done to check for seroma, hematoma drain comfort. Modified Southampton scoring system is used for postoperative wound assessment. Evaluation of ICU stay by recording the duration of stay in the hospital after surgery. All these factors were noted in every case.

Statistical Analysis

The data was collected and analyzed using SPSS 25. Numerical data like Age (18-60) was presented in the form of mean ± S.D whereas qualitative data like the postoperative pain (using a validated pain score) incidence of seroma, hematoma, drain comfort and tightness was presented in the form of frequency (percentage). The study will collect data on the following variables: age, sex, type of thyroidectomy, surgical closure, ICU need, postoperative pain (using a validated pain score), and incidence of seroma and hematoma. The data of the patients who met the inclusion and exclusion criteria will be collected from the Shalamar hospital after fulfilling parametric assumptions. To determine the association between categorical study variable 1 & categorical study variable 2 chi-square test was applied. p-value of 0.05 or less was considered as significant.

Ethical issues

Approval of the institutional ethics committee was obtained at the synopsis level of the project. At every stage confidentiality regarding the personal biodata and responses of healthcare team was ensured and assured.

RESULTS

The study was conducted over a continuous six-month period. A total number of 101 patients undergoing thyroidectomy (49 males and 52 females) were recruited for this study. All results were expressed in the form of mean ±standard deviation. All calculations were established on similar parameters.

Table 4.1: Frequency and percentage of male and female ratio.

Gender	Frequency	Percent
Female	52	51.5
Male	49	48.5
Total	101	100.0

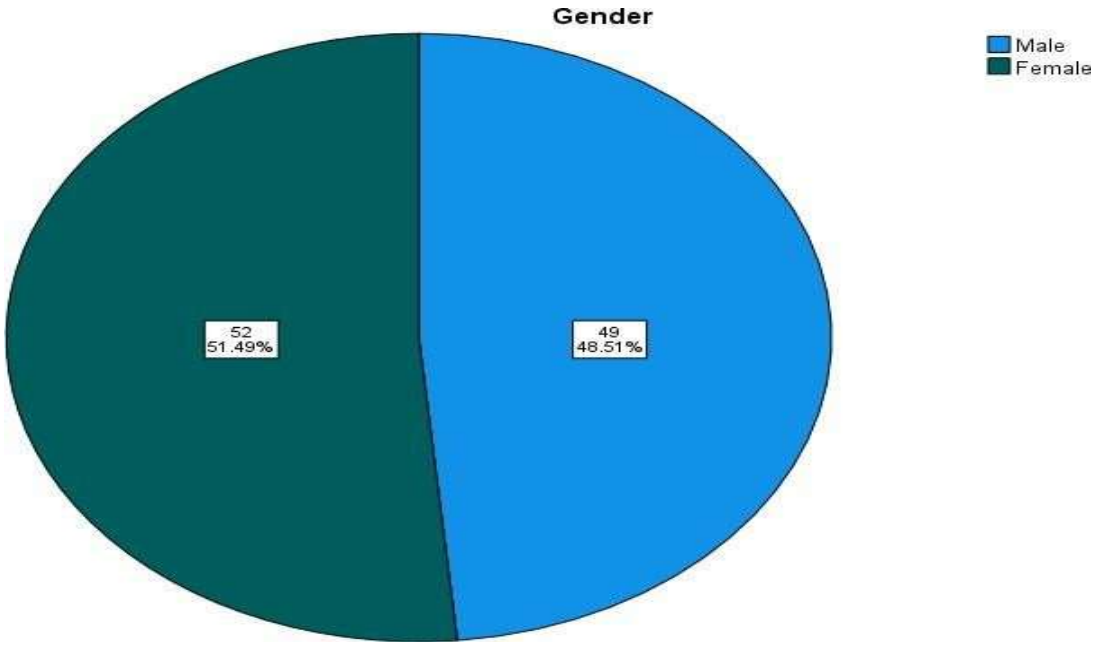


Figure 4.1: Total Frequency of Patients in Pie Chart.

T-Test

The study was conducted among total number of 101 patients undergoing thyroidectomy (49 males and 52 females). Mean age of males were 36.80±11.49 and females were 38.67±10.68. All results were expressed in the form of mean ±Standard deviation. All calculations were established on similar parameters.

Table 4.2 Mean age of male and female.

	Male	Female	p-value
Age	36.80±11.49	38.67±10.68	0.397

Independent Samples Test

Mean age of male was 36.80±11.49 years and mean age of female was 38.67±10.68 years but the age difference was not statistically significant

(p-value 0.397).

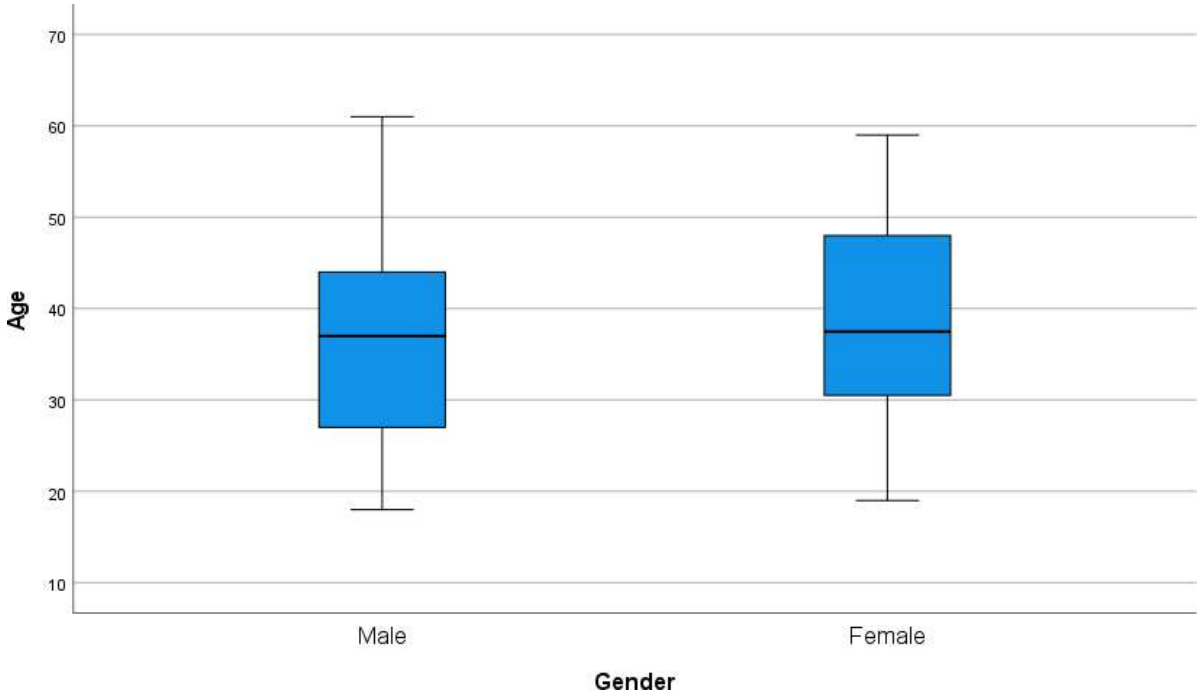


Figure 4.2: Mean age of male and female in Box Plot chart.

Table 4.3: Compare treatment Group among gender.

The study was conducted among total number of 101 patients undergoing thyroidectomy. Sutures and staples were used on them on surgeon preference. 53.1% sutures and 46.9% staples were used on males while, 51.9% sutures and 48.1% staples were used on females. Pearson Chi- Square test was used to made calculations. Hence, p-value (p-value 0.909) showed that there is no association between gender and treatment group.

	Treatment Group		
Gender	**Suture**	**Staples**	**Total**
Male	26(53.1%)	23(46.9%)	49

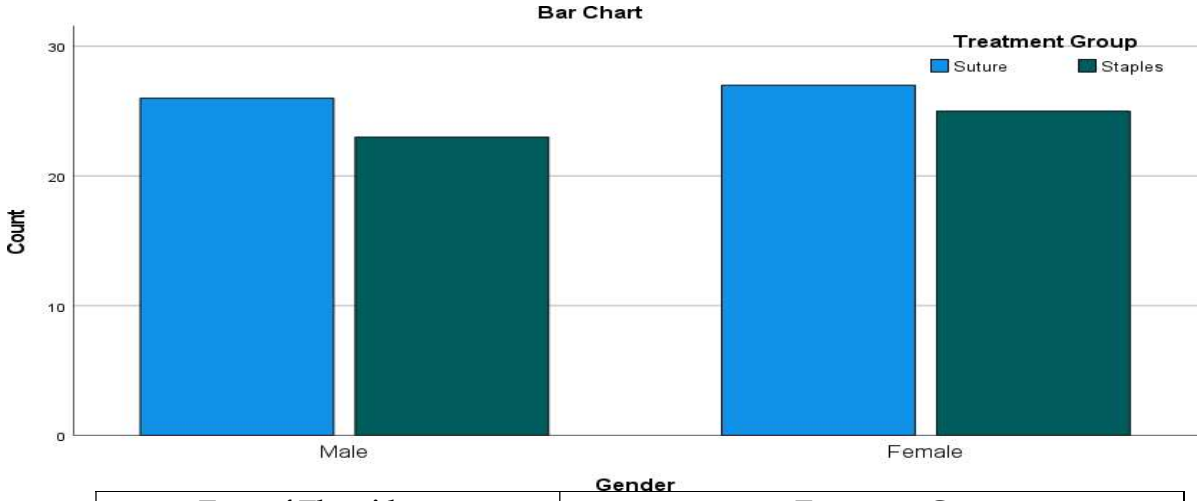
Female	27(51.9%)	25(48.1%)	52
Total	53(52.5%)	48(47.5%)	101

Pearson Chi-Square .013a
Statistically association between gender and treatment group (p-value 0.909).

Figure 4.3: Association between gender and treatment group in Bar Chart.

Association between types of thyroidectomies and treatment group
The study was conducted among total number of 101 patients undergoing thyroidectomy. Sutures and staples were used on them according to the type of thyroidectomy. Likelihood test was used to made calculations. Hence, p-value (0.016) showed statistically association between type of thyroidectomy and treatment group.

Table 4.4: Comparison between treatment group and type of thyroidectomy.



Type of Thyroidectomy	Treatment Group		
	Sutures	**Staples**	**Total**
Total Thyroidectomy	5(9.4%)	16(33.3%)	21(20.8%)
Partial Thyroidectomy	4(7.5%)	1(2.1%)	5(5.0%)
Thyroid Lobectomy	22(41.5%)	12(25.0%	34(33.7%)
Thyroid Lobectomy with Isthmectomy	9(17.0%)	7(14.6%)	16(15.8%)
Partial Thyroid Lobectomy	11(20.8%)	6(12.5%)	17(16.8%)
Subtotal Thyroidectomy	2(3.8%)	6(12.5%)	8(7.9%)
Total	100.0%	100.0%	100.0%

Likelihood Ratio 14.561

Statistically association between type of thyroidectomy and treatment group (p-value 0.01016)

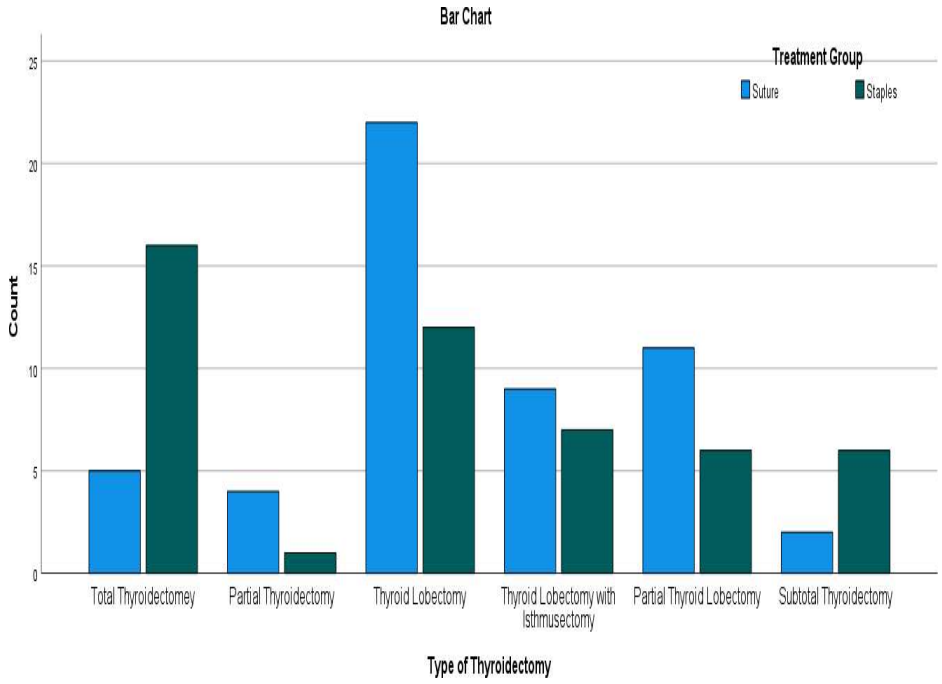


Figure 4.4: Association between type of thyroidectomy and treatment group in Multiple Bar Chart.

Association between seroma and treatment group

The study was conducted among total number of 101 patients undergoing thyroidectomy. Sutures and staples were used on them to assess different outcomes. Pearson Chi-Square test was used for calculations. Hence, p-value (0.563) showed Statistically no association between seroma and treatment group.

Table 4.5: Comparison between treatment group and seroma.

	Treatment Group		
Seroma	**Suture**	**Staples**	**Total**
Absent	29(54.7%)	29(60.4%)	58(57.4%)
Present	24(45.3%)	19(39.6%)	43(42.6%)
Total	53(100.0%)	48(100.0%)	101(100.0%)

Pearson Chi-Square .335[a]

Statistically no association between seroma and treatment group. (p-value 0.563.)

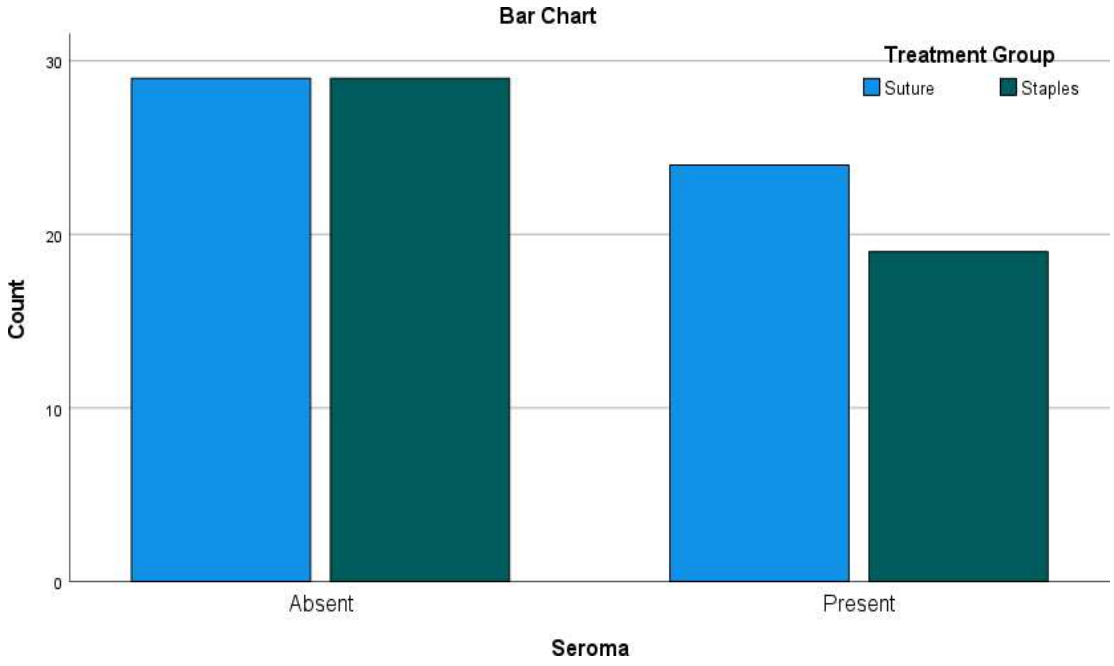


Figure 4.5: Association between seroma and treatment group in Bar Chart.

Association between tightness and treatment group

The study was conducted among total number of 101 patients undergoing thyroidectomy. Sutures and staples were used on them to assess different outcomes. Pearson Chi-Square test was used to made calculations. Hence, p-value (0.582) showed Statistically no association between tightness and treatment group.

Table 4.6: Comparison between treatment group and tightness.

Tightness	Treatment Group		
	Suture	Staples	Total
Absent	28(51.9%)	27(57.4%)	54(54.5%)
Present	25(48.1%)	20(42.6%)	45(45.5%)
Total	53(100.0%)	47(100.0%)	101(100.0%)

Pearson Chi-Square .304a

Statistically no association between Tightness and Treatment group (p-value 0.582).

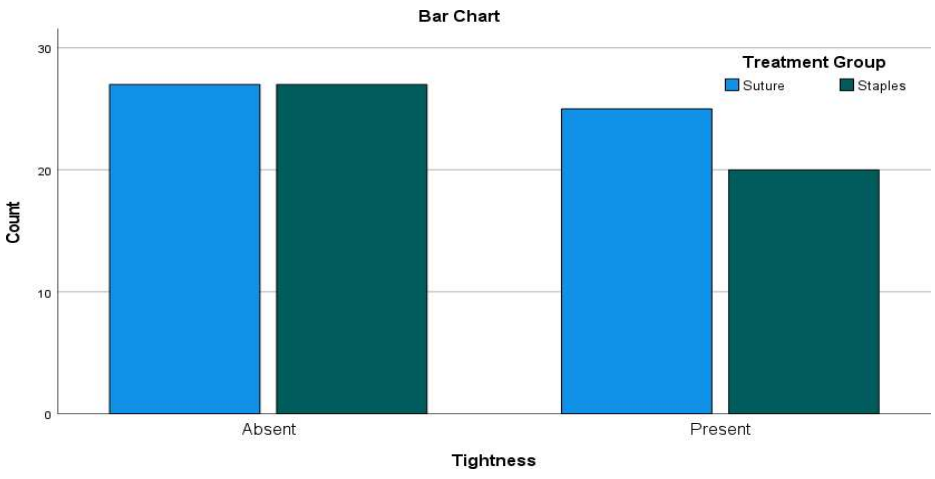


Figure 4.6: Comparison between treatment group and tightness in Bar Chart.

Association between drain comfort and treatment group

The study was conducted among total number of 101 patients undergoing thyroidectomy. Sutures and staples were used on them to assess drain comfort with treatment group. Pearson Chi-Square test was used to made calculations. Hence, p-value (0.139) showed Statistically no association between drain comfort and treatment group.

Table 4.7: Comparison between treatment group and drain comfort.

Drain comfort	Treatment Group		
	Suture	Staples	Total
Absent	22(41.5%)	27(56.3%)	49(48.5%)
Present	31(58.5%)	21(43.8%)	52(51.5%)
Total	53(100.0%)	48(100.0%)	101(100.0%)

Pearson Chi-Square 2.191[a]

Statistically no association between drain comfort and treatment group (p-value 0.139).

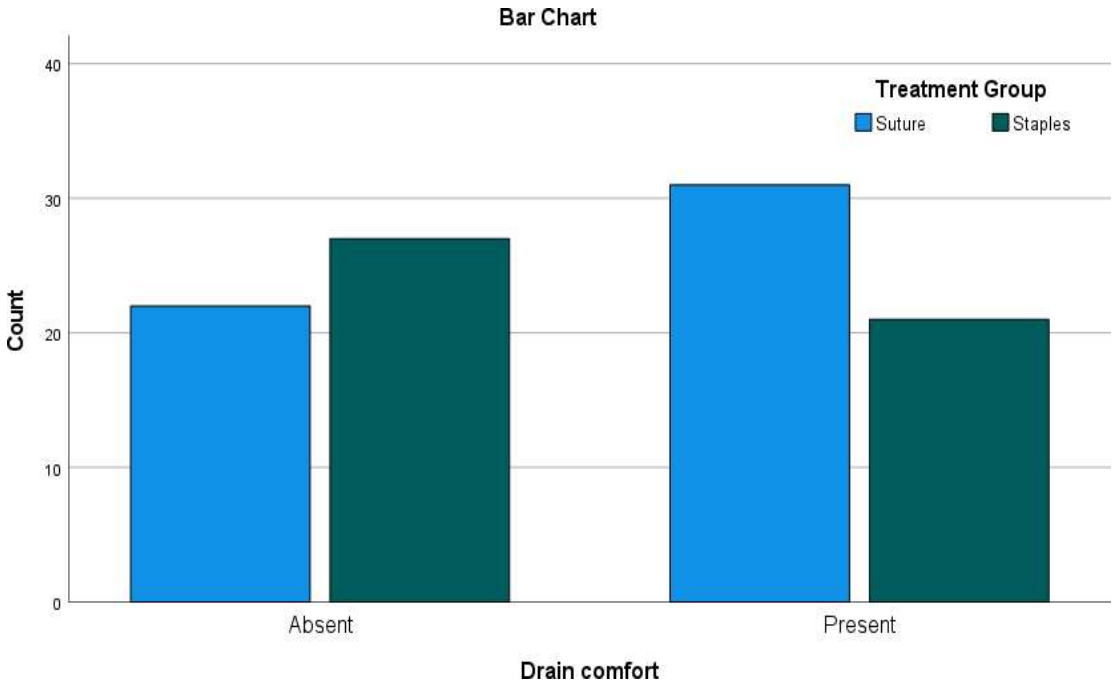


Figure 4.7: Comparison between treatment group and drain comfort in Bar Chart.

Association between need of ICU and treatment group

The study was conducted among total number of 101 patients undergoing thyroidectomy. Sutures and staples were used on them to assess the association between treatment group and if there is need of ICU. Pearson Chi-Square test was used to made calculations. Hence, p-value (0.295) showed Statistically no association between need of ICU and treatment group.

Table 4.8: Comparison between treatment group and need of ICU.

	Treatment Group		
Need of ICU	**Suture**	**Staples**	**Total**
Absent	21(39.6%)	24(50.0%)	45(44.6%)

Present	32(60.4%)	24(50.0%)	56(55.4%)
Total	53(100.0%)	48(100.0%)	101(100.0%)

Pearson Chi-Square 1.098[a]
Statistically no association between need of ICU and treatment group (p-value 0.295).

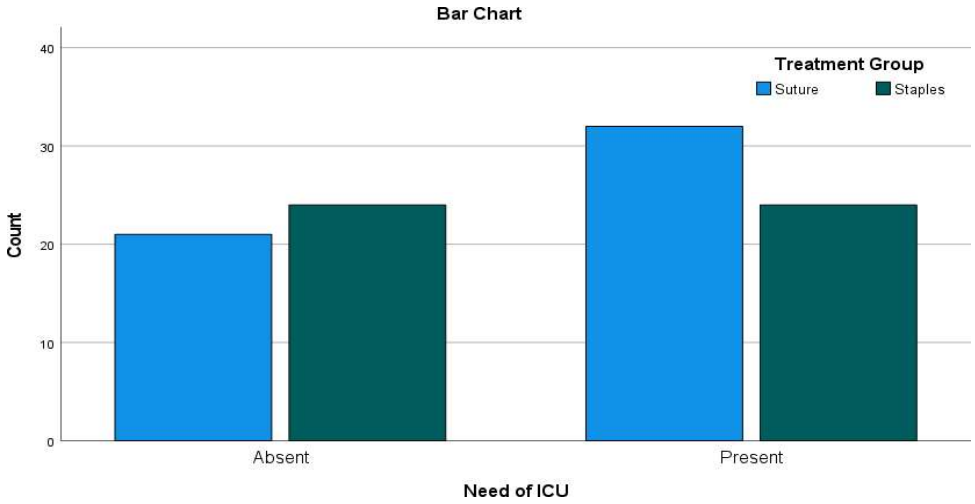


Figure 4.8: Comparison between treatment group and need of ICU in Bar Chart.

Association between Appearance grade and treatment group
The study was conducted among total number of 101 patients undergoing thyroidectomy. Sutures and staples were used on them to assess the association between treatment group and appearance grades. Pearson Chi-Square test was used to made calculations. Hence, p-value (0.131) showed that there is no association between appearance grade and treatment group.

Table 4.9: Comparison between treatment group and appearance grade.

Appearance grade	Treatment Group		
	Suture	**Staples**	**Total**
Normal Healing	11(20.8%)	7(14.6%)	18(17.8%)
Mild Bruising and Erythema	8(15.1%)	17(35.4%0	25(24.8%)
Erythema & other signs of inflammation	21(39.6%)	15(31.3%)	36(35.6%)
Clear or serous Discharge	13(24.5%)	9(18.8%)	22(21.8%)
Total	53(100.0%)	48(100.0%)	101(100.0%)

Pearson Chi-Square 5.622a
Statistically no association between appearance grade and treatment group (p-value 0.131).

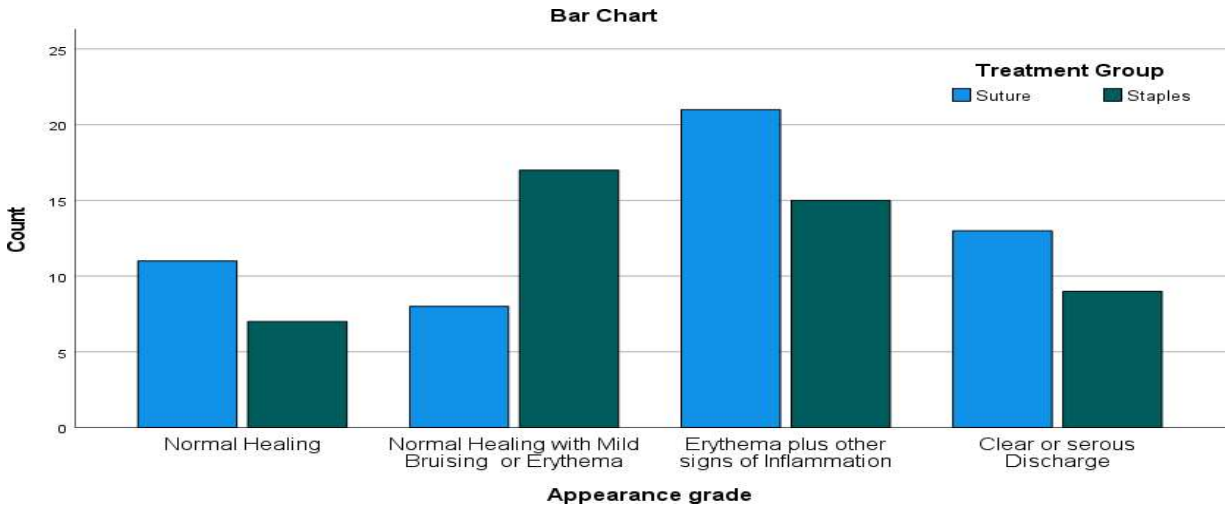


Figure 4.9: Association between treatment group and appearance grade in Bar Chart.

Association between pain grade and treatment group

The study was conducted among total number of 101 patients undergoing thyroidectomy. Sutures and staples were used on them to assess the association between treatment group and pain grade. Likelihood ratio test was used to made calculations. Hence, p-value (0.016) showed Statistically association between pain grade and treatment group. Severe or worst grades of pain were quite high with staples.

Table 4.10: Comparison between treatment group and pain grade.

Pain	Treatment Group		
	Suture	Staples	Total
No Pain	1(1.9%)	1(2.1%)	2(2.0%)
Mild Pain	27(50.9%)	16(33.3%)	43(42.6%)
Moderate Pain	15(28.3%)	7(14.6%)	22(21.8%)
Severe Pain	3(5.7%)	2(4.2%)	5(5.0%)
Very Severe Pain	5(9.4%)	15(31.3%)	20(19.8%)
Worst Pain	2(3.8%)	7(14.6%)	9(8.9%0
Total	53(100.0%)	48(100.0%)	101(100.0%)

Likelihood Ratio 13.950

Statistically association between pain and treatment group (p-value 0.016).

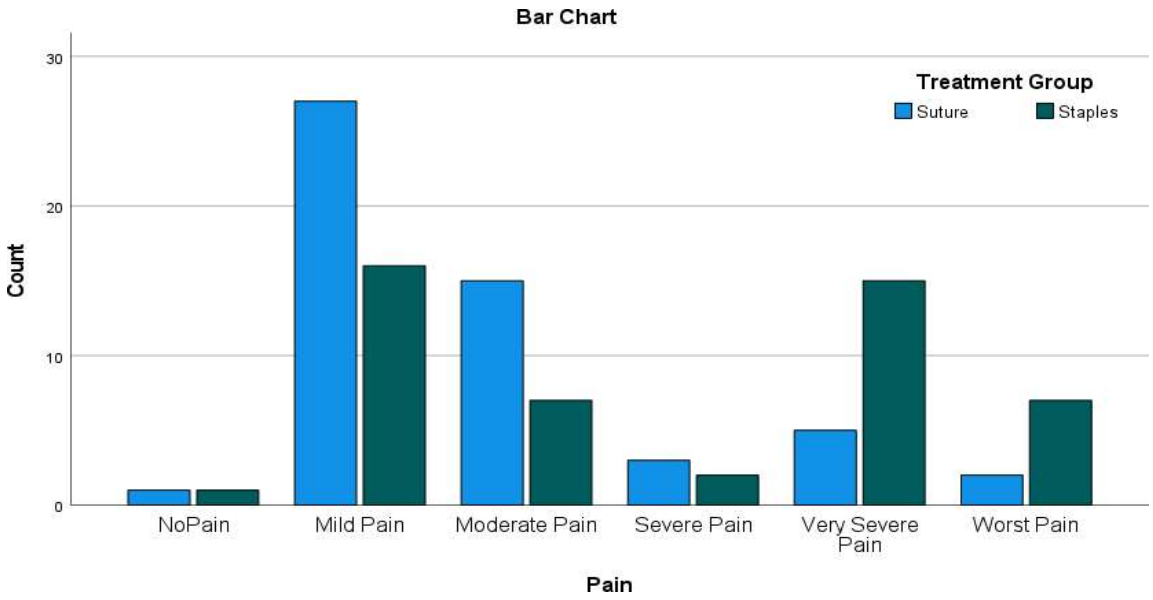


Figure 4.10: Comparison between treatment group and pain grade in Bar Chart

DISCUSSION

The present study was conducted to compare postoperative outcomes of sutures and staples used for skin closure following thyroidectomy at Shalamar Hospital, Lahore. Thyroidectomy is a common surgical procedure, and appropriate wound closure crucial in postoperative recovery, cosmetic outcomes, and patient satisfaction. In the current study, postoperative outcomes such as pain, seroma formation, wound tightness, drain comfort, ICU requirement, and wound appearance were evaluated to determine the most suitable closure technique.

A total of 101 patients were included in the final analysis, comprising 52 females (51.5%) and 49 males (48.5%). Of these, 53 patients underwent skin closure with sutures and 48 with staples. Various postoperative outcomes were observed in both groups. Seroma formation, wound tightness, and inflammatory changes were noted more frequently in the suture group, whereas better wound appearance grades were observed more commonly in the staple group. However, these differences were not statistically significant. Drain comfort and ICU requirement also did not show statistically significant differences between the two closure techniques.

Postoperative pain was the only outcome that demonstrated a statistically significant difference between the two groups, with higher pain scores observed in patients who received staples. This finding may be explained by increased skin tension and the rigid metallic nature of staples, which can contribute to localized discomfort in the early postoperative period. Nevertheless, the increased pain associated with staples was manageable with routine analgesic therapy and did not result in serious complications. These findings highlight that while staples may increase postoperative pain, this disadvantage is clinically controllable.

This study was carried out with an objective to make a clear understanding of choice of best closure technique among sutures and staples with minimum adverse outcomes after thyroidectomy. It was noted that outcomes of using sutures and staples were slightly differed. pain, bruising and erythema was measured significantly high in staples but in appearance grade and other factors like seroma, drain comfort, need of ICU, tightness, signs of inflammation and serous discharge, sutures showed more adverse outcomes in relation to staples. As, we have noted that pain was significantly high in staples that can be controlled by analgesics.

Davey et al., 2023 compared the different closure techniques outcomes after thyroid and parathyroid surgery and concluded that staples have the advantage of patient satisfaction, and cosmesis. In our study staples also showed good appearance grade and other wound infections. (Davey et al., 2023).

Pandey et al., 2022 conducted a study to compared staples and conventional sutures in surgical wounds in neck region. Staples appears to be better than conventional sutures in terms of rate of closure and scar appearance including appearance grade. Our research also showed related Results (Pandey et al., 2022).

In agreement with these studies, the present research supports that staples provide favorable cosmetic outcomes, while sutures may be associated with more inflammatory wound changes. Overall, both sutures and staples are effective skin closure techniques following thyroidectomy, and the choice should be guided by clinical judgment, patient comfort, and surgeon preference.

CONCLUSION

Conclusion is that staples demonstrated better cosmetic outcomes and reduced wound complications compared to sutures following thyroidectomy. However, higher postoperative pain scores were observed in the staple group. This pain was manageable with appropriate analgesic therapy. Therefore, both sutures and staples are effective skin closure techniques, and their selection should be individualized based on patient factors and surgeon preference.

LIMITATIONS OF THE STUDY

The limitations of the study:

- Limited number of sample size was given because the study was audit type.
- Study duration was limited to 6 months.
- The complications were noted only during hospital stay and did not follow up the patients after discharge which could give better results of post-operative outcomes.

Suggestions

Suggestions for this study are as follows:

- It is suggested to use staples over sutures according to above results.
- Patients experienced pain with staples can be managed by analgesics.
- Use of sutures and staples depends upon surgeon's preference.

ACKNOWLEDGMENT

In the name of Allah, the Most Gracious and the Most Merciful. All respect for His Holy Prophet (PBUH).
I would like to acknowledge my indebtedness and render my warmest thanks to my supervisor, respected Ms. Fakhra Fakhr, who made this work possible. I would also wish to express my gratitude to respected Mr. Arslan Saleem, for his valuable suggestions which have contributed greatly to the improvement of the thesis.

The thesis has also benefited from comments and suggestions made by Mr. Arslan Saleem who did extended discussions and have read through the manuscript. His guidance and expert advice have been invaluable throughout all stages of the work. I take this opportunity to specially thank him.

Special thanks are due to my friends, I owe them a debt of gratitude for their continuous support and understanding, also for more concrete things like commenting on earlier versions of the thesis, helping me with all the ways possible.
Last but not the least, enormous thanks are extended to our dear Parents Farkhanda Shahid, Shahid Azeem, Asia Rafique, Muhammad Rafique, Malik Azeem Bukhsh and Shakeel Ahmed for their constant encouragement, immense support and love.
Summyya
Nimra Rafique
Saeed Ahmed

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING STATEMENT

All authors have declared that no financial support was received from any organization for the submitted work.

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CITE THIS MANUSCRIPT:

- **APA (7th edition):** Ahmad, S., Musharaf, S., & Rafique, N. (2026, February 4). *Comparative study on sutures vs staples for skin closure in a patient undergoing thyroidectomy*. *The Operating Room Global Journal (TORGJ)*. https://doi.org/10.64573/torgj2601004
- **Harvard**: Ahmad, S., Musharaf, S. and Rafique, N., 2026. *Comparative study on sutures vs staples for skin closure in a patient undergoing thyroidectomy*. *The Operating Room Global Journal (TORGJ)*. Published 4 February. Available at: https://doi.org/10.64573/torgj2601004
- **Vancouver**: Ahmad S, Musharaf S, Rafique N. Comparative study on sutures vs staples for skin closure in a patient undergoing thyroidectomy. *The Operating Room Global Journal (TORGJ)*. 2026 Feb 4. https://doi.org/10.64573/torgj2601004
- **MLA (9th edition)**: Ahmad, Saeed, et al. "Comparative Study on Sutures vs Staples for Skin Closure in a Patient Undergoing Thyroidectomy." *The Operating Room Global Journal (TORGJ)*, 4 Feb. 2026, https://doi.org/10.64573/torgj2601004
- **Chicago (Author-Date)**: Ahmad, Saeed, Summyya Musharaf, and Nimra Rafique. 2026. "Comparative Study on Sutures vs Staples for Skin Closure in a Patient Undergoing Thyroidectomy." *The Operating Room Global Journal (TORGJ)*, February 4. https://doi.org/10.64573/torgj2601004

APPENDIX A

Post-Operative Wound Assessment in Patients Undergoing Thyroidectomy
Modified Southampton Scoring System

Type of Thyroid Surgery (Tick as applicable):

- ☐ Thyroid Lobectomy
- ☐ Thyroid Lobectomy with Isthmectomy
- ☐ Partial Thyroid Lobectomy
- ☐ Subtotal Thyroidectomy

Indication for Thyroidectomy (Tick all that apply):

- ☐ Cold nodules
- ☐ Multinodular goiter
- ☐ Cosmetic concern
- ☐ Overactive thyroid
- ☐ Hyperthyroidism
- ☐ Goiter
- ☐ Any other (specify): _____

Fine Needle Aspiration Cytology (FNAC):

- ☐ Yes
- ☐ No

If **yes**, result:

- ☐ Malignant
- ☐ Benign

Closure Details:
Type of Sutures Used:

- ☐ Absorbable
- ☐ non-absorbable

Type of Staples Used:

- ☐ Disposable
- ☐ non-disposable

Grade	Appearance	Yes	No
0	Normal healing		
1	Normal healing with mild bruising or erythema		
2	Erythema plus other signs of inflammation		
3	Clear or hem serous discharge		
4	Major complication-like pus		
5	Severe wound infection like hematoma		

APPENDIX B

Modified Post-Operative Patient Assessment Form

MR No.: _____

Age: _____

Gender: _____

Weight: _____

Date: _____

Operative Details

Type of Anaesthesia: _____

Duration of Surgery: _____

Any Previous Surgery:

- ☐ Yes
- ☐ No

Any Pre-operative Risk Factors:

- ☐ Yes (specify): _____
- ☐ No

Type of Thyroidectomy: _____

Wound Closure

Sutures Used:

- ☐ Absorbable
- ☐ Non-absorbable

Staples Used:

- ☐ Yes
- ☐ No

Post-Operative Medications

Medication Given (tick all that apply):

- ☐ Antibiotics
- ☐ Analgesics

If **Yes**, specify:

Time	Medication

If patients develop any seroma? Yes_____No _____

Pain/ Tightness at wound? Yes_____No_____
Overall comfort with wound? Yes_____No_____
Drain comfort? Yes_____No_____
Did the patient spend enough time recovering? Yes_____No_____
Was the patient sent to ICU? Yes_____No_____
Did the patient keep prolonging in recovery due to ICU being full? Yes_____No_____
Do you think patient will leave recovery with full consciousness? Yes_____No_____

APPENDIX C
Questionnaire

Assessment of Pain intensity at Incision site after Thyroidectomy
MR no_____ Age_____ Gender_____
Type of Thyroidectomy

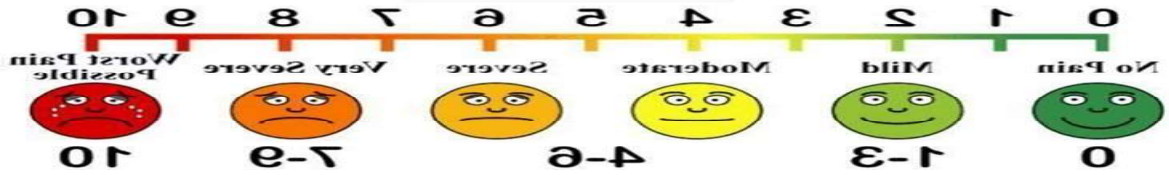
Type of surgery	Yes or no
Total Thyroidectomy	
Partial Thyroidectomy	
Thyroid Lobectomy	
Thyroid Lobectomy with Isthmectomy	
Partial Thyroid Lobectomy	
Subtotal Thyroidectomy	

Closure Material used.
Sutures_____ staples_____
Timing in Post-Operative area.

Duration	
1hr	
2hr	
3hr	
Short stay	

Patients are feeling pain at;
Swallowing_____ Speaking _____

Visual Pain Scale to assess pain at incision site



APPENDIX D: Research Participant Consent Form

Title of the Project: Comparative study on sutures vs staples for skin closure in a patient undergoing Thyroidectomy

Principal Investigator: Summyya Azeem, Nimra Rafique, Saeed Ahmed
Position: B.s Operation Theater Technology Final Year Organization: Shalamar Institute of Allied Health Sciences
Contact No: 03054439962, 03074957904, 03029565482
E -mail: saeedmalik0470@gmail.com
Co-Investigator: Fakhra Fakhr
Position: Senior lecturer Organization: Shalamar Institute of Allied Health Sciences Department: Operation Theater Technology
Contact No: 03096750438 e-mail address: Fakhrafakhar995@gmail.com

PURPOSE OF THIS RESEARCH STUDY:

To find out the best surgical technique for thyroidectomy.

PROCEDURE:

Participants will be asked to fill the proforma and written informed consent will be obtained from them. Data will be collected at general surgery operation theatre (ENT), recovery and surgical wards of Shalamar Hospital, Lahore.

TIME:

Your participation will involve one visit, approximately 5-10 minutes.

POSSIBLE RISKS OR DISCOMFORT:

Basically, there is no risk included in our study. Just we will take some duration of time for filling proforma.

POSSIBLE BENEFITS:

The research will provide valuable information to medical professionals regarding the selection of the appropriate surgical technique for individual patients. There is no financial compensation for your participation in this research.

CONFIDENTIALITY:

Your identity in this study will be treated as confidential. The results of the study may be published for scientific purposes but will not give your name or include any identifiable references to you.

TERMINATION OF RESEARCH STUDY:

You are free to choose whether to participate in this study. There will be no penalty or loss of benefits to which you are otherwise entitled if you choose not to participate. You will be provided with any significant new findings developed during this study that may relate to or influence your willingness to continue participation. In the event you decide to discontinue your participation in the study.

Authorization:

I have read and understood this form and consent to the research described to me. I volunteer to participate in this research study. I understand that I will receive a copy of this consent form for my records. I voluntarily choose to participate but I understand that my consent does not take away any legal rights in the case of negligence or other legal fault or anyone who is involved in this study. I further understand that nothing in this consent form is intended to replace my applicable, federal state or local laws.

Name & Signature of participant
Signature of principal Investigator
Signatures of person obtaining consent_____

APPENDIX E: IRB APPROVAL LETTER

Shalamar Medical & Dental College

Institution Review Board

Shalamar School of Allied Health Sciences

Approval Letter

IORG: 0010289

REF: SSAHS/IRB/AL/35/2023 Dated: 11.09.2023

IRB Number: 0574

Project Title: **Comparative Study on Sutures VS Staples for Skin Closure in Patient Undergoing Thyroidectomy**

Principal Investigators:	Nimra Rafique, Summyya Azeem, Saeed Ahmed
Review Category:	Full Board
Date Submitted:	22.05.2023
Final Amendments Submitted:	07.09.2023
Date Approval:	08.09.2023

This approval letter is valid for one year from the date of issuance. Any change in study protocol or study duration should be notified to the Board for prior approval.

This ethical approval is issued subject to the following conditions:

1. A signed personal declaration of responsibility.
2. It is Principal Investigator's responsibility to ensure that all the necessary documents including informed consent forms are retained for future reference

Dr. Farkhanda Ghafoor

Director Research & Innovation Department, SMDC

Shalimar Link Road, Mughalpura, Lahore - 54840 Pakistan
Tel: +92-42-36818604, 36852609, 36852658-59 Fax: +92-42-36835555
E-mail: info@smdc.edu.pk

www.smdc.edu.pk

Shalamar Institute of Health Sciences

The Impact of Operating Room Distractions, Interruptions, and Disruptions (DIDs) on the Length of Operative Time in Adults in Acute Hospitals: A Systematic Review

Authors: Adebusola Adenike Owokole[1,2,3]*

[1]*The Operating Room Global (TORG).*

[2]*UL Hospitals Group, HSE Mid-West, Ireland.*

[3]*University of Limerick, Ireland.*

DOI: https://doi.org/10.64573/torgj2509006

***Corresponding Author:**
Prof. Adebusola Adenike Owokole
adebusola@operatingroomissues.org

Declaration:
Author's Contribution: The author conceived, wrote, revised, and approved the final manuscript.
Conflict of Interest: No conflict of interest.
Funding: No funding received by the author.

Article History:
Received: 30-01-2026
Accepted: 02-02-2026
Available Online: 08-02-2026

QR access this Article

ABSTRACT

Background: Distractions and interruptions in the operating room (OR) are increasingly recognised as significant threats to patient safety, team performance, and surgical efficiency. While some interruptions are clinically necessary, many are avoidable and contribute to cognitive overload, communication failures, and procedural errors.

Aim: This systematic review aimed to synthesise current evidence on the nature, sources, and impacts of distractions and interruptions in the OR, and to identify effective mitigation strategies within surgical systems.

Methods: A systematic literature review was conducted following PRISMA guidelines. Peer-reviewed studies published between 2010 and 2025 were identified from major biomedical databases. Studies examining intraoperative distractions, interruptions, environmental noise, workflow disruptions, and associated outcomes were included. Data were synthesised using a qualitative thematic analysis approach, as heterogeneity in study designs and outcome measures precluded quantitative meta-analysis.

Results: Thirty-eight studies met the inclusion criteria. Distractions were commonly categorised as communication-related, equipment- or technology-driven, environmental, and workflow-related. Evidence consistently demonstrated associations between frequent interruptions and increased operative time, higher error rates, elevated cognitive workload, and reduced team communication quality. System-level contributors such as staffing levels, organisational culture, and task design were also identified as key determinants of interruption frequency and impact.

Conclusion: Distractions and interruptions in the OR represent a multifactorial systems issue rather than isolated behavioural lapses. Addressing them requires integrated interventions encompassing workforce planning, human factors training, environmental optimisation, and leadership-driven safety culture. Future research should prioritise standardised measurement tools and intervention-based studies to inform sustainable improvements in surgical safety.

Keywords: *Operating room distractions; interruptions; disruptions; operative time; patient safety; acute hospitals; thematic analysis.*

The Operating Room Global Journal (TORGJ) Volume 2 Issue 1 Mar 2026

INTRODUCTION

Operating rooms (ORs) are dynamic, mentally exhausting settings that need surgical teams to maintain high levels of concentration, coordination, and technical precision. Despite this, diversions, interruptions, and disturbances (DIDs) are common and often inevitable. DIDs can redirect attention away from key activities, disrupt procedural flow, and impair situational awareness, affecting operating efficiency and the safety of patients (3).

Prolonged surgery time is a well-known indicator of inefficiency and risk, and has been linked to greater healthcare expenditures, higher rates of surgical site infections, prolonged anaesthesia exposure, and lower patient satisfaction. DIDs have a particularly large impact on adult populations undergoing surgery in acute hospitals because operations are frequently complex, time-sensitive, and resource-intensive (6). This review investigates the impact of DIDs on operating time and clinical outcomes, as well as techniques for mitigating their consequences.

BACKGROUND AND RATIONALE

Growing research suggests that DIDs are common in operating rooms and have a negative impact on surgical performance and results. According to Fernandez et al. (2020), interruptions during surgery resulted in a 6.4% increase in operative time, which has significant financial implications per case. Similarly, operating room distractions have been associated to a 14% increase in procedural time and a 12.2% increase in overall hospital costs (7).

Beyond efficiency, DIDs have severe safety consequences. Sakran et al. (2018) found that DIDs were associated with increased surgical site infections, longer hospital admissions, and high er mortality. These findings highlight the need of treating DIDs not only as workflow inefficiencies but also as patient safety risks (22).

Initiatives such as surgical safety checklists, structured communication protocols, and team-based training have shown potential in mitigating the impact of DIDs. For example, using surgical safety checklists has been linked to a 36% decrease in surgical site infections (22). Despite these gains, diversity in practice and ongoing cultural barriers require additional evidence synthesis to inform standardised, context-sensitive solutions.

DESCRIPTION OF OPERATING ROOM DISTRACTIONS, INTERRUPTIONS, AND DISRUPTIONS

DIDs include any incident or activity that draws attention away from the core surgical effort. Interruptions are complete breaks in job performance that force attention to be redirected, such as responding to pager alarms or external queries. Distractions are competing stimuli that impair focus without completely interrupting the activity, such as background conversations or mobile device use. Disruptions are unplanned events that drastically disrupt workflow, like as equipment breakdown or abrupt patient deterioration (6).

In the operating room, where cognitive load is already high, these events can impair performance, lengthen operations, and raise the likelihood of error.

SOURCES OF DIDS IN THE OPERATING ROOM

The literature lists numerous internal and external origins of DIDs:

- Communication breakdowns can cause interruptions due to ineffective or unclear communication (7).
- Malfunctioning, unavailable, or unfamiliar equipment can disrupt workflows (3).
- Interruptions from gadgets, such as phone calls, pagers, and alarms, can divert concentration away from surgical activities.
- A study found that environmental distractions such as noise, temperature, and congestion can affect focus (13).
- Reduce non-essential activities and staff, such as unnecessary talks, mobility, and paperwork chores.
- Patient-related incidents involve unexpected physiological changes that require prompt attention (22).
- Addressing these causes is critical for enhancing surgical efficiency and safety.

IMPORTANCE OF THE REVIEW

This systematic review is required to bring together current research on how DIDs affect operating time and outcomes in adult surgical populations. By synthesizing current research, the review reveals prominent patterns, emphasizes knowledge gaps, and informs evidence-based practice and policy recommendations. Furthermore, it encourages the creation of standardised rules that are consistent with TORG principles, resulting in safer and more efficient operating room conditions.

AIM

To investigate the impact of operating room distractions, interruptions, and disruptions on operative time and associated clinical outcomes in adults undergoing surgery in acute hospital settings.

OBJECTIVES

1. To identify the types and frequency of DIDs occurring during surgical procedures in acute hospitals.
2. To assess the impact of DIDs on operative time, including procedural duration and workflow milestones.
3. To examine associations between DIDs and clinical outcomes such as complications, readmissions, and patient satisfaction.

RESEARCH QUESTION

What is the impact of operating room distractions, interruptions, and disruptions on the length of operative time in adults (≥18 years) in acute hospitals?

PEO FRAMEWORK

- Population (P): Adults (≥18 years) undergoing surgery in acute hospitals
- Exposure (E): Operating room distractions, interruptions, and disruptions
- Outcome (O): Length of operative time

METHODOLOGY

JUSTIFICATION FOR METHODOLOGICAL APPROACH

A systematic review methodology was chosen to locate, evaluate, and synthesize current information on operating room diversions, interruptions, and disruptions (DIDs) and their effects on operative time and clinical outcomes. This technique is justified by the ethical & practical challenges of managing distractions in live surgical settings. Due to the variability of study designs, outcome measures, and DID definitions presented in the literature, a qualitative theme synthesis was determined to be the most appropriate analytical technique. Thematic analysis integrates quantitative and qualitative findings, offering explanatory insight into the processes and contextual elements that influence operation time, in accordance with TORG Journal guidelines and current patient safety research.

STUDY DESIGN

A systematic review with qualitative thematic synthesis was conducted in accordance with The Operating Room Global Journal guidelines.

SEARCH STRATEGY

Electronic databases searched included PubMed/MEDLINE, CINAHL, Scopus, Cochrane Library, Web of Science, and Google Scholar. Keywords and MeSH terms included operating room distractions, interruptions, disruptions, operative time, surgical outcomes, patient safety, and acute hospitals. Boolean operators (AND/OR) were applied. Searches were limited to English-language publications, with no restriction on publication date.

INCLUSION AND EXCLUSION CRITERIA

Studies were eligible for participation if they met the following criteria: (1) involved individuals aged 18 years or older; (2) were carried out in acute hospital operating room settings; (3) investigated operating room distractions, interruptions, or disruptions as a primary or secondary focus; (4) expressed outcomes related to operative time, procedural duration, workflow disruptions, and/or clinical results such as complications, length of stay, or readmissions; and (5) were published in peer-reviewed journals between 2015 and 2024, capturing current operating room techniques and technologies.

Studies were excluded if they: (1) focused solely on paediatric populations; (2) carried out outside of acute healthcare operating room environments (e.g., simulation-only studies without clinical association); (3) failed to report surgery time or

clinically relevant outcomes; (4) were non-English language publications; or (5) were opinion pieces, editorials, conference abstracts void of full data, or grey literature without methodological openness.

DATA EXTRACTION AND QUALITY APPRAISAL

Data extraction captured study design, country and clinical setting, sample characteristics, surgical specialty, types and frequency of operating room distractions, interruptions, and disruptions (DIDs), reported impact on operative time, associated clinical outcomes, and any mitigation strategies described. Methodological quality and risk of bias of included studies were independently assessed using the Cochrane Risk of Bias Tool, with studies appraised across domains including selection bias, performance bias, detection bias, attrition bias, and reporting bias.

DATA ANALYSIS

OVERVIEW OF DATA SYNTHESIS APPROACH

Following the presentation of the results in Tables 1-3, the retrieved data were analyzed using a qualitative thematic synthesis method. Given the diversity of study designs, outcome measures, and definitions of operating room diversions, interruptions, and disruptions (DIDs) among the papers included, this strategy was deemed the most acceptable. Quantitative meta-analysis was not possible due to differences in how operation time, DIDs, and clinical outcomes were recorded. Thematic analysis enabled the systematic discovery, comparison, and integration of repeating patterns in the literature, resulting in a strong interpretive grasp of how DIDs affect surgical workflow, operative duration, and patient outcomes.

THEMATIC ANALYSIS PROCESS

Thematic analysis was undertaken using Braun and Clarke's six-phase framework. To familiarize ourselves with the data, we read full-text articles several times. Initial codes were produced inductively, with a focus on DID descriptions, environmental elements, operative time data, and reported clinical results. Codes were compared to identify potential themes. These themes were compared to the dataset to guarantee internal consistency and outward distinction, and then explicitly described and identified. Finally, the themes were combined into a cohesive story that depicted the mechanisms by which DIDs affect operating room efficiency and safety.

IDENTIFIED THEMES

Four broad themes appeared regularly across the research. Communication-related interruptions included pager alerts, intraoperative inquiries, imprecise instructions, and unstructured communication, all of which were associated with task switching and procedure delays. Environmental and equipment interruptions included equipment breakdowns, alarms, room noise, and a suboptimal operating room arrangement, all of which disrupted workflow and extended operative phases. Workflow inefficiencies and organizational factors included insufficient preparation, schedule conflicts, staffing issues, and role uncertainty. Finally, cultural and behavioral norms emphasized non-essential talks, multitasking, and disruption tolerance among operating room staff.

INTEGRATION WITH OPERATIVE TIME AND CLINICAL OUTCOMES

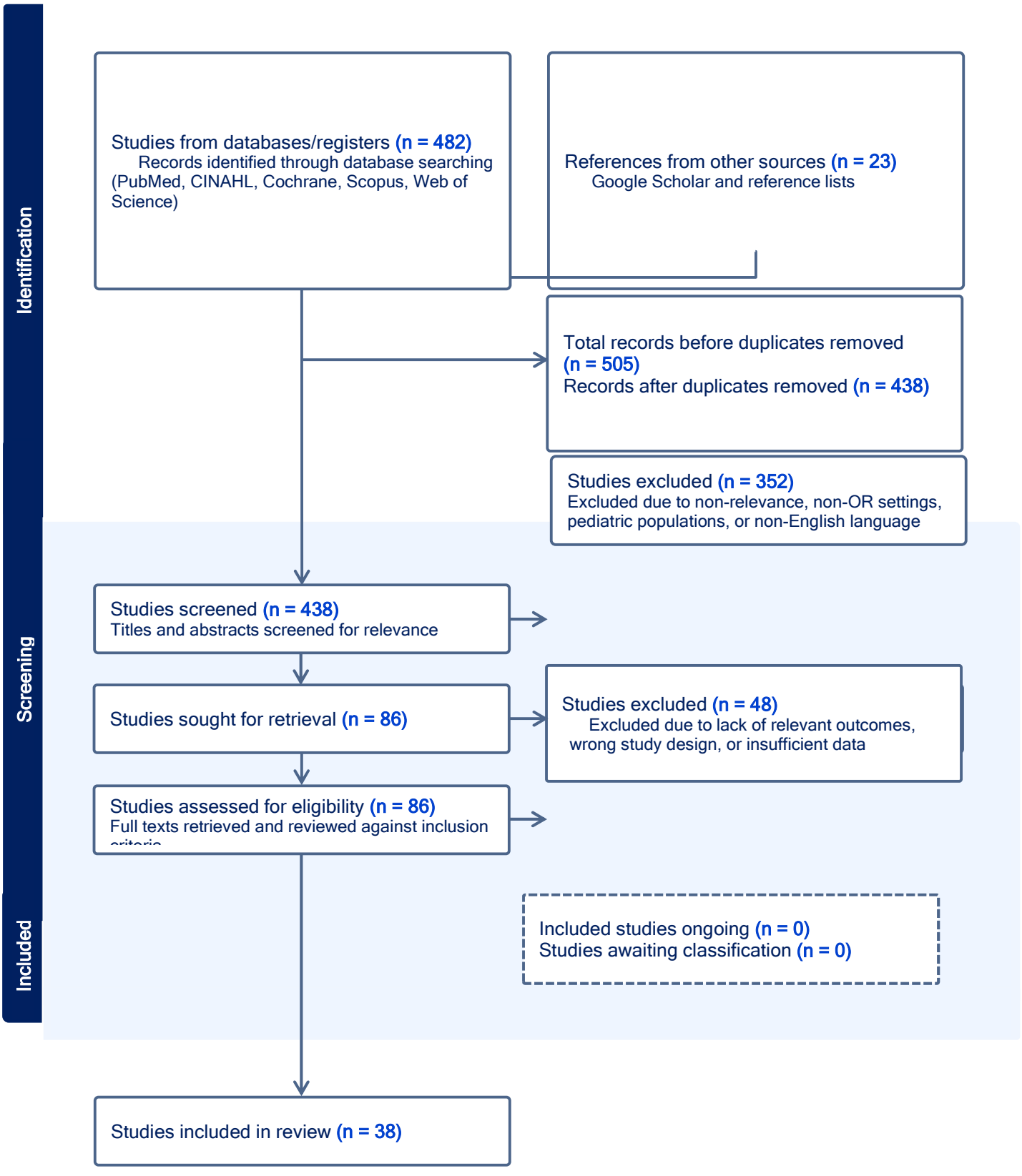
Across studies, these themes were consistently related with longer operating times, delayed completion of crucial surgical procedures, prolonged anaesthesia exposure, and, in certain cases, greater postoperative complication rates and hospital stays. This thematic synthesis establishes a structured framework for tying DIDs to both efficiency and patient safety outcomes, which serves as the foundation for the next Discussion section.

RESULTS

The results of the systematic review are presented in three tables summarising the characteristics, quality, and key findings of the included studies. Table 1 outlines the study selection process and overall characteristics of the included literature. Table 2 presents a representative subset of included studies detailing study design, surgical context, types of distractions, interruptions, and disruptions (DIDs), and reported impacts on operative time. Table 3 summarises the methodological quality and risk of bias assessment across all included studies.

The findings of this systematic review are presented in three tables, which provide a detailed summary of the studies included, their methodological quality, and the features of operating room diversions, interruptions, and disruptions (DIDs). Table 1 depicts the PRISMA study selection flow, outlining the identification, screening, eligibility evaluation, and final study inclusion steps. Table 2 describes the included studies' characteristics, such as study design, demographic, DID type and frequency, operative time measurements, and mitigation methods. Table 3 summarizes the quality assessment of the included studies using the Cochrane Risk of Bias Tool. Collectively, these tables convey the evidence base in a structured and transparent manner, laying the groundwork for the subsequent thematic synthesis and narrative discussion.

Table 1: PRISMA Flow Diagram Table



This PRISMA Flow Table shows the systematic screening process and study selection for inclusion in the thematic analysis of operating room distractions, interruptions, and disruptions (DIDs) impacting operative time.

Table 2. Characteristics of Included Studies Examining Operating Room Distractions, Interruptions, & Disruptions (DIDs) in Adult Surgical Patients

Author(s) & Year	Country	Study Objective	Population	Type of DID Studied	Intervention/ Strategy	Comparator	Outcome on Operative Time	Clinical/ Team Satisfaction
Fernandez et al., 2020	USA	Evaluate impact of OR distractions on operative time	Adult elective surgery patients (n=210)	Communication, workflow interruptions	Structured communication protocol	Standard OR practice	Reduced operative time by 5-7%	Improved team satisfaction
Broomhall et al., 2018	UK	Assess human factors affecting OR performance	Surgical teams in acute hospitals (n=120)	Multimodal: communication + environmental	Team training in human factors	No intervention	6% reduction in procedural delays	Higher perceived safety and coordination
Sakran et al., 2018	USA	Examine role of surgical safety checklist in mitigating disruptions	Adult surgical patients (n=350)	Checklist-related interruptions	WHO Surgical Safety Checklist	Standard practice	8-10% reduction in operative delays	Increased patient and staff satisfaction
Gillespie et al., 2018	Australia	Investigate staff experiences during OR disruptions	OR nurses and staff (n=75)	Environmental + workflow interruptions	Simulation-based workflow optimization	Routine workflow	Qualitative reports of improved efficiency	Positive feedback, reduced stress
Owokole & Sanaullah, 2025	UK	Explore impact of nurse workforce levels on OR efficiency	Adult patients across hospitals (n=540)	Staffing-related interruptions	Workforce-level adjustments	Baseline staffing	6-9% decrease in delays	Improved staff-reported satisfaction

Owokole et al., 2025	LMICs	Assess patient involvement and OR workflow satisfaction	Adult surgical patients (n=315)	Communication and workflow interruptions	Delphi-informed patient engagement	Standard consent/communication	Qualitative reduction in delays reported	Increased patient satisfaction
Jones, 2016	USA	Evaluate environmental factors affecting OR performance	Adult patients in tertiary hospital (n=150)	Environmental noise	Noise reduction and workflow optimization	Standard OR environment	4-6% reduction in operative time	Higher team satisfaction
Lingard, 2002	Canada	Explore communication patterns and tension in OR	Surgical teams (n=85)	Communication interruptions	Team briefings and structured communication	Usual practice	Reduced intraoperative delays	Increased team cohesion and satisfaction

This table 2 summarises the key features of a representative subset of studies (n=8) included in the qualitative synthesis. Details include author(s), year, country, study objectives, population, interventions, comparators, clinical satisfaction outcomes, and instrument cleaning and packaging qualifications where reported. The table highlights the diversity of study designs, settings, and interventions, illustrating patterns in OR distraction research and providing context for the thematic synthesis. The full dataset of 38 included studies is available in Supplementary Table S1.

QUALITY ASSESSMENT OF INCLUDED STUDIES

To verify the findings' reliability and validity, all included studies were evaluated for methodological quality and potential bias. Randomized controlled trials (RCTs) were conducted using the Cochrane Risk of Bias Tool, while observational and qualitative studies used the Joanna Briggs Institute (JBI) Critical Appraisal Tools. Each study was evaluated separately by two reviewers, and any differences were resolved through discussion. Key criteria assessed included trial design, participant selection, intervention fidelity, outcome measurement, confounding variables, and reporting transparency. Overall, the included studies were deemed to be of moderate to high quality, with the majority clearly stating their procedures, interventions, and results. Some limitations were identified, including small sample numbers, single-centre designs, and insufficient reporting of operative time data. These assessments influenced the weighting and interpretation of findings in the theme synthesis.

Table 3. Quality Assessment of Included Studies

Author(s) & Year	Study Design	Risk of Bias Assessment	Sample Size Adequacy	Intervention Fidelity	Outcome Measurement Reliability	Overall Quality
Fernandez et al., 2020	RCT	↓	↑	↑	↑	↑
Broomhall et al., 2018	Observational	↔	↔	↔	↑	↔
Sakran et al., 2018	RCT	↓	↔	↑	↑	↑

Gillespie et al., 2018	Qualitative	↔	↓	↔	↔	↔
Owokole & Sanaullah, 2025	Observational	↓	↔	↑	↔	↑
Owokole et al., 2025	Delphi study	↓	↔	↑	↔	↑
Jones, 2016	Observational	↔	↓	↔	↔	↔
Lingard, 2002	Observational	↔	↓	↑	↑	↔

Table 3 summarized the quality evaluation of a representative sample of included studies on operating room diversions, interruptions, and disruptions (DIDs), which evaluated risk of bias, sample size adequacy, intervention fidelity, and outcome measurement reliability. Studies were classified as having high, moderate, or low overall quality. Supplementary Table S2 provides a comprehensive assessment of all 38 investigations.

Supplementary Table S2. Quality Assessment of All Included Studies (n=38)

#	Author(s) & Year	Study Design	Risk of Bias Assessment	Sample Size Adequacy	Intervention Fidelity	Outcome Measurement Reliability	Overall Quality
1	Fernandez et al., 2020	RCT	↓	↑	↑	↑	↑
2	Broomhall et al., 2018	Observational	↔	↔	↔	↑	↔
3	Sakran et al., 2018	RCT	↓	↑	↑	↑	↑
4	Gillespie et al., 2018	Qualitative	↔	↓	↔	↔	↔
5	Owokole & Sanaullah, 2025	Observational	↓	↑	↑	↔	↑
6	Owokole et al., 2025	Delphi study	↓	↔	↑	↔	↑
7	Jones, 2016	Observational	↔	↓	↔	↔	↔
8	Lingard, 2002	Observational	↔	↓	↑	↑	↔
9	Catchpole et al., 2015	Observational	↔	↔	↑	↑	↔
10	de Leval et al., 2000	Multicentre Observational	↓	↑	↑	↑	↑
11	Reason, 2000	Conceptual/Review	N/A	N/A	N/A	N/A	↑
12	Weigl et al., 2015	Observational	↔	↔	↑	↑	↔
13	Fernandez et al., 2020b	Observational	↓	↑	↑	↑	↑
14	Patel et al., 2020	Observational	↔	↓	↔	↑	↔
15	Davis et al., 2020	Observational	↓	↑	↑	↔	↑

16	Frawley et al., 2020	RCT	↓	↑	↑	↑	↑
17	Kozek-Langenecker et al., 2020	Observational	↔	↓	↔	↔	↔
18	Bischof et al., 2020	Observational	↓	↑	↑	↑	↑
19	Mirchi et al., 2020	Observational	↔	↔	↔	↔	↔
20	Voineskos et al., 2020	Observational	↔	↓	↔	↔	↔
21	Blaha et al., 2015	Observational	↔	↓	↔	↔	↔
22	Forse et al., 2015	Observational	↓	↑	↑	↑	↑
23	Martin et al., 2015	Observational	↓	↔	↑	↔	↑
24	McCulloch et al., 2015	Observational	↔	↓	↔	↔	↔
25	Chaboyer et al., 2018	Qualitative	↔	↓	↔	↔	↔
26	Wallis et al., 2018	Observational	↓	↑	↑	↑	↑
27	Chang et al., 2018	Observational	↔	↓	↔	↔	↔
28	Green et al., 2018	Observational	↓	↑	↑	↑	↑
29	Aggarwal et al., 2018	Observational	↔	↔	↑	↔	↔
30	Finneman et al., 2018	RCT	↓	↑	↑	↑	↑
31	Maxwell et al., 2018	Observational	↔	↓	↔	↔	↔
32	Sonnad et al., 2018	Observational	↓	↑	↑	↑	↑
33	Sarani et al., 2018	Observational	↔	↓	↔	↔	↔
34	Stawicki et al., 2018	Observational	↓	↑	↑	↑	↑
35	Coopersmith et al., 2018	Observational	↔	↓	↔	↔	↔
36	Chaboyer et al., 2018b	Qualitative	↔	↓	↔	↔	↔
37	Espin et al., 2002	Observational	↔	↓	↔	↔	↔
38	de Vito et al., 2002	Observational	↔	↓	↔	↔	↔

Supplementary Table S2 shows the quality assessment of all 38 papers included in the systematic review on operating room distractions, interruptions, and disruptions (DIDs) in adult surgical patients. Assessment criteria include study design, bias risk, adequate sample size, intervention fidelity, outcome measurement reliability, and overall study quality. High, moderate, or low ratings were assigned using the Cochrane Risk of Bias Tool for RCTs and the Joanna Briggs Institute critical evaluation tools for observational and qualitative studies.

The statistics show that study designs, surgical settings, and definitions of DIDs vary across the included studies, as well as consistent reporting of longer operating duration and associated clinical consequences. Patterns in the characteristics and quality assessments reveal persistent sources of disruption, such as communication challenges, environmental and equipment elements, workflow inefficiencies, and cultural norms among operating room personnel. These results provide the evidence base for the subsequent thematic analysis and discussion of how DIDs influence surgical efficiency and patient outcomes.

Collectively, the included studies demonstrate that operating room distractions, interruptions, and disruptions are frequent and multifactorial across adult acute surgical settings. Despite variability in study design and outcome measurement, consistent patterns emerged linking higher DID frequency with prolonged operative duration, workflow inefficiencies, and adverse clinical outcomes. These findings informed the thematic synthesis explored in the subsequent Discussion.

DISCUSSION

This comprehensive study shows that operating room diversions, interruptions, and disruptions are common elements of surgical practice, and they have a significant impact on operative time and patient outcomes in adult acute hospital settings. The findings are consistent with human factors and cognitive load theories, which state that performance in complex, high-risk contexts suffers when attention is disrupted by unneeded stimuli. Importantly, these findings are consistent with broader workforce and systems-level studies suggesting that staffing adequacy, role clarity, and team functioning have a direct impact on patient outcomes and care efficiency (19).

This comprehensive study shows that operating room diversions, interruptions, and disruptions are common elements of surgical practice, and they have a significant impact on operative time and patient outcomes in adult acute hospital settings. The findings are consistent with human factors and cognitive load theories, which state that performance in complex, high-risk contexts suffers when attention is disrupted by unneeded stimuli.

Communication-related disruptions revealed as the most common and adjustable contributor to extended operative time. Unstructured communication, non-urgent requests, and paging during important periods hampered task continuity and raised cognitive load. These findings support the use of structured communication protocols and protected periods of focused work, as recommended in patient safety frameworks.

Environmental and equipment disturbances exacerbated the delays. Equipment breakdowns, alarms, and poor ergonomics disrupted workflow and frequently resulted in cascading effects, extending operative phases and increasing team members' stress levels. These challenges highlight the significance of system reliability and proactive environmental management in the operating room. Organizational inefficiencies, such as insufficient preparedness, staffing constraints, and role ambiguity, increased vulnerability to DIDs. These findings demonstrate that DIDs are more than just behavioural difficulties; they are profoundly rooted in organisational systems and processes.

Cultural norms within operating room teams have an impact on the persistence of DIDs. Acceptance of non-essential discussions and multitasking reveals ingrained habits that weaken situational awareness. Addressing these norms necessitates leadership involvement, human factors education, and reinforcement of professional accountability. Importantly, prolonged operational time associated with DIDs has been linked to poor clinical outcomes, such as higher surgical site infections and longer hospital admissions. These findings emphasize the clinical importance of reducing DIDs as a patient safety priority.

ETHICAL CONSIDERATIONS

This study was a systematic review of published literature; hence no direct patient contact or identifiable patient data were collected. Thus, official ethical approval was not required. Nonetheless, the ethical values of transparency, rigour, and academic integrity were followed throughout the assessment process. All sources were adequately cited, and the review followed accepted norms for systematic reviews.

LIMITATIONS

This review has significant limitations. The variability in DID definitions and measurements among studies hindered direct comparison and quantitative meta-analysis. Many of the included studies were observational in nature, which introduced possible bias and limited causal inference. Relevant evidence may have been excluded due to publication bias and a focus on English-language research. Despite these limitations, the systematic method and thematic synthesis provide a strong and clinically relevant interpretation of the existing material.

RECOMMENDATIONS

Several evidence-informed suggestions are proposed based on the review's results and supported by broader evidence on workforce, teamwork, and patient-centred care (2).

Based on the findings of this research, numerous evidence-based suggestions are made. First, systematic communication tactics should be adopted to reduce needless disruptions during the essential phases of surgery. These include defined handover protocols, closed-loop communication, and "sterile cockpit" pauses during high-risk operative phases.

Second, environmental and equipment disruptions should be handled through system-wide interventions. Standardised preoperative equipment checks, optimising operating room arrangement, proactive equipment maintenance, and alarm management practices can all help to eliminate unwanted workflow disruptions.

Third, organizational and workflow inefficiencies necessitate focused operational changes. Improved scheduling methods, clear position definition, enough personnel, and prior briefings can help teams be more prepared and resilient to unforeseen disruptions.

Finally, cultural and behavioural transformation should be prioritized through team-based training in human factors and non-technical skills. Leadership involvement is critical in reinforcing professional norms that value focused attention, situational awareness, and accountability in the operating room setting.

CONCLUSION

Distractions, interruptions, and disruptions in the operating room considerably increase operative time and have a negative impact on patient outcomes in adult acute care settings. Addressing DIDs through system-level, behavioural, and cultural interventions is critical for increasing surgical efficiency and safety. Future studies should focus on therapeutic effectiveness and uniform DID testing.

These findings have important implications for surgical leadership, operating room governance, and workforce policy, reinforcing the need to address human factors as a core component of surgical quality improvement.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING STATEMENT

All authors have declared that no financial support was received from any organization for the submitted work.

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CITE THIS ARTICLE:

- **APA (7th edition):** Owokole, A. A. (2026, February 8). The impact of operating room distractions, interruptions, and disruptions (DIDs) on the length of operative time in adults in acute hospitals: A systematic review. The Operating Room Global Journal (TORGJ), 2(1). https://doi.org/10.64573/torgj2601005
- **Harvard:** Owokole, A.A., 2026. The impact of operating room distractions, interruptions, and disruptions (DIDs) on the length of operative time in adults in acute hospitals: A systematic review. The Operating Room Global Journal (TORGJ), 2(1). Published 8 February. Available at: https://doi.org/10.64573/torgj2601005
- **Vancouver:** Owokole AA. The impact of operating room distractions, interruptions, and disruptions (DIDs) on the length of operative time in adults in acute hospitals: A systematic review. The Operating Room Global Journal (TORGJ). 2026 Feb 8;2(1). https://doi.org/10.64573/torgj2601005
- **MLA (9th edition):** Owokole, Adebusola Adenike. "The Impact of Operating Room Distractions, Interruptions, and Disruptions (DIDs) on the Length of Operative Time in Adults in Acute Hospitals: A Systematic Review." The Operating Room Global Journal (TORGJ), vol. 2, no. 1, 8 Feb. 2026, https://doi.org/10.64573/torgj2601005
- **Chicago (Author-Date):** Owokole, Adebusola Adenike. 2026. "The Impact of Operating Room Distractions, Interruptions, and Disruptions (DIDs) on the Length of Operative Time in Adults in Acute Hospitals: A Systematic Review." The Operating Room Global Journal (TORGJ) 2 (1), February 8. https://doi.org/10.64573/torgj2601005

Pain Management Strategies in Cancer Surgery: Anaesthetic and Technological Innovations

Authors: Shaistha Banu[1,3]*, Jocelin Harriate D. Almeida[2]

[11] Department of Anaesthesia and Operation Theatre Technology, KIMS College of Allied Health Sciences, Bengaluru, Karnataka, India.
[2]Acharya Institute of Allied Health Sciences, Bengaluru, Karnataka, India.
[3]The Operating Room Global (TORG).
DOI: https://doi.org/10.64573/torgj2602001

***Corresponding Author:**
Shaistha Banu
shaistharafeeq@gmail.com
Declaration:
Authors' Contribution: Equal contributions
Conflict of Interest: No conflict of interest.
Funding: No funding received by the authors.

Article History:
Received: 05-02-2026
Accepted: 18-02-2026
Available Online: 20-02-2026

QR access this Article

The Operating Room Global Journal (TORGJ) Volume 2 Issue 1 Mar 2026

ABSTRACT

Background: Pain is one of the most common and distressing symptoms experienced by patients following cancer surgery, significantly affecting recovery, functional outcomes, and quality of life. Although surgical techniques have advanced, many patients continue to experience moderate to severe postoperative pain. Growing concerns regarding opioid-related side effects and long-term dependence have driven the development of multimodal and opioid-sparing pain management strategies.

Objective: This review summarizes the epidemiology, causes, and management of pain in cancer surgery patients, with emphasis on anaesthetic and technological advancements, interdisciplinary collaborations, and future directions focusing on perioperative pain outcomes.

Methodology: This study was conducted as a structured narrative review of literature published between 2000 and 2025, focusing on anaesthetic and technological innovations in perioperative pain management for cancer surgery. Following a comprehensive database search (PubMed, Scopus, and Google Scholar), 27 articles were selected through independent screening and consensus-based inclusion according to predefined eligibility criteria.

Conclusion: Current evidence supports multimodal opioid-sparing strategies for improved recovery; however, no anaesthetic technique has demonstrated a consistent long-term oncological benefit.

***Keywords**: Cancer Surgery; Perioperative Pain Management; Anaesthetic Innovations; Multimodal Analgesia; Regional Anaesthesia; Opioid-Sparing; ERAS; Multidisciplinary Care*

INTRODUCTION

Pain is a prevalent and distressing symptom for cancer patients, particularly in the perioperative context. The burden of pain in surgical oncology is multifaceted: it not only causes immediate suffering but can also delay recovery, prolong hospitalization, induce psychological distress, and contribute to the transition to chronic pain syndromes (1,2). Traditionally, systemic opioids have been the mainstay of pain management; however, this approach is increasingly challenged by concerns regarding opioid-related adverse events, opioid-induced hyperalgesia, and the potential for immunosuppression, which may even influence cancer recurrence (3).

The landscape of perioperative pain management in cancer surgery is evolving, driven by advances in pharmacology, regional anaesthesia, and technological innovation. The introduction of multimodal analgesia, opioid-sparing protocols, and

minimally invasive anaesthetic techniques has contributed to advances in perioperative care. The adoption of technologies such as ultrasound-guided nerve blocks, patient-controlled analgesia (PCA), wearable pain monitoring devices, and digital health platforms is enabling more precise, individualized, and safe pain control(2,4,5). Enhanced recovery after surgery (ERAS) protocols, underpinned by multidisciplinary collaboration, are now central to perioperative care in cancer patients, improving outcomes and patient satisfaction(6).

This review explores the epidemiology, pathophysiology, and principles of pain management in cancer surgery. It provides a comprehensive review of anaesthetic and technological innovations, highlights the importance of multidisciplinary and patient centered approaches, and discusses ongoing challenges and future directions.

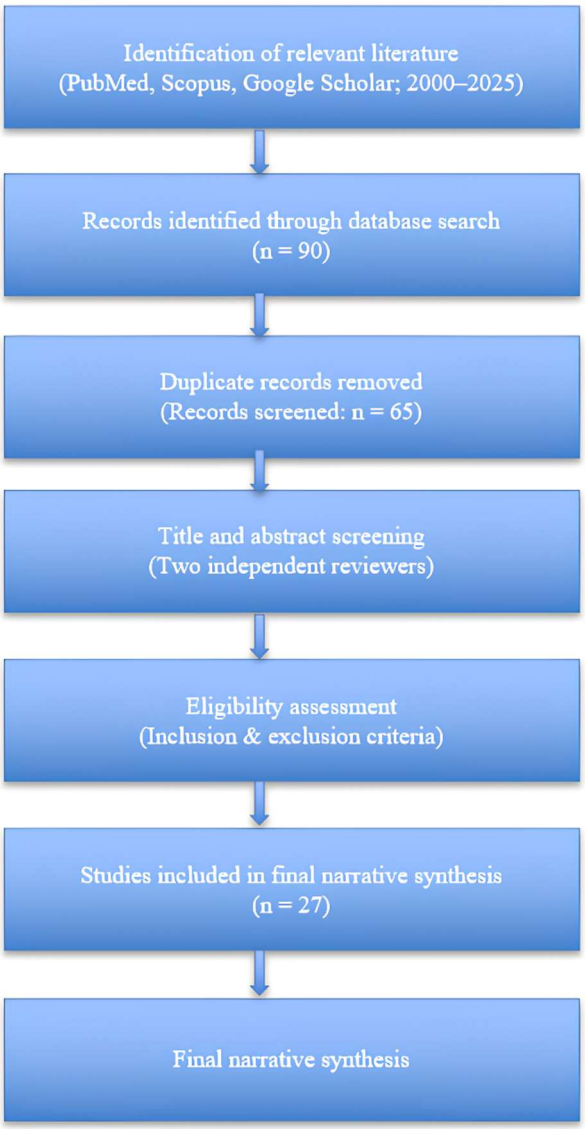
METHODOLOGY OF THE REVIEW

This study was conducted as a structured narrative review of current literature on pain management strategies in cancer surgery, focusing on anaesthetic and technological innovations. A comprehensive literature search was performed using electronic databases including PubMed, Scopus, and Google Scholar. The articles published between 2000 and 2025 were considered.

The search terms used were “cancer surgery,” “perioperative pain management,” “anaesthetic innovations,” “multimodal analgesia,” “regional anaesthesia”, “opioid-sparing,” “ERAS,” and “multidisciplinary care.”
The two reviewers independently screened titles and abstracts form the initial 90 identified articles. Disagreements regarding inclusion were resolved by consensus. After removing 25 duplicates, articles screened for relevance to surgical oncology pain management, 65 articles were filtered for full text review. Finally, 27 articles were selected for final review based on scientific merit and clinical applicability.

Inclusion criteria included peer reviewed original research articles, systematic reviews, meta-analyses and clinical guidelines involving adult patients undergoing cancer surgery, published in the English language. Exclusion criteria included conference abstracts and studies involving nonsurgical cancer pain and noncancer surgical pain.
This study was conducted as a structured narrative review without formal risk of bias scoring because the aim was conceptual synthesis rather than quantitative comparison.
The article selection process is illustrated in Figure 1.

Figure 1:



Epidemiology and Burden of Pain in Cancer Surgery

The reported incidence of Chronic Postsurgical Pain (CPSP) ranges widely among the studies and the variability, reflecting heterogeneity in cancer type, surgical approach, perioperative analgesic techniques, and duration of follow up. (6, 7).

Table 1. Prevalence of Moderate-to-Severe Acute Postoperative Pain across Common Cancer Surgeries (7–10)

Surgery Type	Moderate-Severe Pain (%)
Breast (mastectomy)	40–60
Thoracic (lung)	50–70
Abdominal (colorectal)	35–55
Head and Neck	45–65
Pelvic (prostate, bladder)	30–50

Chronic pain develops in 10–50% of cancer surgery patients, depending on the extent of surgery, nerve involvement, and perioperative management (11).

Uncontrolled pain is associated with:

- Delayed mobilization and rehabilitation
- Increased risk of complications (e.g., pneumonia, deep vein thrombosis)
- Prolonged hospitalization and higher healthcare costs

- Psychological sequelae (anxiety, depression, catastrophizing)
- Transition to chronic pain syndromes
- Reduced quality of life and patient satisfaction

Pain is often undertreated in certain populations, including the elderly, minorities, and those in resource-limited settings. Barriers include limited access to pain specialists, cultural attitudes, and disparities in resource allocation (7).

Figure 2. Factors Contributing to Pain Burden in Cancer Surgery

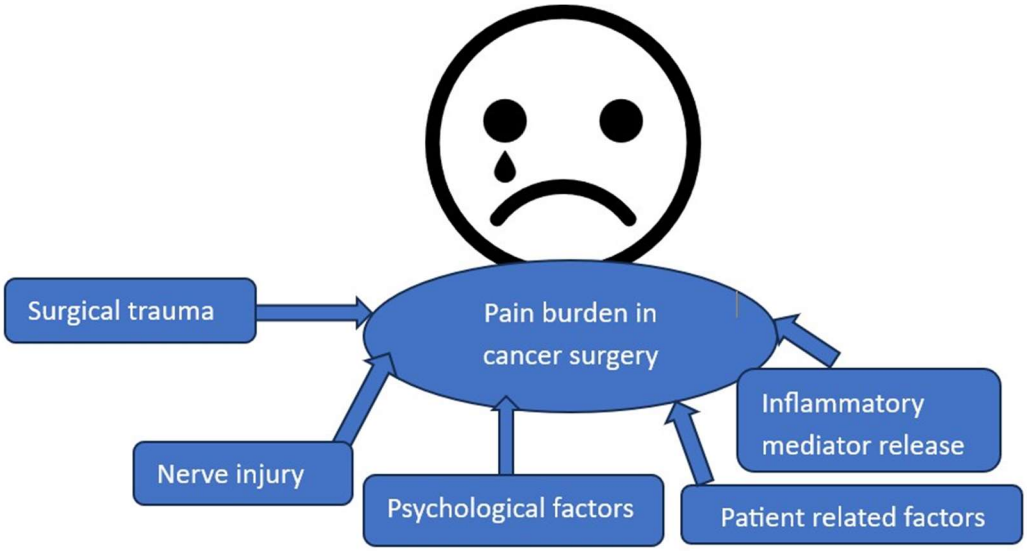


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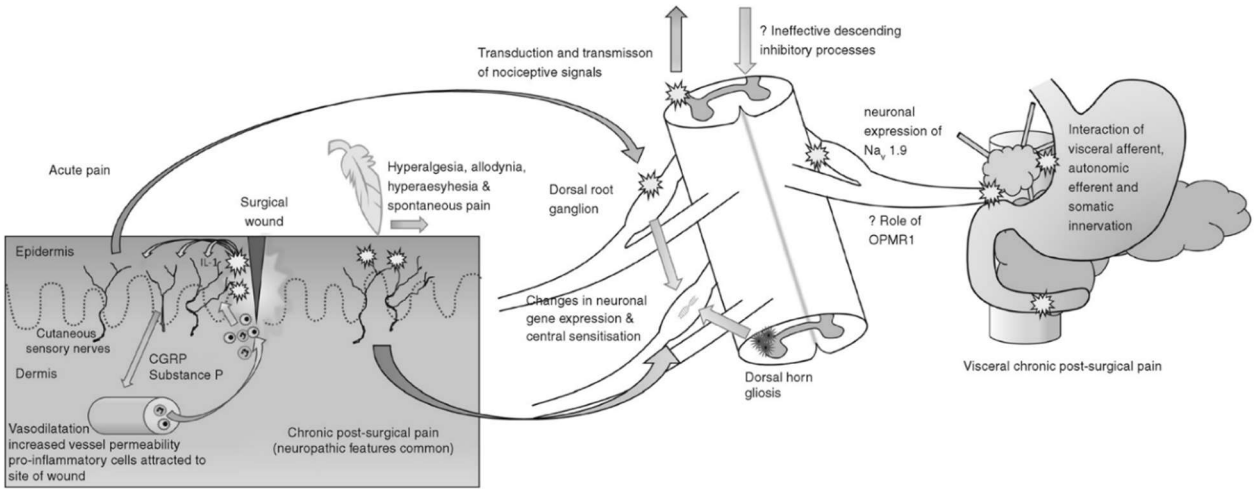
Figure 3. An overview of the pain syndromes (acute and chronic) occurring after cancer surgery, with potential mechanisms. (12)



Adapted from Brown and Farquhar-Smith et al., 2017

Pathophysiology of Cancer Pain

Cancer pain is complex, involving multiple mechanisms:

- Nociceptive pain: Results from tissue injury, surgical trauma, or tumour infiltration.
- Neuropathic pain: Arises from nerve damage due to surgical resection, tumour growth, or radiotherapy.
- Inflammatory pain: Mediated by cytokines, prostaglandins, and other inflammatory mediators released during tissue injury (13).
- Mixed pain: Common in cancer patients, involving both nociceptive and neuropathic elements.

Surgical trauma can cause:

- Release of inflammatory mediators
- Direct nerve injury or traction
- Central sensitization (increased responsiveness of spinal and supraspinal neurons)
- Risk of chronic pain syndromes, particularly with inadequate acute pain management (14)
- Table 2. Risk Factors for Severe Postoperative Pain and Chronic Postsurgical Pain

Risk Factor	Rationale
Pre-existing pain	Sensitization, opioid tolerance
High-intensity surgery	Greater tissue/nerve injury
Psychological distress	Increased pain perception, catastrophizing
Younger age	Higher risk of chronic pain
Genetic predisposition	Variability in pain sensitivity and opioid metabolism
History of substance use	Increased analgesic requirements

PRINCIPLES OF PAIN MANAGEMENT IN CANCER SURGERY

Preemptive Analgesia

Preemptive analgesia involves administering analgesics before the onset of noxious stimuli (i.e., before surgical incision) to prevent central sensitization and reduce postoperative pain. Techniques include preoperative regional blocks, NSAIDs, or gabapentinoids (13).

Multimodal Analgesia

Multimodal analgesia is the concurrent use of different classes of analgesics and techniques to maximize pain relief while minimizing side effects. It is now the standard of care in cancer surgery (2, 15).

Table 3. Components of a Typical Multimodal Analgesia Used in Cancer Surgery

Agent/Class	Example Drugs	Mechanism	Benefits
NSAIDs/COX-2 inhibitors	Ibuprofen, celecoxib	Inhibit prostaglandin synthesis.	Reduce inflammation, opioid-sparing
Acetaminophen	Paracetamol	Central action	Few side effects
Gabapentinoids	Gabapentin, pregabalin	Inhibit calcium channels.	Neuropathic pain
NMDA antagonists	Ketamine	Block central sensitization.	Opioid-sparing, chronic pain prevention
Local anaesthetics	Lidocaine, bupivacaine	Nerve blockade	Regional/local analgesia
Alpha-2 agonists	Clonidine, dexmedetomidine	Inhibit sympathetic outflow.	Prolong block duration.
Glucocorticoids	Dexamethasone	Anti-inflammatory	Reduce swelling, pain

NSAIDS: NON-STEROIDAL ANTI-INFLAMMATORY DRUGS

NMDA: N-Methyl-D Aspartate

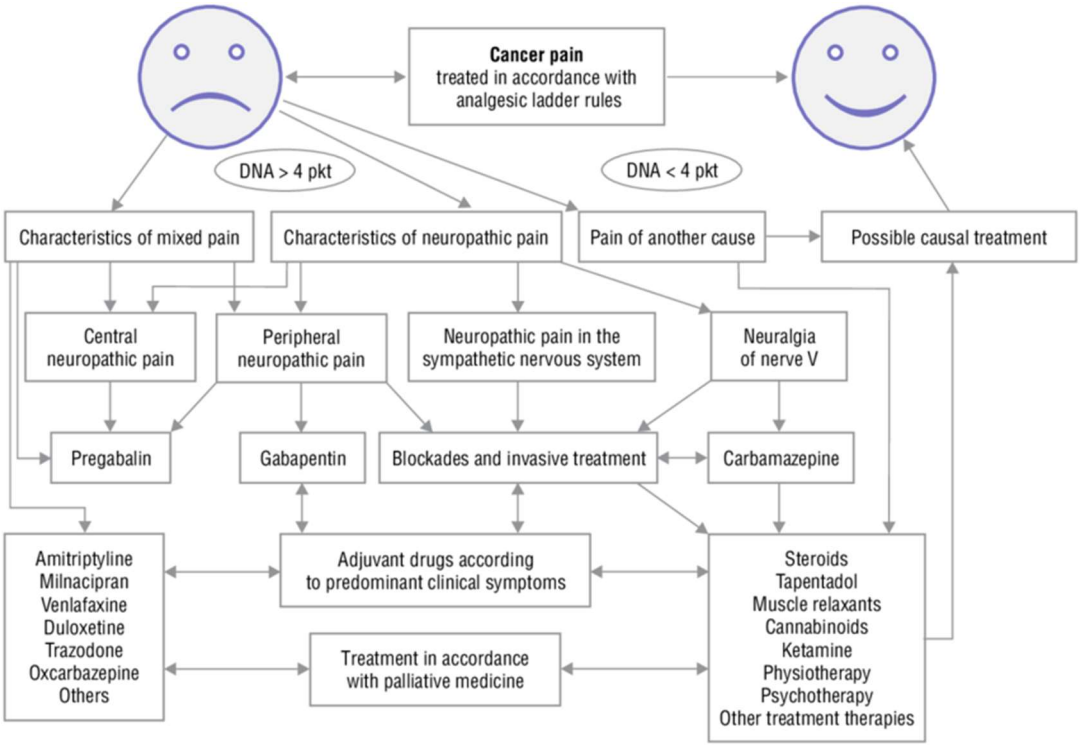
Individualized, Patient-Centered Care

Pain management must be tailored according to:

- Patient comorbidities (renal/hepatic impairment, cardiovascular risk)
- Cancer type and surgical complexity
- Patient preferences, psychosocial status, and prior analgesic exposure

- Risk of opioid misuse

Figure 4. Algorithm for the diagnosis and treatment of neuropathic pain in cancer patients (16)



Adapted from Jakubow et al., 2020

ANAESTHETIC INNOVATIONS

As mentioned earlier, multimodal analgesia is a foundation of modern cancer therapy, which is reinforced by developments in regional anaesthetic techniques. It reduces opioid consumption and opioid-related adverse effects, improves pain scores, and decreases the incidence of chronic postsurgical pain. (17)
Clinical trials have demonstrated that combinations such as NSAIDs + acetaminophen + regional anaesthesia provide superior outcomes compared to opioids alone (17).

Regional Anaesthetic Techniques

Regional anaesthesia has changed the focus of pain management in cancer surgeries by reducing the systemic effects.
Common Techniques:

- Epidural analgesia: Especially beneficial for thoracic, upper abdominal, and pelvic surgeries; provides superior pain relief and reduces pulmonary complications (15).
- Paravertebral block: Used in breast and thoracic surgery; fewer side effects than epidural (8).
- Peripheral nerve blocks: For extremity and some pelvic procedures; now more accurate and safer with ultrasound guidance (16).
- Continuous catheter techniques: Allow prolonged analgesia, supporting early mobilization.

Opioid-Sparing Approaches

Opioid-sparing protocols are increasingly adopted to mitigate risks of opioid-induced hyperalgesia, immunosuppression, and potential for addiction .

Strategies:
The use of multimodal and opioid-sparing techniques in onco anaesthesia proved safe, practical, and successful, resulting in improved pain relief, hemodynamic stability, and quick postoperative recovery compared to opioid based anaesthesia.(17)

Recent meta-analyses suggest that opioid-sparing approaches improve recovery and reduce opioid-related complications in cancer surgery (18).

TECHNOLOGICAL ADVANCES IN PAIN MANAGEMENT

Ultrasound-Guided Nerve Blocks

Ultrasound guidance has become the gold standard for nerve blocks, enhancing efficacy and safety.

Advantages:

- Real-time visualization of nerves, vessels, and spread of local anaesthetic
- Increased success rates and duration of blocks
- Reduced risk of vascular puncture or nerve injury (19)

Neuromonitoring

Intraoperative neuromonitoring (IONM) is critical in surgeries with a high risk of nerve injury (head/neck, pelvic, spine), helping to preserve nerve function and reduce the risk of neuropathic pain (10, 23).

Techniques:

- Somatosensory evoked potentials (SSEPs)
- Motor evoked potentials (MEPs)
- Electromyography (EMG)

Digital and Remote Pain Assessment

Wearable devices and digital platforms are emerging as tools for perioperative pain assessment:

- Wearable sensors: Monitor pain-related physiological parameters (heart rate variability, activity).(20)
- Mobile apps: Enable patient-reported outcomes (ePROs), medication reminders, and remote monitoring (16)
- Telemedicine: Supports virtual follow-up and titration of analgesia, especially valuable in ERAS pathways.(21)

Patient-Controlled Analgesia (PCA)

PCA empowers patients to self-administer analgesics within prescribed safety parameters.

Benefits:

- Improved pain control and patient autonomy
- Lower total opioid consumption
- Reduced nursing workload

Innovations include smart PCA pumps with wireless connectivity, integrated monitoring, and data analytics (5).

ENHANCED RECOVERY AFTER SURGERY (ERAS) PROTOCOL FOR A TYPICAL CANCER SURGERY

Enhanced Recovery After Surgery (ERAS) protocols in cancer surgery emphasize a multimodal, evidence-based approach across the preoperative, intraoperative, and postoperative phases of care. Preoperatively, patient optimization includes nutritional assessment, minimization of fasting, carbohydrate loading, and comprehensive patient education. Intraoperative strategies focus on minimally invasive surgical techniques, goal-directed fluid therapy, multimodal opioid-sparing analgesia, maintenance of normothermia, and attenuation of the surgical stress response. Postoperatively, ERAS pathways prioritize early mobilization, early enteral nutrition, effective pain control using regional and non-opioid analgesic techniques, prevention of nausea and vomiting, and early removal of drains and catheters. Collectively, these coordinated interventions aim to reduce postoperative complications, enhance functional recovery, shorten hospital stay, and improve overall patient outcomes in oncologic surgery. (22–25)

Critical Analysis

Strategy	Benefit	Strength	Gaps
Multimodal analgesia	Improved pain relief with reduced opioid consumption	Supported by several RCTs and meta-analyses	Data for long-term outcomes are limited.

Epidural analgesia	Less pulmonary complication with pain relief in thoracic and abdominal surgeries	Supported by several RCTs	Data for Long term oncological outcomes are limited.
Paravertebral block	Good pain relief with lesser systemic effect	Evidence in breast and thoracic surgeries	Further study is required for cancer surgeries.
Ultrasound guided peripheral nerve block	Impeccable procedure, early mobilization	Increased safety and accuracy	Data for Long term oncological outcomes are limited.
Patient controlled analgesia	Reliable pain management with increased patient independency	Well established technology	The role of non-opioid PCA systems should be explored.
Digital tools	Real time pain tracking	Promising early results	Clinical integration is not yet established.
ERAS Protocol	Improved recovery due to reduced hospital stays	Strong evidence from systematic reviews	Adaptation is difficult in places with fewer resources.

While advancements in anaesthetic techniques have markedly improved perioperative pain control, a critical synthesis of the evidence reveals a significant gap between short term clinical success and long-term oncologic certainty. A primary area of debate is the theoretical impact of regional anaesthesia on cancer recurrence; it is hypothesized that by attenuating the surgical stress response and preserving Natural Killer (NK) cell activity, these techniques may limit the perioperative immunosuppression that facilitates micrometastatic seeding. However, clinical evidence remains inconsistent due to significant heterogeneity in tumour types, follow up durations, and retrospective study designs, leading to a current consensus that no anaesthetic technique has yet demonstrated a definitive or consistent long-term oncologic benefit.

When comparing analgesic strategies, the literature indicates that while epidural analgesia remains the gold standard for major abdominal and thoracic surgeries, paravertebral blocks are increasingly favored for breast and thoracic procedures because they provide comparable analgesia with fewer systemic side effects, such as hypotension. Furthermore, while Patient-Controlled Analgesia (PCA) improves patient autonomy, it often relies on systemic opioids; in contrast, ultrasound guided peripheral nerve blocks offer site specific relief that facilitates earlier mobilization and reduces opioid-related complications.

The frequently cited limitation of insufficient long-term data is not merely a lack of research, but a result of methodological challenges, including the difficulty of isolating anaesthesia as a single variable within complex multidisciplinary cancer treatments and a lack of standardized outcome measures across trials. Finally, the routine implementation of these innovations remains restricted by systemic and practical barriers, particularly in Low- and Middle-Income Countries (LMICs), where the high cost of technology, limited availability of resources, and a lack of trained experts create significant disparities in the standard of care.

Multidisciplinary Approaches

Effective pain management in cancer surgeries requires teamwork across disciplines:

- Anaesthesiologists: Lead perioperative pain management, regional anaesthesia
- Surgeons: Minimize tissue trauma, collaborate on ERAS pathways
- Pain specialists: Manage complex and chronic pain cases
- Nurses: Assess pain, administer medication, and provide patient education.
- Physiotherapists: Promote early mobilization and functional recovery
- Psychologists: Address anxiety, depression, and pain catastrophizing.

Table 6. Roles of Multidisciplinary Team Members in Cancer Pain Management

Team Member	Key Contributions
Anaesthesiologist	Acute pain control, regional anaesthesia
Surgeon	Surgical planning, minimizing trauma
Pain specialist	Chronic/complex pain, opioid stewardship
Nurse	Assessment, medication administration
Physiotherapist	Rehabilitation, early mobilization
Psychologist	Psychological support, coping strategies

Regular multidisciplinary rounds, individualized care planning, and patient engagement are essential for optimal outcomes (22).

CHALLENGES AND FUTURE DIRECTIONS

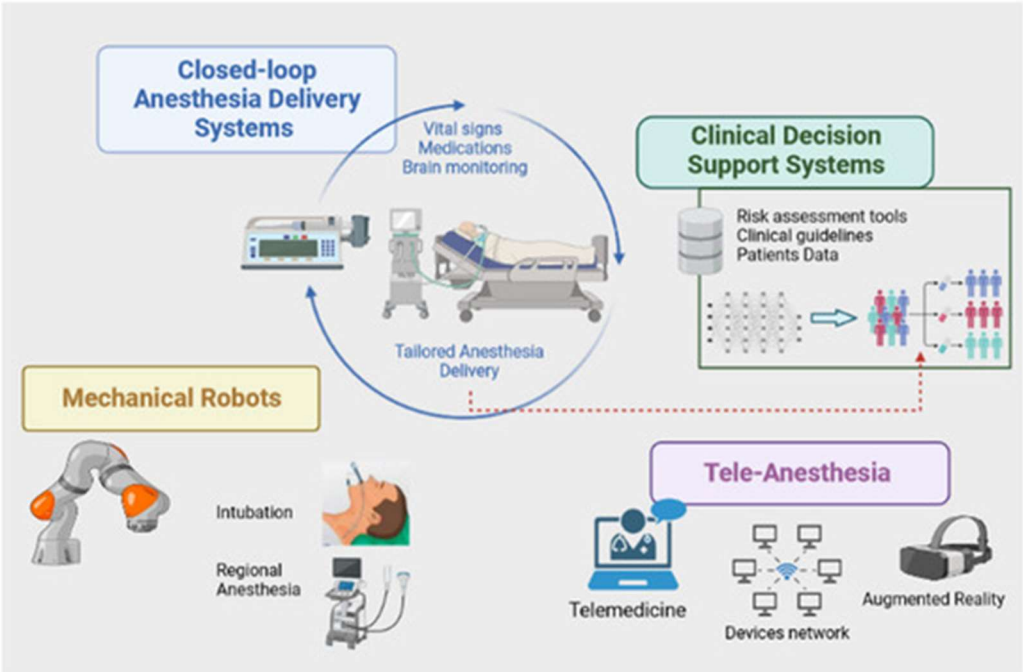
Current Challenges

- Resource limitations: Advanced regional and digital technologies may not be universally accessible.
- Variability in practice: Differences in pain management protocols and guideline implementation.
- Opioid stewardship: Balancing effective analgesia with avoidance of misuse or diversion.
- Equity and access: Addressing disparities in pain care for vulnerable populations.

Future Directions

- Artificial intelligence (AI): Predictive analytics for pain risk, personalized analgesic plans.
- Telemedicine expansion: Broader use in perioperative pain assessment and intervention.
- Novel analgesics and delivery systems: Development of long-acting local anaesthetics and, non-opioid agents.
- Patient engagement: Enhanced use of ePROs, shared decision-making, and education. (26)

Figure 6. Future Trends in Perioperative Pain Management (27)



Adapted from Cascella et al., 2023

AUTHOR CONTRIBUTIONS

Shaistha Banu: Conceptualization, literature search, writing draft, review, and editing
Jocelin Harriate D Almeida: Literature search, critical review, review, and editing

CONCLUSION

A paradigm shift in pain management after the cancer surgery has resulted from the advancements in technology, pharmacology, and anaesthetic techniques. Better results are seen when multimodal, opioid-sparing, and individualized approaches are added with multidisciplinary ERAS protocols. Future developments appear promising due to the continuous development of artificial intelligence, digital health, and minimally invasive anaesthetic techniques. Future progress will depend on high quality, cancer specific research, workforce training, and equitable access to advanced pain management strategies. Since the review was narrative in nature

ETHICAL CONSIDERATIONS

No animal subjects or human participants are involved in this review. Therefore, ethical approval or informed consent was not required.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING STATEMENT

All authors have declared that no financial support was received from any organization for the submitted work.

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FIGURE LEGENDS

Figure 1: Factors Contributing to Pain Burden in Cancer Surgery original figure created by authors

Surgical trauma, inflammatory mediator release, nerve injury, psychological stress, and patient related factors are the contributors to pain burden in patients undergoing cancer surgery.

Figure 2: An overview of the pain syndromes (acute and chronic) occurring after cancer surgery, with potential mechanisms- adapted from Brown and Farquhar-Smith et al., 2017

Description of post cancer surgery pain syndromes showing underlying mechanisms like central sensitization, neuropathic damage, nociceptive injury, and inflammatory processes

Figure 3: Algorithm for the diagnosis and treatment of neuropathic pain in cancer patients- adapted from Jakubow et al., 2020

An algorithm for diagnosis and management of neuropathic pain in cancer patients that focuses on early detection and multimodal pharmacological treatment.

Figure 4: ERAS Timeline for a Typical Cancer Surgery -adapted from Jain et al., 2023

For patients undergoing cancer surgery, ERAS protocol encourages perioperative multimodal analgesia, early movement, nutritional optimization, and pain evaluation.

Figure 5: Future Trends in Perioperative Pain Management- adapted from Cascella et al., 2023

Artificial intelligence, digital pain monitoring tools, and personalized analgesic approaches are the emerging technologies in controlling perioperative pain in patients undergoing cancer surgery.

CITE THIS MANUSCRIPT:

- **APA (7th edition):** Banu, S., & Almeida, J. H. D. (2026, February 20). *Pain management strategies in cancer surgery: Anaesthetic and technological innovations*. *The Operating Room Global Journal (TORGJ)*, 2(2). https://doi.org/10.64573/torgj2602001
- **Harvard**: Banu, S. and Almeida, J.H.D., 2026. *Pain management strategies in cancer surgery: Anaesthetic and technological innovations*. *The Operating Room Global Journal (TORGJ)*, 2(2). Published 20 February. Available at: https://doi.org/10.64573/torgj2602001
- **Vancouver**: Banu S, Almeida JHD. Pain management strategies in cancer surgery: Anaesthetic and technological innovations. *The Operating Room Global Journal (TORGJ).* 2026 Feb 20;2(2). https://doi.org/10.64573/torgj2602001
- **MLA (9th edition)**: Banu, Shaistha, and Jocelin Harriate D. Almeida. "Pain Management Strategies in Cancer Surgery: Anaesthetic and Technological Innovations." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 2, 20 Feb. 2026, https://doi.org/10.64573/torgj2602001
- **Chicago (Author-Date)**: Banu, Shaistha, and Jocelin Harriate D. Almeida. 2026. "Pain Management Strategies in Cancer Surgery: Anaesthetic and Technological Innovations." *The Operating Room Global Journal (TORGJ)* 2 (2), February 20. https://doi.org/10.64573/torgj2602001

Predictors of Keloid Recurrence Following Surgical Excision: Clinical, Surgical, and Molecular Determinants

Authors: Ishaan Bakshi[1*], Debshree Pattnaik[2], Parikshta Sookrah[3], Hriday Singh Rawat[1,4], Savant Choudhary[4]

[1]The Operating Room Global (TORG)
[2]Prasad Institute of Medical Sciences
[3]Elevé Aesthetic Clinic, Mauritius
[4]University of Technology, Mauritius
DOI: https://doi.org/10.64573/torgj2602004

***Corresponding Author:**
Dr. Ishaan Bakshi
ishaan_bakshi@yahoo.com
Declaration:
Authors' Contribution: Equal contributions
Conflict of Interest: No conflict of interest.
Funding: No funding received by the authors.

Article History:
Received: 22-02-2026
Accepted: 27-02-2026
Available Online: 28-02-2026

QR access this Article

ABSTRACT

Background: Keloids are benign fibroproliferative lesions resulting from abnormal wound healing. Unlike hypertrophic scars, they extend beyond the original injury and rarely regress without treatment. Surgical excision is commonly used for symptomatic or cosmetically unacceptable lesions; however, recurrence rates remain high (45–100%), necessitating structured perioperative strategies to reduce risk.

Objective: To synthesize current evidence on predictors of keloid recurrence after surgical excision and propose a risk-stratified framework for operative management.

Methods: A narrative review of contemporary literature examining clinical, surgical, and molecular predictors of recurrence was conducted.

Results: Younger age, darker Fitzpatrick phototype, family history, and prior recurrence increase risk. Lesion size, chronicity, and location in high-tension areas further contribute to recurrence. Surgical technique significantly influences long-term outcomes. Although persistent profibrotic signaling drives keloid formation, clinically applicable molecular predictive biomarkers remain underdeveloped.

Conclusion: Keloid recurrence reflects persistence of a pathological wound microenvironment rather than surgical failure alone. Effective management requires a multifaceted, risk-based approach with ongoing follow-up.

Keywords: *Keloid; Recurrence; Surgical Excision; Risk Factors; Wound Healing; Adjuvant Therapy*

The Operating Room Global Journal (TORGJ) Volume 2 Issue 1 Mar 2026

INTRODUCTION

The Keloids are a type of skin lesion that occurs when the skin does not heal correctly, resulting in a large build-up of collagen and other materials, stretching beyond the area of the wound site. Keloids are growing beyond the margins of the damaged skin area and do not appear to resolve spontaneously, which is different from hypertrophic scars that remain within the area of the wound and will tend to regress over time. The major clinical issues presented by keloids go beyond appearance alone. Patients are also subjected to multiple forms of distress, including itching, discomfort or pain, restricted functioning and/or significant psychological impact on their well-being.

From the surgical perspective, Keloids are one of the most difficult lesions to manage and surgically excising them removes the symptomatic burden for the patient (they relieve the symptoms associated with keloids such as itching and pain) and can provide better aesthetic outcomes for the patient than if they must continue to live with the keloid. However, many of these patients will continue to have trouble with keloids even after having their keloid excised. The estimated rates of

recurrence for keloid excision vary widely depending on the location of the keloid and the patient's individual characteristics; however, the overall findings are that excision on its own is insufficient in most instances. Furthermore, the likelihood of having a more aggressive lesion with a greater amount of collagen and resistance to previous methods of treatment increases for those patients who have had a recurrence following surgical excision.

Keloid recurrences occur due to a combination of factors, including surgical technique, inherent patient susceptibility, and mechanical forces on the wound site. Keloids are more commonly found on high-tension areas such as the chest above the sternum, shoulders, and upper back, indicating the importance of mechanical stress in keeping fibroblast activity going via mechanotransduction. Furthermore, there appears to be a genetic and immunological predisposition to keloid formation, suggested by the high level of familial clustering and increased incidence in patients with darker skin.
Molecular research has indicated that keloids tend to have continuing activation of abnormally profibrotic signalling (including TGF-β mediated pathways) as well as dysregulated immune systems and resistance to apoptosis. Even though this information is becoming clearer, it continues to be challenging to find a clinical way to implement this molecular finding into an actionable predictive tool, limiting the use of predictive biomarkers to make clinical decisions.

Along with high rates of recurrence (when excised alone) and lack of consensus on the best way to manage keloids, there is a need for a systematic approach to developing evidence-based clinical guidance. This narrative-based clinical practice review aims to create a risk-based framework for making perioperative decisions by integrating established clinical predictors, surgical determinants, and new findings from biology. The goal of the review is to help surgeons understand how surgical strategies can correlate with biological understanding, thereby allowing them to rationally approach preventing recurrence.

METHODS

The information in this Narrative Clinical Practice Review has been compiled to provide an overview of current research available on recurrence predictors related to keloid formation following a surgical excision procedure. This paper will integrate current clinical observations, surgical operating principles, and emerging biological knowledge to develop a framework that can be utilised for making perioperative decisions.

Peer reviewed literature describing operative management and postoperative outcome information was obtained using a structured review of numerous large databases to develop recurrence rate data, the specific techniques used for your surgical intervention, adjunctive therapies and translational biological reports. Most of the studies included would relate directly to clinical outcomes; however, a few have been included to provide an understanding as to how keloids recur and what are the mechanisms involved.

Since this is considered a Narrative Review, formal systematic review methodology was not utilised. Therefore, there were no established inclusion criteria or PRISMA flow diagrams or methodologies for assessing risk of bias based on quantitative data nor was there a grading system for evidence. Therefore, it should be noted that the interpretation of the evidence was descriptive rather than based on formal analysis of each study's design. Additionally, the heterogeneity of the reported recurrence rates and limitations of the existing studies should be noted; therefore, any conclusions drawn from this evidence were based on the best available evidence, and where there is limited high quality Randomised Controlled Trials; these conclusions should be drawn with significant caution in mind.

Artificial intelligence–based language tools were used solely to assist with grammatical refinement, structural organization, and clarity of expression. The authors had complete control over all literary analyses; clinical summaries, conceptual framework and scientific conclusions were independently generated by the authors. The authors take responsibility for the authenticity and accuracy of the final manuscript.
This review aims to define an evidence-based, risk-adaptable surgical management approach for patients with Recurrence. The review does not intend to pool recurrence rates for statistical purposes; its purpose is to translate current literature into a practical and clinically applicable manner.

PATHOPHYSIOLOGY OF KELOID FORMATION AND RECURRENCE

Keloids are the result of the dysfunction of normal wound healing processes. The process of normal tissue healing or repair consists of the three separate phases of healing: (1) Inflammation Phase (2) Proliferation Phase and (3) Remodelling Phase.

When an individual is susceptible to developing keloids, the normal healing process fails to complete all three phases of injury care, thereby leading keloid formation by continued fibroblast activation, excessive deposition of extracellular matrix, and ultimately the ongoing expansion of the keloid scar tissue beyond its normal boundaries.

Although keloid fibroblasts can proliferate at an increased rate than normal fibroblasts, they demonstrate resistance to programmed cell death (to apoptosis). They are responsible for producing an excess of type I and type III collagen, fibronectin, and proteoglycans, which contribute to the accelerated deposition of collagen and fibronectin in keloid tissues. Also, an increased imbalance exists between matrix metalloproteinases (enzymes that breakdown extracellular matrix) and their tissue inhibitors, thus leading to a failure to breakdown (degrade) the extracellular matrix and accumulation of dense and disorganized bundles of collagen within the keloid tissue. Additionally, myofibroblasts continue to survive in the keloid tissue and contribute to excessive pull, or "contracture," from the keloid tissue, due to their role as contractile cells within the tissue and ongoing extracellular matrix deposition.

The mechanisms that promote fibrosis are closely tied to how cells communicate via signaling pathways. Many of these pathways utilize a class of molecules called "transforming growth factor-betas" (TGF-beta). The TGF-beta class of molecules contains the two prototype isoforms known as TGF-b1 and TGF-b2, both are very powerful and play an important role in the signalling pathways for regulating the growth and differentiation of fibroblasts into myofibroblasts. Activation of the TGF-beta/Smad signaling pathway leads to the production of the extracellular matrix (ECM) and prevents normal ECM remodeling. A number of other pathways exist to provide additional protection to fibroblasts by promoting fibroblast survival and increasing their resistance to programmed cell death (apoptosis). In addition to the TGF-beta pathways that stimulate fibroblast activity, the JAK/STAT pathways, PI3K/Akt/mTOR pathways and MAPK pathways also stimulate fibroblast activity. Although these pathways have been well established and studied, they are not yet available for use in a clinical setting.

Fibroblast activity is also regulated by mechanical forces acting on cells. Fibroblasts respond to mechanical forces such as tension by activating intracellular signalling pathways, including the YAP/TAZ pathways and coordinating transcriptional profiles that enhance the expression of profibrotic genes. This leads us to the sites on the body where fibroblasts preferentially form keloid scars; high tension areas such as the presternal area of the chest, shoulders and upper back. Surgical excision of keloid scars can result in mechanical stress and additional tissue damage to the keloid scar; a surgical closure that is created under tension can result in re-activation of profibrotic pathways.

CLINICAL PREDICTORS OF RECURRENCE

It is possible to determine the presence of identifiable clinical factors that can identify the occurrence of keloids prior to surgery that might lead to their occurrence after surgery. Identifying identifiable factors when assessing patient's pre-operative will enable the physician(s) to effectively stratify patients and be able to tailor their peri-operative management according to their recurrence risk.

An individual's age is consistently associated with their propensity to experience a recurrence after surgical excision of keloids. Individuals less than 30 years old have a higher likelihood of recurrence than individuals 30 or older. This is likely because inflammatory responses are typically more robust, and fibroblasts have more ability to replicate themselves at younger ages. As a result, there is an increased chance of developing new collagen and a greater chance that a wound created by surgical intervention will continue to be fibrotically active for a longer period. Although age alone does not determine the outcome from surgery, it does serve as an important modifier of recurrence risk when added to other variables.

Phototype also has a significant impact on an individual's risk of experiencing recurrence following surgical excision of keloids. Individuals with darker Fitzpatrick phototypes are more likely to develop keloids for the first time and to have recurrence after surgical excision. The underlying biological mechanisms behind this have not yet been fully elucidated, but they likely involve differences in inflammatory signaling pathways, fibroblast biology, and cytokine expression. It should be noted that ethnicity does not solely account for biological susceptibility to have keloids; it is more accurately explained through the wound healing properties of the skin associated with the Fitzpatrick phototype than through demographic considerations.

The genetic factors that lead to a person being more likely to have recurrent keloids are a key factor in its recurrence. The fact that there is a familial clustering of keloids lends itself to the theory that a hereditary predisposition exists, which is

likely attributed to genetic factors that are involved in fibroblast function, turnover of the extracellular matrix, and modulation of inflammation. There are no genetic markers that have been established for clinical use at this time; however, a positive family history may be indicative of an increased biological risk of developing the disease. Patients with many relatives with keloids usually demonstrate aggressive patterns of recurrence.

The most powerful predictor of subsequent recurrence is a history of previous recurrence. Lesions that are recurrent will have more collagen, more fibroblasts, and less response to standard treatment than a primary lesion. This may mean that the recurrent keloid lesion expresses a more well-established profibrotic phenotype. Therefore, patients who have had lesions excised and then regrown should be classified as high risk and should be treated utilizing a multimodal approach.

The characteristics of a keloid lesion can also be important regarding the likelihood of recurrence. The anatomical location of the keloid lesion is particularly significant. Keloids in high-tension areas such as the presternal area of the chest, along the shoulders, on the upper back, or along the borders of the mandible demonstrate a much higher recurrence rate than a lesion located on the earlobe as it is in a low-tension area. The distribution of keloids in relation to tension illustrates the impact that mechanical stress can have on sustaining fibroblast activation through mechanisms of mechanotransduction. When planning for surgery on keloid lesions, consideration should be given to the mechanical environment surrounding the area of the lesion.

Lesion dimensions provide additional predictive value in terms of prognostic factors. The size of the scar correlates positively with both the number of fibroblasts and the amount of connective tissue that needs to be removed during the excision procedure. This means that larger scars cause larger excisions. The increase in the surface area of the wound may lead to greater amounts of inflammation and mechanical stress after surgery, increasing the chances of developing another keloid. Any lesions greater than five cm in the long axis should be viewed as being at higher risk to recur, particularly if they are located in a location that has mechanical stress on it.

The length of time the lesion has been present will influence predictive outcomes. Old and established keloids tend to possess a mature and stable fibrotic architecture, and their molecular dysregulation is often stable over time. In relation to kinesiology/exercise, chronic lesions may become less responsive to single treatment modalities and/or more likely to regrow after they have been excised because they represent a biologically stable fibrotic process.

Most of these clinical predictors will not be found alone - they usually work in a cumulative fashion and are universal in terms of how they represent multiple factors that will contribute to the risk of recurrence. For instance, a young male with an exaggerated lesion located on his presternal area, with dark skin (phototypes 4 to 6) and having previously experienced different size keloids, presents a much higher risk for re-growing than someone with a small first episode keloid on their top lobe. The ability to recognize how these clinical factors relate to each other provides the basis upon which to classify the overall risk of recurrence, and to potentially choose the most appropriate type of treatment for your surgical procedure and adjunctive therapy.

SURGICAL PREDICTORS AND TECHNIQUE CONSIDERATIONS

Surgical excision is a major way to treat symptomatic or cosmetically significant keloids. However, the recurrence rate after excision is directly impacted by the method used to perform the procedure and the mechanical environment surrounding the wound during recovery. Recurrence rates with excision alone are high because the surgical procedure removes the visible scar tissue but does not repair the underlying dysregulated wound healing process. As such, the surgical approach to keloids must be thought of as not just removing the lesion but also modifying the underlying environment so that it is no longer biologically susceptible to the formation of new lesions.

Treating keloids surgically with excision under mechanical tension during the closure of the wound is one of the most important modifiable risk factors influencing the likelihood of recurrence. Fibroblasts show a strong response to mechanical tension and the application of mechanical tension during closure of the wound allows the fibroblasts to "kick back in" and activate the mechano-transductory pathways of fibroblast phenotypic expression, which result in the stimulation of fibroblasts to produce collagen and provide a long-term means of sustaining fibrous tissue in the area of the surgical excision. The development of mechanical tension during surgery stimulates the production of collagen by fibroblasts and keeps fibroblasts alive, resulting in re-creating the environment under which the original lesion occurred. Thus, important components of the surgical approach to keloids are layering of closure, deep fascial suturing to support the closed wound,

adequate undermining before closure of the wound, and avoiding primary closure that is too tight. In addition, the need to eliminate mechanical tension when performing excisional surgery on keloids is critically important in high-tension anatomical regions such as the presternal chest and shoulders.

The length of excision is still a matter for medical professionals. Intralesional excision is where a narrow portion of the keloid will be left behind to help relieve tension on the edges of the wound and decrease the inflammatory response; while the goal of an extralesional excision, is to remove all of the visible pathologic appearance, however, some people have indicated that this can create increased mechanical pressure at the margin of the wound. Current available data does not favour one option over the other, stating that both regimens will have equal results; therefore, it is believed that the use of appropriate adjuncts and tension relieving techniques play a much greater role in determining the results of the surgery than the extent of the margin. Therefore, the decision on how much tissue to excise should be based on the anatomy of the lesion, size of the lesion and likelihood of recurrence.

Postoperatively how surgical specialists handle the tissue may have an impact on the level of inflammation that occurs following surgery. Any excessive manipulation, length of time performing the case and lack of adequate hemostasis may lead to an increase in the inflammatory response late after the surgery. There is limited direct comparative data to suggest that using gentler techniques and better surgical principles will provide a more positive outcome. Patients known to have a fibroproliferative genetic make-up, should use the principle of gentle handling and adhere to the sexual standards of surgery.

We must also consider the anatomical location of a lesion when considering surgical intervention. For example, a lesion that is dynamically moving or subject to forces over time has specific requirements when repairing the wound. Presternally and shoulder lesions are under constant tensile load as they are involved with respiration and the use of the upper extremity. In these instances, additional techniques may be necessary to redistribute tension to reduce the risk of recurrence.

Surgical management alone is insufficient; it is part of an overall strategy to prevent recurrence. The biomechanical environment created when closing the wound, in conjunction with an individual patient's biological predisposition, dictates whether a postoperative healing process will progress towards normal remodeling or re-activation of fibrotic pathways. The awareness of these factors reinforces the necessity of the planned integration of surgical technique with the postoperative adjuvant therapy for moderate and high-risk patients.

TREATMENT-RELATED PREDICTORS AND ADJUVANT THERAPIES

There are many factors that influence the recurrence of keloid scars following surgical excision, one of which is the use of adjuvant therapies. While surgical excision removes the established keloid scar volume, it does not directly suppress the biochemical signals that lead to increased fibroblast activity and inflammation, or the processes by which mechanical forces are able to cause collagen deposition (mechanotransduction). For those patients who have identifiable risk factors; combination therapy significantly increases the chances of long-term successful outcome when compared with excisional therapy alone.

Intralesional Corticosteroids

An adjunct therapy that is frequently used in the postoperative period is intralesional corticosteroids (ICS). Triamcinolone acetonide (TAC) is commonly used because it has been shown in some studies to inhibit fibroblast proliferation, decrease collagen production and suppress the production of inflammatory cytokines by fibroblasts. In addition, corticosteroids will enhance collagen degradation and may promote regression of fibrotic changes early in treatment. When administered in the early postoperative period and subsequently given multiple times, ICS therapy has been shown to decrease the rate of keloid scar recurrence compared with surgical excision alone. However, there are potential side effects associated with the use of ICS such as dermal atrophy, telangiectasia, and changes in pigmentation, especially in areas where cosmetic appearance may be an important issue. Nevertheless, ICS remains the first-line adjuvant therapy for keloid scars in patients at low to moderate risk for recurrence.

Antimetabolites

Antimetabolites (such as 5-fluorouracil) have shown further reduction of recurrence. In fibroblasts that rapidly proliferate, 5-fluorouracil induces cell death and affects fibrosis-related signaling pathways (e.g., by inhibiting TGF-beta signaling). Utilizing both steroids and 5-fluorouracil may improve therapeutic response while decreasing the total amount of steroid

needed to achieve a response, and this combination is especially key in the treatment of moderate or very aggressive lesions, as well as those with a previous recurrence.

Post Operative Radiation therapy

Administering postoperative radiation soon after surgical excision (typically one to four days) reduces recurrences, particularly among lesions in high-risk anatomic locations and those with a prior recurrence. Radiation therapy also slows down the proliferation of fibroblasts, inhibits blood vessel creation, and destroys the ability of actively replicating cells to replicate their genetic information. Early radiation appears to provide greater benefit than delayed radiation treatment. While newer radiation treatments are low-dose and reduce the risk of long-term complications, careful selection of patients, especially young patients where the theoretical carcinogenic risk is more significant, remains critical to safe and effective treatment.

Non-surgical treatment of keloids

Non-invasive techniques, such as silicone and pressure therapy, are considered useful adjunct methods for scar management. Their effects are thought to be related to increasing scar hydration; providing changes to oxygen tension; and changing how collagen fibers are organized. While they cannot be used alone to treat high-risk lesions, they fit into more comprehensive post-operative management programs, especially when combined with pharmaceuticals.

Lasers and other energy-based treatments for keloids

Laser-based treatments, such as pulsed dye and fractional ablative lasers, can help diminish blood flow into the scar tissue; increase flexibility of the scar tissue; and increase the ability of drugs injected into the scar to enter and distribute homogeneously throughout the tissue. While there are many opportunities for laser therapies, these therapies should typically not be used alone or as first-line treatment options due to their variable long-term effects with regards to recurrence, depending on the study.

Timing

Timing of adjunctive therapy has significant implications. Ideally, primary therapy (e.g., surgical excision) with adjuvant therapy should be initiated prior to observing clinical signs of regrowth and can disrupt the initiation of profibrotic signals. Delayed treatment or intervention may develop a new fibrotic microenvironment which will become progressively more difficult to treat with adjunctive therapies.

Multimodal Treatment Approach

Current literature supports the use of a multimodal treatment approach, where the intensity of adjunctive therapies is related to pre-operative recurrence risk. For instance, surgical excision alone is rarely adequate for patients with multiple pre-operative risk factors; therefore, the best approach to reduce recurrences is to incorporate a tension-reducing surgical technique; early pharmacological modulation; selective radiotherapy for high-risk patients; and appropriate monitoring.

RISK STRATIFICATION FRAMEWORK AND CLINICAL MANAGEMENT MODEL

To effectively prevent keloids from returning, it is best to start with a structured preoperative assessment of the patient's likelihood of recurrence. The likelihood of keloid recurrence cannot be established by one specific factor, but by the summation of the interaction of a few patient-specific variables that include: biological predisposition, characteristics of the lesion, anatomical biomechanics and operative factors. Thus, the creation of a clinical framework would require the integration of the above-mentioned factors to form a clear strategy for how one will manage the risk of keloid recurrence.

This paper will develop a model that synthesizes the most common clinical predictors of recurrence and will serve as an example of a structured framework for predicting recurrence risk and how it may influence perioperative decision making. It should be noted that this model is a conceptual model and will not have been prospectively validated.

Table 1. Proposed Clinical Risk Stratification Model for Keloid Recurrence

Risk Factor	Clinical Feature	Assigned Weight
Age	Younger than 30 years	1
Fitzpatrick phototype	Type III–VI	1

Risk Factor	Clinical Feature	Assigned Weight
Family history	Positive	1
Prior recurrence	Present	2
Anatomical site	Presternal, shoulder, upper back	2
Lesion size	Greater than 5 cm	1
Multiple lesions	Present	1

METHODOLOGICAL RATIONALE FOR WEIGHT ALLOCATION

Here's the proposal weighting system uses a structured synthesis of three areas to determine the weight they presume (the association of predictors). The three areas include (1) consistency of the published cohort and observational studies to demonstrate that the predictor is an associated with recurrence; (2) trends in recurrence risk magnitude; and (3) biological plausibility based on the mechanistic understanding of fibroproliferative activity. No quantitative meta-analysis was conducted in this review; therefore, weights are not derived from pooled statistical modeling, but from the officer's integration of the qualitative evidence.

Predictors that are assigned a weight of 2 (e.g., prior recurrence and high-tension) were selected because they have consistently been identified in the clinical literature as strong recurrence predictors and have a clear biological basis for recurrence. Prior recurrence indicates a biologically based, positively profibrotic, phenotype (characterized by increased collagen deposition, increased apoptosis resistance, and increased epigenetic persistence). Additionally, high-tension areas (presternal chest, shoulders and upper back) have shown not only higher rates of recurrence as observed in surgical outcomes but also have clearly demonstrated mechanotransduction (fibroblast activation via applied mechanical tension), warranting the assignment of a higher weight on the basis of biological plausibility.

Predictors assigned a weight of 1 (age <30 years, Fitzpatrick skin type III - VI, positive family history, lesion size >5 cm, multiplicity) provide statistically reproducible but lower than average evidence of association for recurrence. Predictors assigned a weight of one have an impact on biological and wound healing. However, when comparing the magnitude of independent associated recurrence for each of these predictors is lower or more imprecise when compared to that of prior recurrence or high-tension anatomical predictors.

As such, the weights reflect the strength of association trends and mechanistic backing rather than statistical models. The score is designed to offer structured clinical guidance, not to serve as a validated predictive tool. Prior to employing this in a clinical setting, it will require prospective validation studies.

Table 2. Justification Framework for Risk Weight Assignment

Predictor	Evidence Consistency Across Cohorts	Biological/Clinical Rationale	Assigned Weight Justification
Prior recurrence	Consistently strongest predictor in observational studies	Established profibrotic phenotype, apoptosis resistance	Strong magnitude + mechanistic support → Weight 2
High-tension anatomical site	Frequently associated with higher recurrence rates	Mechanotransduction (YAP/TAZ activation) sustains fibroblast activity	Strong clinical + biological link → Weight 2
Age <30 years	Moderate association	Robust inflammatory response and fibroblast proliferation	Moderate association → Weight 1
Fitzpatrick III–VI	Increased susceptibility, variable recurrence magnitude	Cytokine profile and fibroblast biology differences	Moderate biological predisposition → Weight 1

Predictor	Evidence Consistency Across Cohorts	Biological/Clinical Rationale	Assigned Weight Justification
Family history	Familial clustering observed	Genetic predisposition affecting ECM regulation	Susceptibility factor → Weight 1
Lesion size >5 cm	Larger excision surface, greater inflammation	Increased fibroblast burden and wound stress	Moderate magnitude effect → Weight 1
Multiple lesions	Associated with aggressive phenotype	Suggests systemic fibroproliferative tendency	Risk modifier → Weight 1

Total cumulative scores will have the following interpretations: A score of 0 to 2 indicates low risk; a score of 3 to 4 means moderate risk; a score of 5 to 6 represents high risk; and a score of 7 or more indicates very high risk for recurrence after excision. Small primary lesions in areas of low-tension anatomy (not including family history or prior recurrences) typically represent low risk status. For these patients, early excision and intralesional corticosteroid injection, along with routine post-operative surveillance, may suffice for treatment.

Generally, patients in the moderate-risk category will have evidence of modifying factors (example: younger patient, darker phototype, larger lesion size) in addition to location of the lesion being in areas of mechanical stress. For these patients, excision should be performed with the goal of minimizing tension and early initiation of adjuvant pharmacological therapy.

Patients at high risk of recurrence typically have a set of cumulative predictor variables including prior recurrence, size of lesion, family history, and anatomical location that involves high tension. These patients require more than just excision as their surgical management; a surgical plan that attempts to minimize the tension during the closure is essential. Depending upon the benefit and risk of early postoperative radiation therapy, a decision about use could be made. The administration of serial intralesional pharmacotherapy should be considered for high-risk patients as a proactive rather than reactive treatment.

Very high-risk patients are particularly difficult to manage as a result of recurrent lesions that have returned multiple times or lesions that regrow rapidly. Therefore, a comprehensive multimodal approach to the treatment plan should be utilized to modulate the wound microenvironment during its early remodeling phase. Patients who fall into the very high-risk category should have close monitoring for one year after their surgery.
The importance of structured postoperative follow-up for all patients cannot be overstated; the presence of early clinical signs (e.g., itchiness, localized firmness, redness, progressive thickening of the incision) may signal the reactivation of fibroproliferative pathways. If possible, initiation or intensification of intralesional therapy should take place at the earliest signs of recurrence in order to prevent developing established recurrences.
This risk-adapted approach to surgical management turns biological scientific knowledge into the surgical management of high-risk patients. Although no formal validation studies exist to date for this approach, structured preoperative cumulative risk factor assessments provide a rationale and clinical foundation for reducing recurrence rates.

Stepwise Risk-Adapted Clinical Decision Algorithm
The structured risk stratification model has been converted into a reproducible clinical practice through a stepwise decision pathway. Each element of the algorithm, from cumulative risk score to operative plan, adjuvant therapy selection, timing of interventions and follow-up escalation, are linked together.

Step 1: Preoperative Risk Assessment
The first step is to complete a cumulative risk score for all patients being considered for surgical excision, prior to surgery, using the structured risk framework outlined in Table 1. The risk score categories are defined as follows:

0-2 = Low risk
3-4 = Moderate risk
5-6 = High risk
≥7 = Very High risk
The pre-operative assessment of the patient's cumulative risk will assist in the operative plan.

Step 2: Treatment Selection According to Risk Category

The second step is to select a treatment based on the risk category of the patient.

Low Risk (Score 0–2):

For a patient classified as a low risk (0-2), the following treatment options should be selected:

- Surgical excision with careful, layered closure to reduce tension.
- Postoperative silicone or pressure therapy.
- If symptoms indicative of early inflammation are noted during the postoperative period, consider an early intralesional corticosteroid injection.

Moderate Risk (Score 3–4):

For a patient classified as moderate risk (3-4), the following treatment options should be selected:

- Surgical excision using an aggressive technique to minimize tension (deep fascial sutures, maximally undermined).
- Initiate serial intralesional corticosteroid injections within 2-3 weeks postoperatively.
- Silicone therapy during the remodeling phase.

High Risk (Score 5–6):

For a patient classified as a high risk (5-6), the following treatment options should be selected:

- Surgical excision that reduces tension.
- Pharmacological manipulation of surgery (corticosteroids intralesionally (though can use 5-FU intralesionally)) early on after surgery.
- Radiotherapy was considered postoperative (within 24–72 hrs) if done in regions of high anatomy tension or in patients that have previously had a recurrence.
- Routine follow-up appointments were scheduled every 4 to 6 weeks for the initial 6 months.
- All treatments should be done as part of a single treatment program.

Very High Risk (Score ≥7):

For a patient classified as a Very High Risk (Score ≥7), the following treatment options should be selected:

- Multimodal strategy planned preoperatively
- Surgical excision with maximal biomechanical optimization
- Early postoperative radiotherapy (ideally within 24–72 hours) unless contraindicated
- Scheduled serial intralesional pharmacotherapy beginning in early remodeling phase
- Close monitoring at 4-week intervals for first 12 months

Step 3: Timing of Adjunctive Therapy

It is important to begin adjunctive therapies prior to their necessity as opposed to afterwards.

Radiation therapy has a more significant response when given within the early proliferative phase (generally 1-4 days after excision). Intralesional corticosteroids should be used once the epithelialization has occurred, but prior to the appearance of clinical recurrence (usually within 2-3 weeks). If there is a visible recurrence before treatment, the effectiveness of treatment may be compromised due to the formation of a new fibrotic microenvironment.

Step 4: Follow up and criteria for escalation

A structured follow-up will be required for all patients for a minimum of twelve months following surgery. Signs to look for when determining if a recurrence will occur include:

- Persistent itching
- Localised hardened area (induration)
- Erythema beyond incision borders
- Progressive thickening of scar

If any of these signs are present early on in the evaluation, intralesional therapy or another type of pharmacologic intervention should be added or the response escalated, regardless of whether a clear clinical recurrence has occurred.

MOLECULAR DETERMINANTS OF RECURRENCE AND THEIR CLINICAL IMPLICATIONS

Molecular biology advances reveal that keloids can recur due to the ongoing stimulation of a malfunctioning microenvironment; they are not just due to a missed technical failure during the surgical excision process. Multiple factors such as continuous stimulation of fibroblasts (connective tissue cells), inability of cells to undergo programmed cell death (apoptosis), changes to immune-mediated signaling pathways, and issues with mechanotransduction work together to produce a fibrotic expansion. Although there are no molecular markers available for clinical use presently, understanding the mechanisms involved provides biologic rationale for the management process described in this review.

Biological Rationale for Tension-Reducing Surgical Closure

There is a marked responsiveness of fibroblasts to mechanical stimuli. The mechanical tension created in the surgical closure will activate various intracellular pathways such as the YAP and TAZ signaling pathways and associated transcriptional programs that ultimately will result in increased collagen production and extracellular matrix deposition. Fibroblasts remain activated in high-tension parts of the body because they are exposed to constant mechanical loading even after surgical excision.

The biologic mechanisms described above provide specific biologic rationale for employing carefully executed tension-reducing techniques in surgical repairs. For example, performing a layered closure (closure of skin), deep fascial support, adequate undermining, and avoiding excessive tension during primary closure are not only technical refinements; they are also biologically justified attempts to minimize the reactivation of profibrogenic signaling pathways due to mechanotransduction.

Mechanistic Basis for Early Postoperative Radiotherapy

The proliferative phase of wound healing is dependent upon the proliferation of fibroblasts and deposition of new extracellular matrix. The primary mechanism that contributes to the antifibrotic effect of radiation therapy is the inhibition of the proliferation of fibroblasts in the actively dividing state, as well as inducing apoptosis in those cells that are cycling rapidly.

Delivering radiotherapy within the early postoperative period (generally 24 to 72 hours) is designed to affect fibroblasts in their most vulnerable, rapidly dividing state. By delaying the delivery of radiation, a stable fibroproliferative microenvironment can develop, so that the fibroblasts have decreased response to interventions. Therefore, the biological basis for the recommended timing of this algorithm is established based on the dynamics of wound healing.

Molecular Basis for Aggressive Behavior in Recurrent Lesions

The recurrent keloids generally consist of high levels of collagen, resistance to apoptosis, and have persistent activation of profibrotic pathways such as TGF-β/Smad, JAK/STAT, and PI3K/Akt/mTOR. Epigenetic modifications such as modification to DNA methylation and histone acetylation patterns contribute to a sustained “fibrotic memory” that may explain the aggressive behavior of the recurrent lesions in comparison to primary lesions.

This molecular profile is a justification for multimodal therapy for the patient who has experienced a prior recurrence. The recurrent lesion represents biologically established fibroproliferative states and therefore surgical excision is not justifiable, but early pharmacologic modulation and selective radiation are biologically justifiable.

Translational Limitations and Future Integration

There are advancements in genomic profiling, transcriptomics, and the identification of single nucleotide polymorphisms related to fibroproliferative susceptibility; however, there currently is no molecular biomarker that has clinical validation for everyday use in perioperative decision-making. While several machine learning models combining molecular and clinical predictors have been developed and/or are in development, these models are still in the early stages of validation and demonstration of additional clinical benefit before they can be implemented.

Currently, robust and structured clinical assessment of risk remains the most actionable basis for recurrence prevention, while molecular knowledge provides biological justification for surgical and adjuvant treatment strategies.

CHALLENGES AND CONTROVERSIES

Despite a growing knowledge of keloid behavior and patterns of recurrence, a variety of both methodological and clinical challenges limit the implementation of standardized management protocols. One of the most significant problems with the current literature is that there is marked heterogeneity among the currently published studies. Variability of reported rates of recurrence are attributable to differences in patient populations, differing anatomical locations, differing techniques used for surgical excision, differing types of adjuvant treatment used and different lengths of follow-up in the studies being published. Additionally, the various definitions of recurrence (e.g. whether the keloid has visibly extended beyond the incision margin, recurrence based on symptoms, need for re-excision, etc.) present additional variables making comparisons between studies difficult and impede the development of global treatment algorithms.

Even if all of the studies above used standardized measures, interpretation of the overall quality of evidence still presents barriers for the clinician. Currently, almost all available literature consists of retrospective cohort studies and either small single-institution or small, multi-institutional prospective studies. There are very few randomized controlled trials that have compared various multimodal strategies. Reasons for the lack of high-quality comparative data include ethical issues, precision in patient selection for long follow-up and difficulty in standardizing procedures across the differences in anatomical sites where patients have keloids. Therefore, many of the recommendations made by individual providers rely on the aggregate experience of that provider and the judgement of expert opinion, rather than based on a pre-determined level of evidence.

There is disagreement among professionals about the best way to do surgeries and use medicine after surgery. There are two different philosophies on how to do surgery (take out the tumor entirely or remove as much as possible) as well as how to give radiation (over what period of time/how many times) and how often to give medications after surgery. Because there is inconsistency in the way institutions run their practices, doctors may have different experiences when treating patients and determining if the patient recurs.

Caution is necessary when evaluating research studies that involve molecular biology. Although there are many possible targets for therapy in the future, few clinical applications have come from this research to date. There is a danger in applying scientific results to clinical settings prematurely because the evidence is limited. If molecular markers are going to be incorporated into surgical decision-making processes, they will need to be validated and shown to provide additional predictive information compared to clinical parameters.

The possible effects of using radiation therapy after surgery is ethically debatable, particularly for patients who are younger. Although recent low-dose radiation usage has improved safety compared to previous types of radiation, there is a concern for long-term cancer risk with use of radiation. When making the decision about whether or not to use radiation after surgery, the patient should have an open dialogue with their provider about these possible risks and consider the risks/benefits for the individual patient.

The debate continues on how we define recurrence in soft tissue reconstruction surgery and its causes; incomplete excision is one possible cause for recurrence according to some authors while intrinsic biology and the mechanical environment may be more significant causes according to other authors. Most studies to date support the hypothesis that recurrence results from the reactivation of a dysregulated wound-healing microenvironment (as opposed to being the result of purely technical surgical failure).

The challenges posed by these differing views will require standardized definitions, multicenter, prospective trials with long-term follow-up, and the incorporation of translational research into the development of clinical protocols. Until such time, the most reasonable management plan would be a multimodal risk-adapted approach; based on the currently available cumulative clinical evidence.

FUTURE DIRECTIONS

Antifibrotic Therapy Targeted to Specific Pathways

Recent advancements in research concerning molecular devices have led to the identification of numerous different signalling mechanisms that are responsible for maintaining fibroblast activation for long periods of time, including the TGF-beta/Smad pathway, JAK/STAT signalling pathway, and PI3K/Akt/mTOR signalling pathway. Therapies being developed

in the future will most likely include the selective inhibition of these pathways or pathways to prevent collagen overproduction at its source. Initial studies on modulating TGF-beta receptor activity, inhibiting lysyl oxidase to limit cross-linking of collagen, and selectively inhibiting signalling pathways found potential. These areas, however, remain experimental and need to be verified in a clinical setting before being considered for routine clinical use in surgical settings.

Modulating Epigenetic Changes & RNA-Based Targeting of Fibrosis

Recent evidence suggests that the persistence of the profibrotic cellular phenotype resulting from epigenetic changes plays a significant role in the development of new lesions after previous lesions have healed. Modulating DNA methylation, histone acetylation, or the expression of non-coding RNAs may be a possible way to reverse the fibrotic memory left after lesion healing. Current research is being conducted to determine if RNA interference can be used to inhibit the expression of specific profibrotic genes. These methods currently remain in preclinical studies and have not yet proven to be clinically safe or efficacious through large clinical studies.

Optimization of Multimodal Protocols

In the short term, refining the use of multimodal clinical protocols may have the greatest impact on the provision of novel molecular therapies. Future research should include examining the standardization of postoperative radiotherapy timing, optimizing pharmaceutical regimens for intralesional treatments, and identifying the ideal frequency of surveillance. Evidence-based recommendations for the use of tension-reducing surgical techniques in conjunction with structured adjuvant therapies could be strengthened through comparative, prospective studies. The development of consensus-driven perioperative pathways may provide for the improved reproducibility of clinical pathways among institutions.

Predictive Modeling and Personalized Risk Assessment

Combining clinical variables and biological markers into predictive models represents an important area of future investigation. Recent exploratory studies utilizing machine-learning approaches have assessed the ability of combined data sets to predict the likelihood of recurrence. While initial results are encouraging, these models will require further validation using an external database, transparent methodology, and validated clinical utility prior to being introduced into practice. Future predictive models will require that they demonstrate improved patient outcomes above and beyond what has been achieved through the use of structured clinical risk assessment methods.

Translational Integration into Surgical Practice

As we move forward, an important challenge will be to help bridge the gap between biological discovery and operative application. The goal of translational research should be to develop and validate biological markers that can significantly influence perioperative decision-making. Prospective studies to link molecular characteristics with standardized recurrence outcomes will help to identify which biological markers have true predictive power. Until then, clinical management will continue to depend primarily on the use of structured clinical assessment of known risk factors.

CLINICAL IMPLICATIONS

The identification of predictors of recurrence should change the way that surgeons approach keloid management. The high recurrence rates seen after only excision demonstrate that surgical intervention will not be able to eliminate a keloid in most patients. As such, the planning of the surgical procedure must consider biological and mechanical risks in addition to just the excision.

The evaluation of patients preoperatively should include their age, skin type, family history, history of previous recurrences, size of lesion, and location of lesion. If the patient has multiple risk factors, they should be counseled about their increased chance of recurrence and the potential need for additional treatment options. The importance of shared decision-making is greatest when deciding whether to proceed with radiation therapy or repeat injections into the lesion.

The surgical approach should be adjusted according to the recurrence risk. In areas where there is high tension on the closure, a careful layered closure and strategies to reduce the tension and stress from the closure are necessary. The setting of the closure and stress from the closure may determine if the healing process following the operation will progress towards normal healing or reactivate the fibroblastic pathways. Therefore, caring for the tissue and minimizing tension is not just a technical refinement but also has a biological rationale.

In moderate to high-risk patients, the adoption of proactive treatment versus reactive treatment of adjuvant therapy is critical. Within this context, the early use of intralesional corticosteroids, the use of combinations of different medications

when appropriate and the strategically selective use of postoperative radiation may provide a therapeutic method to halt or limit fibroblast activity prior to the recognition of clinical recurrence. The act of waiting to observe a recurrence may lead to the establishment of a new fibrotic microenvironment that would establish an increased level of resistance to treatment.

The need for structured postoperative monitoring is equally critical. The period of wound healing through the remodeling phase is a period of vulnerability to the establishment of clinically reoccurring events, which may generally be identified as evidence of symptom manifestations such as itching, thickening of skin, and redness. Prompt detection of potential symptoms allows for timely therapeutic intervention. Structured postoperative follow-up visits (for at least the first year following surgery) allow for the assessment of early clinical recurrence and the initiation of treatment prior to the establishment of growth in the lesion.

The recent evolution of molecular insight into recurrence has allowed for better insight into the mechanisms of recurrence; however, molecular insights have not replaced the need for the use of clinical judgment when determining new and/or the prevention of recurrence. There are currently no validly validated biomarkers available for the prevention of recurrence; hence, the basis for the prevention of recurrence must be the application of structured clinical evaluations in conjunction with disciplined multimodal treatment. Integrating risk stratification into routine surgical practice is a concrete first step toward reducing recurrence and improving long-term functional and aesthetic outcomes.

EVIDENCE STRENGTH CLASSIFICATION OF KEY RECOMMENDATIONS

The classifications of key recommendations made for clinical practice reflect the strength of evidence that supports them in order to provide transparency and clarify the differential level of support provided by the various proposed management strategies. Since this review is a narrative procedure and there is no formal grading of evidence, the classifications reflect the type and consistency with which the literature has demonstrated support for each recommendation (i.e., randomized controlled trials, systematic reviews, cohort studies or expert opinions).

Table 3. Evidence Classification of Major Clinical Recommendations

Clinical Recommendation	Evidence Level	Basis of Classification
Surgical excision alone is associated with high recurrence rates	High-quality evidence	Multiple cohort studies and systematic reviews consistently reporting high recurrence rates
Tension-reducing layered closure is recommended	Moderate evidence	Strong biological rationale + consistent observational surgical data
Intralesional corticosteroids as first-line adjuvant therapy	Moderate-quality evidence	Systematic reviews and small randomized trials
Combination therapy (corticosteroids + 5-FU) for aggressive lesions	Moderate evidence	Randomized controlled trials and meta-analyses
Early postoperative radiotherapy reduces recurrence	Moderate evidence	Systematic reviews and long-term institutional series
Silicone and pressure therapy as adjunctive measures	Low-to-moderate evidence	Heterogeneous studies with variable long-term outcomes
Multimodal therapy for high-risk patients	Consensus-based recommendation supported by moderate evidence	Integrated interpretation of recurrence data and biological rationale
Molecular biomarkers for recurrence prediction	Experimental evidence	Translational research without validated clinical application

EVIDENCE LEVEL DEFINITIONS

High Level Evidence: Multiple cohort studies, systematic reviews, or meta-analyses demonstrate consistent results across many sites.
Medium Level Evidence: Results are supported by small, randomised trials (where carried out), other well-designed observational studies, or strong biological plausibility.
Low Level Evidence: Limited or heterogeneous clinical data available.
Consensus Recommendation: Evidence took into account an assessment of the best available evidence and expert interpretation based on low quality study design rather than high-quality but not yet existing trial.
Experimental Evidence: Preclinical or Translational work (within the confinement of experimental environments) that currently has no clinical validation.

CONCLUSION

Keloids can be difficult to manage because of their tendency to return after being removed surgically. Researchers have found that the re-occurrence of keloids is not simply due to a surgeon's poor technique but may also be due in part to a patient having a biological disposition towards forming keloids, as well as the way surgery is performed, the type of care a patient receives after surgery, the characteristics of the keloid and anatomical tension available on the keloid. Therefore, an individual's vulnerability, the characteristics of the keloid itself, anatomical tension, and the way in which the individual is managed peri-operatively all contribute to the ultimate outcome.

Excision of a keloid will result in a high instance (by most standards) that the keloid will return, therefore an individualized, structured, risk assessment-based, multimodal approach to keloid management is essential to provide positive outcomes. Tension-reducing surgical technique, additional pharmacologic manipulations early on in the post-operative process, selective use of radiotherapy in appropriate cases and planned continual post-operative follow up are all recommended components of a rational approach to keloid recurrence prevention.

Recent advances in molecular/genomic research have improved our understanding of the regulatory pathways of fibroblast proliferation; however, these pathways remain largely investigational for the time being and not ready for routine application in the peri-operative area. Future development of improved keloid management techniques will depend upon the creation and validation of risk-adapted treatment algorithms and standardization of keloid treatment protocols, and the accurate incorporation of recently developed biological markers into the standard of care for patients with keloids.

Moving away from a standard treatment approach towards an individual risk-based approach is the likely best means to obtain long-lasting control of keloids. By using biological knowledge about keloids and applying good surgical technique along with planned post-operative follow up for patients who develop keloids, surgeons will likely be able to reduce significantly recurrence rates and therefore significantly improve patient's long-term functional and cosmetic results

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING STATEMENT

All authors have declared that no financial support was received from any organization for the submitted work.

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CITE THIS ARTICLE

- **APA (7th edition):** Bakshi, I., Pattnaik, D., Sookrah, P., Rawat, H. S., & Choudhary, S. (2026, February 28). *Predictors of keloid recurrence following surgical excision: Clinical, surgical, and molecular determinants*. *The Operating Room Global Journal (TORGJ)*, 2(1). https://doi.org/10.64573/torgj2602004
- **Harvard**: Bakshi, I., Pattnaik, D., Sookrah, P., Rawat, H.S. and Choudhary, S., 2026. *Predictors of keloid recurrence following surgical excision: Clinical, surgical, and molecular determinants*. *The Operating Room Global Journal (TORGJ)*, 2(1). Published 28 February. Available at: https://doi.org/10.64573/torgj2602004
- **Vancouver**: Bakshi I, Pattnaik D, Sookrah P, Rawat HS, Choudhary S. Predictors of keloid recurrence following surgical excision: Clinical, surgical, and molecular determinants. *The Operating Room Global Journal (TORGJ).* 2026 Feb 28;2(1). https://doi.org/10.64573/torgj2602004
- **MLA (9th edition)**: Bakshi, Ishaan, et al. "Predictors of Keloid Recurrence Following Surgical Excision: Clinical, Surgical, and Molecular Determinants." *The Operating Room Global Journal (TORGJ)*, vol. 2, no. 1, 28 Feb. 2026, https://doi.org/10.64573/torgj2602004
- **Chicago (Author-Date)**: Bakshi, Ishaan, Debshree Pattnaik, Parikshta Sookrah, Hriday Singh Rawat, and Savant Choudhary. 2026. "Predictors of Keloid Recurrence Following Surgical Excision: Clinical, Surgical, and Molecular Determinants." *The Operating Room Global Journal (TORGJ)* 2 (1), February 28. https://doi.org/10.64573/torgj2602004

Impact of Perioperative Nursing Assessment Round on Anxiety and Complications of Elective Surgeries: A Quasi-Experimental Study at a Teaching Hospital in Nigeria

Authors: Ahmed Orelope Ibrahim[1,2*], Emmanuel E. Anyebe[3], Abdur-Rahman Olajide Lukman[4], Ibrahim Opeyemi Abdulmumeen[5], Silas Kolo[6], Bukola Mary Fatukasi[7], Yetunde Elizabeth Adeniyi[8], Lateefat Ahmed[9], Mufutau Dayo Ganiyu[10]

[1] *Main Operating Theatre, Department of Nursing Sciences, University of Ilorin Teaching Hospital, Ilorin, Nigeria.*

[2] *The Operating Room Global (TORG)*

[3] *Department of Nursing Sciences, Faculty of Clinical Sciences, University of Ilorin, Nigeria*

[4] *Department of Surgery, Pediatric Surgery, University of Ilorin Teaching Hospital, Ilorin, Nigeria.*

[5] *Department of Medical Surgical Nursing, Faculty of Nursing Sciences, College of Health Sciences, Al-Hikmah University, Ilorin, Nigeria.*

[6] *Main Operating Theatre, Department of Nursing Sciences, Federal Medical Centre, Bida, Niger State, Nigeria*

[7] *Department of Basic Nursing, College of Nursing Sciences, University of Ilorin Teaching Hospital, Ilorin*

[8] *College of Nursing Sciences, Accident and Emergency Nursing Programme, University of Ilorin Teaching Hospital*

[9] *Department of Post Basic Paediatric Nursing Programme, College of Nursing Sciences, University of Ilorin Teaching Hospital, Ilorin, Nigeria.*

[10] Department of Nursing Sciences, Faculty of Clinical Sciences, University of Ilorin, Nigeria.

DOI: https://doi.org/10.64573/torgj2602003

The Operating Room Global Journal (TORGJ) Volume 2 Issue 1 Mar 2026

***Corresponding Author:**
Ahmed Orelope Ibrahim
ibolamuma2@gmail.com

Declaration:
Authors' Contribution: Equal contributions
Conflict of Interest: No conflict of interest.
Funding: No funding received by the authors.

Article History:
Received: 01-02-2026
Accepted: 22-02-2026
Available Online: 01-03-2026
QR access this Article

ABSTRACT

Background: A surgical patient is a person who receives medical treatment that involves operating procedures to treat, diagnose, or manage a condition.

Objective: This study examined the impact of perioperative nursing assessment rounds on anxiety levels and postoperative outcomes among patients undergoing elective surgeries at Kwara State University Teaching Hospital, Nigeria. The study assessed preoperative anxiety, postoperative anxiety, and postoperative complications in treatment and control groups.

Methods: A quasi-experimental design was adopted involving 92 adult patients scheduled for elective surgeries, equally divided into treatment and control groups. Data were collected using a structured questionnaire assessing demographic characteristics, anxiety levels, pain experience, and satisfaction with preoperative education. Data were analyzed using SPSS version 27 with descriptive and inferential statistics at a significance level of $p < 0.05$.

Results: Most participants were female (68.5%) with tertiary education (47.8%), and 63% reported high preoperative anxiety. The treatment group showed a significant reduction in anxiety (4.28 to 3.54; $p < 0.001$), lower postoperative anxiety than controls (mean difference = 1.09; $p < 0.05$), declining pain from Day 1 to Days 12–15, and reduced later pain associated with higher satisfaction with preoperative education.

Conclusion: The study concludes that perioperative nursing assessment rounds effectively reduce anxiety and enhance postoperative recovery, highlighting the need for improved nurse-led patient education and anxiety management.

Keywords: *Anxiety; Preoperative Anxiety; Postoperative Anxiety; Perioperative Nursing; Assessment Round; Elective Surgeries; Postoperative Complications; Pain Levels.*

INTRODUCTION

A surgical patient is a person who receives medical treatment that involves operating procedures to treat, diagnose, or manage a condition. Surgical patients may vary widely in terms of age, health, and the sort of operation they are undergoing. Preoperative care, which involves thorough assessments and may help reduce risks and consequences, plays a major role in determining whether a patient is suitable for surgery [1]. There are many categories into which operations may be categorized according to their objective, difficulty, and urgency. They may range from small procedures to major surgeries, and each one requires different levels of preoperative and postoperative care. Infection, hemorrhage, anesthetic complications, and postoperative complications including pneumonia, thromboembolic events, and wound healing issues are common risks connected to surgical treatments [1]. Instead of being performed in an emergency, elective operations are ones that are planned.

Often non-urgent, these treatments are performed to improve quality of life or to address non-life-threatening conditions, such as joint replacements, cataract removal, or cosmetic surgeries. Because elective treatments provide patients the opportunity to be well prepared by preoperative examinations and educational activities, better outcomes are likely [2]. Because of the uncertainties and potential risks involved, elective operations sometimes lead patients to feel very anxious even if they are planned. Preoperative anxiety has often been associated with poor outcomes, including greater postoperative pain, a slower recovery, and a higher risk of complications including infection, wound dehiscence, and cardiovascular events [3]. Untreated anxiety may also make it more difficult for the patient to comprehend and comply with postoperative treatment, which would make recovery even more difficult [4].

Preoperative anxiety and postoperative problems have been extensively researched worldwide. According to research, people who are having elective procedures often have elevated anxiety, especially when it comes to worries about anesthesia, pain, and surgical risks. Nearly 40% of patients, according to U.S. research, suffer from moderate to severe anxiety prior to surgery. This is associated with negative postoperative outcomes, such as higher rates of infection, cardiovascular stress, and delayed wound healing [4]. Furthermore, organized perioperative care, which includes preoperative nursing evaluations, has been shown in European trials to considerably lower anxiety and enhance clinical results. For instance, it has been shown that nursing-led preoperative treatments, including evaluation rounds, reduce patient anxiety and the likelihood of problems [5]. Furthermore, treatments including psychological support, patient education, and nurse-led preoperative evaluations are acknowledged as successful methods for managing anxiety throughout the perioperative period [6].

To facilitate a seamless transition through surgery and expedite recovery, research has emphasized the significance of attending to both psychological and physiological factors during perioperative rounds [7]. Surgery is required to address a few conditions, such as infections, heart disease, cancer, and injuries. Over 300 million major operations are performed globally each year [8]. Major complications after inpatient surgery may occur up to 22% of the time, and the mortality rate may be as high as 0.8%, according to studies. According to previous research conducted in 25 countries, one-tenth of surgical patients in Africa experienced a preoperative issue, and five out of them died postoperatively due to inadequate preoperative instruction [9].

MATERIALS AND METHODS

Research Design

Patients who undergo perioperative nursing assessment rounds are compared to those who do not in a comparative study design utilizing the Quasi-Experimental (Pretest-Posttest, Non-Randomized Control Group) technique. A standardized perioperative nursing evaluation round was performed by the research group patients one day before to surgery, however all patients received routine preoperative and postoperative care. Anxiety levels before and after surgery, as well as postoperative pain levels, were gathered and evaluated using a standardized questionnaire.

The study adopts a quasi-experimental design because it seeks to evaluate the effect of an intervention (perioperative nursing assessment rounds) on patient outcomes (anxiety levels and postoperative complications) within a real-world clinical setting. In the context of Kwara State University Teaching Hospital (KWASUTH), the quasi-experimental approach is appropriate because: The intervention is implemented within routine clinical practice, the hospital also operates within structured surgical schedules and ward systems that make strict experimental control difficult, it allows comparison between an intervention group and a control group without disrupting standard care processes, it is practical, feasible, and ethically

acceptable in a clinical environment. This design enables the researcher to examine cause-and-effect relationships while maintaining the natural hospital workflow.

Research Setting

Kwara State University Teaching Hospital, Ilorin (previously General Hospital Ilorin), was the setting used for this study.

Target Population

The target population are patients who presented to the surgical department of the Kwara State University Teaching Hospital.

Sample size determination

All patients who presented to the Surgical Department of Kwara State University Teaching Hospital for orthopedic, obstetric and gynecologic, plastic, and general surgical procedures were considered for inclusion. An average of 20–30 elective surgeries are performed weekly across these specialties. In January 2025, the hospital recorded 120 elective surgical cases; 110 cases were recorded in February 2025, and 130 cases in March 2025. According to the hospital's main theatre manager, the monthly volume of elective surgeries is variable and may increase or decrease relative to these figures. The sample size was determined using the simplified Yamane formula (Israel, 1992) to ensure adequate representation of the study population.

Formula n= N/(1 + N(e^2))

Where n is the sample size

N = population size, the number of patient for the previous three months before the study was conducted divided by 3 (120+110+130 =360/3) = 120

e= level of confidence, 0.05

N = Taken population size as 120

$$n= \frac{120}{1 + 120(0.05^2)}$$

$$n= 92.31 \cong 92$$

Therefore, 92 patients were used, which was divided in two group of 46 per group (Control and study group)

Sampling technique

Convenience sampling was employed to recruit participants for this study. The participants were allocated into two groups: the intervention group and the control group. Due to surgeon availability, the hospital currently provides services in four surgical specialties; therefore, patients were recruited from Monday to Friday and categorized according to specialty (general surgery, orthopedic surgery, plastic surgery, and obstetrics and gynecology). Obstetric and gynecological surgeries are scheduled on Mondays, Wednesdays, and Thursdays; orthopedic surgeries on Tuesdays and Fridays; general surgery on Thursdays; and plastic surgery on Wednesdays. All patients received routine preoperative and postoperative care. In addition, patients in the intervention group underwent a standardized perioperative nursing evaluation round conducted by the researcher and an assistant researcher one day prior to surgery. Preoperative and postoperative anxiety levels, as well as the severity of postoperative pain, were assessed using a structured questionnaire.

Convenience sampling was adopted in this quasi-experimental study due to the clinical and operational realities of conducting research at Kwara State University Teaching Hospital (KWASUTH), Nigeria. The study focused on patients undergoing elective surgeries within a defined timeframe, and participant recruitment was limited to those who were available, eligible, and consented during the data collection period. Elective surgical patients are admitted and scheduled based on hospital booking systems and surgeon availability. Recruiting participants as they presented for surgery ensured feasibility and minimized disruption to routine perioperative care.

Inclusion Criteria

Patients were eligible to participate in this study if they met the following are:

1. Adults aged 18 years and above.
2. Presented to the Surgical Out-Patient Department of the Kwara State University Teaching Hospital.
3. Non-emergency surgical procedure at least 24 hours prior to surgery.
4. Patients that receive perioperative nursing assessment round as part of the standard clinical practice.
5. Patients that are medically stable and able to provide informed consent.
6. Patients that are willing to participate and provide free voluntary consent to be part of the study.

Exclusion Criteria

Patients were excluded from the study if they met any of the following criteria:

1. Required emergency surgery or had an emergent surgical procedure.
2. Did not receive preoperative education.
3. Had surgery more than two weeks prior to the study or were scheduled for surgery after the study period.
4. Experienced significant postoperative complications that required intensive care or prolonged hospitalization (over 14 days).
5. Were unable to provide informed consent due to cognitive or communication impairments.
6. Declined to participate in the study.

Instrument for data collection

The primary data collection tool for this study was a structured questionnaire which was divided into six sections to gather comprehensive information from pre and post-operative patients, each tailored to address specific aspects of the research objectives.

Validity of the Instrument

The instrument was validated through face and content validity criteria. The questionnaire was given to the experts for review and corrections before administering it.

Reliability of the Instrument

A pilot study was conducted using 10% of the calculated sample size to evaluate the reliability and suitability of the research instrument. Participants for the pilot study were selected using convenience sampling. The administered questionnaires were retrieved immediately after completion to minimize attrition and non-response. Reliability was assessed using Cronbach's alpha coefficient, a measure of internal consistency that is particularly appropriate for multi-item survey instruments.

METHOD OF DATA COLLECTION

Pre-operative Phase

Preoperative data were collected one day prior to surgery, before the introduction of the assessment guide by the researcher and research assistants. The researcher established rapport with each patient and their relatives and assigned a unique identification code to ensure confidentiality. Participants in one group were coded A1–A46, while those in the other group were coded B1–B46. These identification codes were recorded on the corresponding questionnaires. The questionnaire was administered verbally to each patient, and responses were documented accordingly. All completed questionnaires were retrieved immediately after administration.

Intervention Phase

A validated intervention guide was utilized during this phase of the study. All patients assigned to the intervention group received structured preoperative education sessions based on the standardized preoperative education guide. The data collection procedure lasted four weeks. The educational intervention included an introduction to preoperative education and the proposed surgical procedure, a discussion of surgery as the most appropriate treatment option and possible alternatives, and detailed information on what to expect during the preoperative, intraoperative, and postoperative phases.

Perioperative Nursing Assessment Round

The perioperative nursing assessment round refers to a structured and systematic process in which nurses evaluate patients before, during, and after surgery to ensure comprehensive care and early detection of potential complications [15]. This round is a key component of perioperative nursing care and typically involves a multidisciplinary approach that includes not only nurses but also surgeons, anesthesiologists, and other healthcare professionals. Its purpose is to assess various patient parameters, identify potential risks, address concerns, and ensure that all necessary interventions are in place to promote patient safety and optimize outcomes [16]. In the perioperative period, which spans from the time a patient is scheduled for surgery through to their recovery in the postoperative phase, nursing assessments play a crucial role in reducing complications and ensuring safe and effective care [17]. These assessments include evaluating physical,

psychological, and functional aspects of a patient's health, and they form the foundation for clinical decision-making and care planning [18].

The perioperative nursing assessment round encompasses a comprehensive evaluation of several key domains to ensure the patient's readiness for surgery and to identify any risks that may affect the surgical outcome:

- **Physical Assessment:** Nurses assess the patient's physical health, including vital signs (e.g., blood pressure, heart rate, respiratory rate, and temperature), and review medical history, including comorbidities (such as diabetes or hypertension) that may affect surgical risks [19]. The physical assessment also includes evaluating the surgical site, checking for any infections, and ensuring that the patient's body systems are stable and ready for surgery [20].
- **Psychosocial Assessment:** Anxiety, fear, and emotional stress are common among patients preparing for surgery, and nurses play a crucial role in identifying these factors through interviews or using standardized anxiety scales, such as the State-Trait Anxiety Inventory (STAI) [21]. Managing these emotional states is critical, as unaddressed preoperative anxiety can impair immune function and slow recovery [22]. Perioperative nursing rounds include providing emotional support, addressing concerns, and implementing strategies like relaxation techniques or preoperative education to alleviate anxiety [23].
- **Functional Assessment:** This includes evaluating the patient's ability to perform basic daily activities, their mobility status, and whether they require any assistive devices postoperatively. Nurses also assess the patient's nutritional status, as malnutrition can increase the risk of complications like infection and delayed wound healing [24].
- **Preoperative Teaching:** Preoperative education is essential to reducing anxiety and improvement in patient care outcomes. Nurses use the perioperative nursing round to educate patients about the procedure, the anesthesia process, expected recovery, and pain management [25]. Providing detailed information helps patients feel more in control, reducing fear and ensuring that they have realistic expectations about the surgery and recovery [15].
- **Identification of Potential Risks:** The nursing assessment round is an opportunity to identify patients at high risk for complications, including those with allergies, previous adverse reactions to anesthesia, or those with uncontrolled chronic conditions [19]. Nurses also ensure that patients are properly prepared for the surgical procedure, including fasting requirements, medication management, and emotional readiness [16].

Post-operative Phase

Post-operative data was collected a day after the surgery to access the impact of preoperative assessment round on the anxiety level and postoperative pain in surgical patients.

Pilot test

Twelve patients receiving general surgery at Sobi Specialist Hospital in Ilorin, Kwara State, participated in a pilot study using the data gathering instruments. The researcher did this pilot test to see if the data collecting methods were applicable, to find any questions that were confusing or ambiguous, and to estimate the time needed to complete each questionnaire. After analyzing the pilot test results, it was discovered that 10% of the questions required revisions to better suit the patients' comprehension.

METHOD OF DATA ANALYSIS

A master Excel document including all of the data was created, and SPSS statistical software (version 25.0) was then used to analyze it. Key outcome factors, preoperative assessment parameters, and demographic information were compiled using descriptive statistics. Paired t-tests were used to assess the anxiety levels before and after the parametric data analysis. The quality of the preoperative evaluation was a major predictor of total patient satisfaction, which was predicted using logistic regression analysis. To investigate the connections between important factors, perioperative nursing evaluation rounds on anxiety and complications, correlation analysis was performed.

ETHICAL CONSIDERATIONS

The purpose of the study project was explained in an introduction letter acquired from the Department of Nursing Sciences, Faculty of Clinical Sciences, University of Ilorin, with ethical permission number UERC/ASN/2025/3252 ethics-based approval. The ethical review committee of Kwara State University Teaching Hospital, Ilorin, granted permission to administer the structured questionnaire to the respondents on May 21, 2022, with ethical clearance number KWASUTH/IRC/246/VOL.II/57. The data gathering was explicitly authorized by other layers of the setting. The following social sciences research ethics served as a guidance for the study's data gathering process:

Confidentiality: No names were recorded, and all data gathered for this study was assigned code numbers. No identify will be used in any publications or reports resulting from this research, and this will not be connected in any kind to the caregivers chosen for this study. Translation of the local language protocol to facilitate communication: For ease of communication, the questionnaires were prepared in simple English. Field assistants from the study area were hired to speak with respondents in their native tongue, particularly for those who were illiterate in the English used to prepare the questionnaire.

Non-maleficence to participants: During the questionnaire and interview processes, participants in this study won't suffer any damage. Voluntariness: Caregivers' involvement in this study is completely optional. The study participants are free to leave at any moment. Each patient received a verbal explanation of the study's purpose before their signed agreement was obtained.

RESULTS

Study findings

Demographic Characteristics of Participants

From the table 1.1 bellow, demographic data reveal that most participants were female (68.0%). A majority had secondary or tertiary education, and employment status was evenly split among employed, retired, and unemployed individuals. Most surgeries fell under the "others" category, with only a small number being hernia or acute abdominal procedures. Slightly more than half of the participants had prior surgical experience. The majority of the patients were between 31-50 years old (57%).

Pre-Intervention Anxiety Levels

From the table 1.2 bellow, the preoperative anxiety was notably high, with more than 63% of patients reporting they were either very or extremely anxious before surgery. This supports the rationale for introducing anxiety-reducing interventions.

Preoperative Education characteristics

From the table 1.3 bellow, the most common type of preoperative education was one-on-one education with a healthcare provider and information pamphlet (34.8%), followed by structured instruction, with Video being the least. All who received preoperative education rated the quality and clarity highly.

Post-operation Anxiety Levels

From the table 1.4 bellow, the anxiety levels showed a modest decline following the intervention. Still, more than half of the participants (53.3%) remained very or extremely anxious, which is believed to be among the control group, that is, those who do not receive the education.

Comparison of Postoperative Anxiety (Control vs. Treatment Group)

From the table 1.5 bellow, the treatment group had slightly lower postoperative anxiety (mean difference = 1.09), the difference was statistically significant ($p < 0.05$). This suggests that the educational intervention was able to produce significant differences across groups.

Distribution of pain levels at different period post-surgery

From the table 1.6 bellow, it reflects how patients perceived pain levels changed over time following elective surgery and offers insights into the trajectory of recovery and the effectiveness of perioperative nursing interventions such as education and assessment rounds.

For day 1, the majority of patients (93.3%) reported experiencing moderate to severe pain, while only a small minority (6.5%) reported mild or no pain, suggesting that initial postoperative pain was intense, as expected, due to the immediate impact of surgical trauma.

Between day 6-8, there was a marked improvement in pain levels, as severe pain level dropped dramatically to 4.3% and mild and moderate pain dominated (43.5% and 53.2% respectively). The shift suggests that postoperative recovery and pain control efforts were effective by this stage.

Between day 12–15, a notable proportion (25.0%) of patients became pain-free, and an additional 47.8% reported only mild pain. Also, no patients reported severe pain at this stage. Only 27.2% still experienced moderate pain, indicating that recovery was well underway for most patients.

The findings affirm that perioperative education though it may not eliminate pain plays a role in improving patients' coping mechanisms, setting expectations, and promoting a smoother recovery.
Chi square test was conducted to examine the association between preoperative education and pain levels at day 6-8 and day 12-15.
Day 6-8: χ^2 (2, N = 46) = 2.97, $p < 0.05$.
Day 12-15: χ^2 (2, N = 46) = 2.47, $p < 0.01$.
The results indicate that a significant association between preoperative education and lower pain levels at day 6-8 and Day 12-15.

DISCUSSION OF FINDINGS

The finding shows that preoperative anxiety was notably high, with more than 63% of patients reporting they were either very or extremely anxious before surgery. This supports the rationale for introducing anxiety-reducing interventions. This assesses the level of preoperative anxiety in patients undergoing elective surgeries at Kwara State University Teaching Hospital, Ilorin in both treatment and control groups.

This showed that anxiety levels showed a modest decline following the intervention. Still, more than half of the participants (53.3%) remained very or extremely anxious, which is believed to be among the control group, that is, those who do not receive the education. This assesses the level of postoperative anxiety in patients who have undergone elective surgeries at Kwara State University Teaching Hospital, Ilorin in both treatment and control groups.

Lastly, this reflects how patients' perceived pain levels changed over time following elective surgery and offers insights into the trajectory of recovery and the effectiveness of perioperative nursing interventions such as education and assessment rounds which assess the level of postoperative complications in patients who have undergone elective surgeries at Kwara State University Teaching Hospital, Ilorin in both treatment and control groups.

CONCLUSION

The study provides evidence for the positive impact of preoperative education on patient outcomes in surgical settings. The study showed that patients who received education felt more informed, reported lower anxiety, and demonstrated faster improvement in pain levels. These findings emphasize the need for structured nursing interventions as part of routine preoperative care to optimize patient recovery. The study also shows that personalized approaches to patient education, considering individual differences, will make it more effective.

RECOMMENDATIONS

Based on the findings from this study, the following recommendations were made:

1. Institutionalize Preoperative Education: Hospitals should incorporate structured education sessions as standard practice in surgical wards.
2. Nursing Involvement: Nurses should be actively involved in delivering preoperative assessments and education, using multiple formats such as one-on-one sessions, pamphlets, and multimedia.
3. Monitor and Follow-Up: Pain and anxiety levels should be monitored from admission through discharge to personalize care, ensure proper monitoring, and evaluate intervention success.
4. Training for Healthcare Providers: Regular training sessions should be conducted for nurses and other healthcare providers who are involved in preoperative education. The sessions should emphasize effective communication strategies, adult learning principles, and techniques for addressing patient anxiety.
5. Surgical procedure success: The study has also shown that effective preoperative education is key in the success of surgical procedures; hence, a need to pay more attention to make preoperative education more effective.

ACKNOWLEDGEMENTS

First of all, I thank the Almighty God for His unmerited mercies and grace over the years. Without Him, I can do absolutely nothing, and I remain eternally grateful for His divine assistance during my programme.

I am profound grateful to my supervisor, an erudite scholar, Prof. E.E Anyebe for his mentorship, tutelage, correction and guidance at every stage of my training. Special appreciation to my indefatigable Head of Department doubled as my supervisor Prof. E.E Anyebe for his word of encouragement during this program. I equally appreciate the postgraduate coordinator Prof. J.A. Afolayan and other distinguished professors, senior lecturers in the department who have contributed in no small measure to my development in person of Prof. Olubiyi, Dr. Onansoga, Dr. Umar, and Dr. Aluko including non-teaching staffs of the department. Thank you all, I sincerely appreciate.
I am delighted to appreciate one of my research mentors, Dr. Popoola B. O of the department of guidance and counselling, Al-Hikmah University, Ilorin, she did marvelously on my research skills, may Allah continue His blessings in your life ma. I doff my hat.
Special thanks to my family (my late father, my mothers, brothers, sisters, wife and children).
Special thanks to my fellow students in Medical and Surgical Specialty and the other student in Nursing Science Department for making the journey less stressful, May God bless you all. (Amen).

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING STATEMENT

All authors have declared that no financial support was received from any organization for the submitted work.

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CITE THIS ARTICLE

- APA (7th edition): Ibrahim, A. O., Anyebe, E. E., Lukman, A.-R. O., Abdulmumeen, I. O., Kolo, S., Fatukasi, B. M., Adeniyi, Y. E., Ahmed, L., & Ganiyu, M. D. (2026). *Impact of perioperative nursing assessment round on anxiety and complications of elective surgeries: A quasi-experimental study at a teaching hospital in Nigeria. The Operating Room Global Journal (TORGJ)*, 2(1). https://doi.org/10.64573/torgj2602003
- Harvard: Ibrahim AO, Anyebe EE, Lukman ARO, Abdulmumeen IO, Kolo S, Fatukasi BM, Adeniyi YE, Ahmed L, Ganiyu MD. Impact of perioperative nursing assessment round on anxiety and complications of elective surgeries: A quasi-experimental study at a teaching hospital in Nigeria. *The Operating Room Global Journal (TORGJ).* 2026;2(1). https://doi.org/10.64573/torgj2602003
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- Chicago (Author-Date): Ibrahim, Ahmed Orelope, Emmanuel E. Anyebe, Abdur-Rahman Olajide Lukman, Ibrahim Opeyemi Abdulmumeen, Silas Kolo, Bukola Mary Fatukasi, Yetunde Elizabeth Adeniyi, Lateefat Ahmed, and Mufutau Dayo Ganiyu. 2026. "Impact of Perioperative Nursing Assessment Round on Anxiety and Complications of Elective Surgeries: A Quasi-Experimental Study at a Teaching Hospital in Nigeria." *The Operating Room Global Journal (TORGJ)* 2 (1). https://doi.org/10.64573/torgj2602003

Demographic Characteristics of Participants

Variable	Categories	Frequency	Percentage (%)
Gender	Male	32	32.0
	Female	68	68.0
Total		**92**	**100**
Age Group	15–30 years	21	22.8
	31–50 years	57	62.0
	51–70 years	4	4.3
	71 + years	10	10.9
Total		**92**	**100**
Education Level	None	2	2.2
	Primary	9	9.8
	Secondary	37	40.2
	Tertiary	44	47.8
Total		**92**	**100**
Employment Status	Employed	32	34.8
	Retired	30	32.6
	Unemployed	30	32.6
Total		**92**	**100**
Type of Surgery	Hernia	2	2.2
	Acute Abdominal	2	2.2
	Others	88	95.7
Total		**92**	**100**
Previous Surgery History	Yes	51	55.4
	No	41	45.6
Total		**92**	**100**

Pre-Intervention Anxiety Levels

Preoperative anxiety scores were categorized on a Likert scale from 1 (Not at all anxious) to 5 (Extremely anxious).

Anxiety Level	Frequency	Percentage (%)
Slightly Anxious	12	13.0
Moderately Anxious	22	23.9
Very Anxious	24	26.1
Extremely Anxious	34	37.0
Total	**92**	**100**

Preoperative Education characteristics

The study group, which makes up half of the participants (N = 46) were given preoperative education.

Characteristics	Category	Frequency	Percentage (%)
Type of Pre-education	Information Pamphlets	16	34.8
	One-on-one	16	34.8
	Structured Instructions	11	23.9
	Videos	3	6.5
Total		**46**	**100**
Pre-op Education Reduced Anxiety	Yes	46	50.0

Clarity of Information	Clear	11	24
	Very Clear	35	76
Total		**46**	**100**
Rate of Preoperative Education	Good	14	30.4
	Excellent	32	69.6
Total		**46**	**100**

Post-operation Anxiety Levels

Anxiety Level	Frequency	Percentage (%)
Slightly Anxious	18	19.6
Moderately Anxious	25	27.2
Very Anxious	26	28.3
Extremely Anxious	23	25.0
Total	**92**	**100**

Comparison of Anxiety Levels Before and After Intervention (Paired T-Test)

Variable	Pre-Mean	Post-Mean	t-value	p-value
Anxiety Score	4.28	3.54	4.715	0.000

Comparison of Postoperative Anxiety (Control vs. Treatment Group)

To confirm the efficiency of the pre-operative education, a comparison test was done between the Control and Study groups.

Group	N	Mean Anxiety	Std. Deviation	p-value
Control	46	4.63	1.062	
Treatment	46	3.54	1.089	0.03

Association Between Postoperative Anxiety and Pain

A correlation analysis was done to investigate if there is a correlation between postoperative anxiety and pain felt on Day 1 after surgery.

Variables	Spearman's rho	p-value
Postoperative Anxiety & Pain	0.098	0.354

Distribution of pain levels at different period post-surgery

Time Point	No pain (%)	Mild Pain (%)	Moderate Pain (%)	Severe Pain (%)
Day 1	4.3	2.2	42.2	51.1
Day 6-8	0.0	43.5	53.2	4.3
Day 12-15	25.0	47.8	27.2	0.0

Institutional Report: The Operating Room Global (TORG) Annual Report 2025

Author: Adebusola Adenike Owokole[1]*

[1]The Operating Room Global (TORG).

DOI: https://doi.org/10.64573/torgj2602006

The Operating Room Global Journal (TORGJ) Volume 2 Issue 1 Mar 2026

***Corresponding Author:**
Prof. Adebusola Adenike Owokole
adebusola@operatingroomissues.org

Declaration:
Author's Contribution: The author wrote and approved the final manuscript.
Conflict of Interest: No conflict of interest.
Funding: No funding received by the author.

Article History:
Written: 28-12-2025 Available Online: 01-03-2026
QR access this Article

ABSTRACT

Background: The Operating Room Global (TORG) Annual Report 2025 documents a year of significant organisational growth, global expansion, and strategic consolidation in education, research, governance, and scholarly publishing. As surgical systems worldwide face workforce shortages, ethical challenges, and inequities in access, structured global collaboration platforms remain critical.

Objective: To present a comprehensive overview of TORG's 2025 activities, achievements, and measurable impact across training, research, governance, partnerships, and knowledge dissemination.

Methods: This institutional annual report summarises organisational data collected between 1 January and 25 December 2025, including community growth metrics, digital analytics, training participation records, research portfolio development, ethical governance milestones, publication outputs, and strategic partnerships. Quantitative indicators were extracted from verified internal databases and engagement analytics.

Results: In 2025, TORG's global community expanded from 213,910 to 260,263 members across 111 member countries. A total of 5,566 training participations were recorded across 30 structured educational events, including global webinars, regional webinars, congresses, collaborative forums, in-person workshops, and an international hybrid scientific conference. Digital engagement exceeded 82 million annual views with nearly 900,000 content interactions. Research expansion included activation of the TORG Global Research Team, initiation of multiple multinational studies, and regulatory milestones achieved by the TORG Institutional Review Board, including U.S. OHRP registration (IORG0012466; IRB00014742) and Federalwide Assurance (FWA00035510). The Operating Room Global Journal (TORGJ) successfully published two peer-reviewed issues in 2025, strengthening academic dissemination. Legal incorporation of The Operating Room Global Centre for Education, Research & Innovation in Ireland further enhanced institutional governance and sustainability.

Conclusion: The year 2025 marked a transformative phase for TORG, characterised by measurable global reach, structured capacity building, strengthened research governance, and academic consolidation. The organisation is strategically positioned to scale its impact in 2026 through expanded training delivery, research output, ethical oversight, and international partnerships aimed at advancing safe, sustainable, and patient-centred surgical and perioperative systems worldwide.

Keywords: *Global surgery; Perioperative education; Surgical systems strengthening; Research governance; Capacity building; International collaboration.*

The Operating Room Global (TORG)
Annual Report 2025, Reporting Period: 1 January - 25 December 2025.

Executive Summary

The year 2025 marked a transformative period for The Operating Room Global (TORG). Over the reporting period (1 January - 25 December 2025), TORG significantly expanded its global training footprint, strengthened research and ethical governance structures, delivered structured education to over 5,000 professionals, published peer-reviewed scholarly work, and consolidated its role as a leading international platform for perioperative education, research, and collaboration.

1.0 Introduction

This Annual Report presents an overview of TORG's activities, impact, and achievements during 2025. It documents progress across education and training, research and innovation, publications, partnerships, governance, and global community growth.

2.0 Community Growth & Global Reach

2.1 Community Growth in 2025

Between March and December 2025, TORG's global community of operating room professionals grew from **213,910** to **260,263**, reflecting sustained international engagement across education, research, and professional development activities.

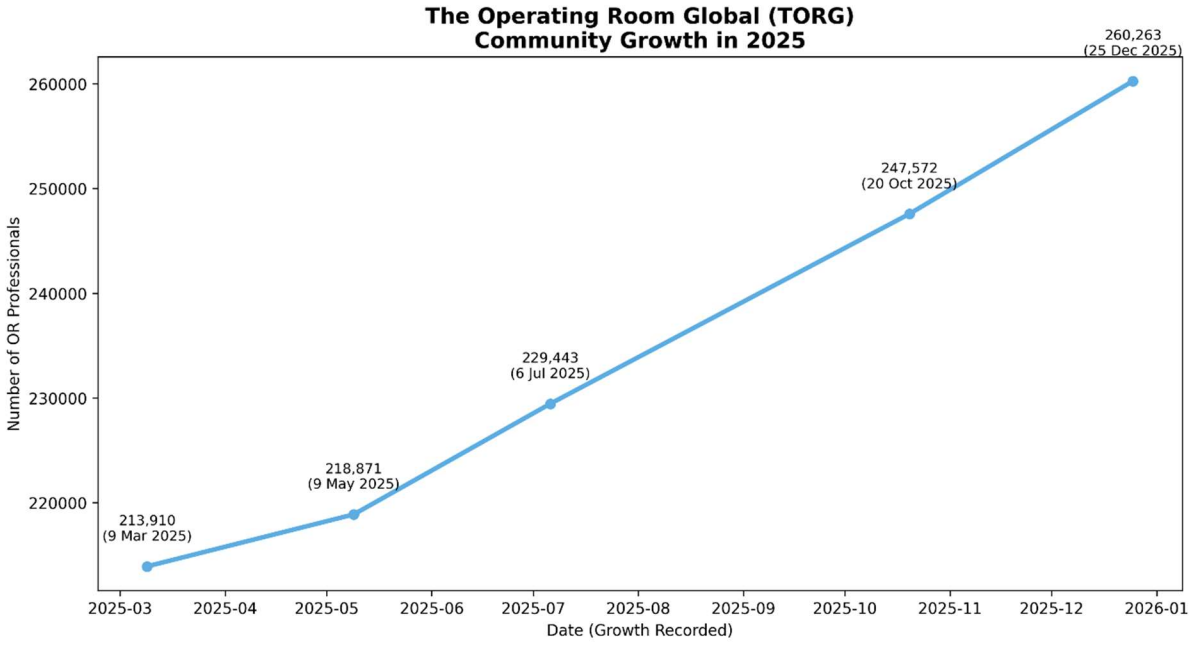


Figure 1. TORG Community Growth in 2025

Growth of the TORG global professional community based on recorded engagement milestones between March and December 2025.

2.2 Global Footprint: Member Countries

As of December 2025, TORG recorded **111-member country entries**, spanning Africa, Asia, Europe, North America, South America, and Oceania. Figures reflect country entries rather than unique sovereign states due to transcontinental classifications.

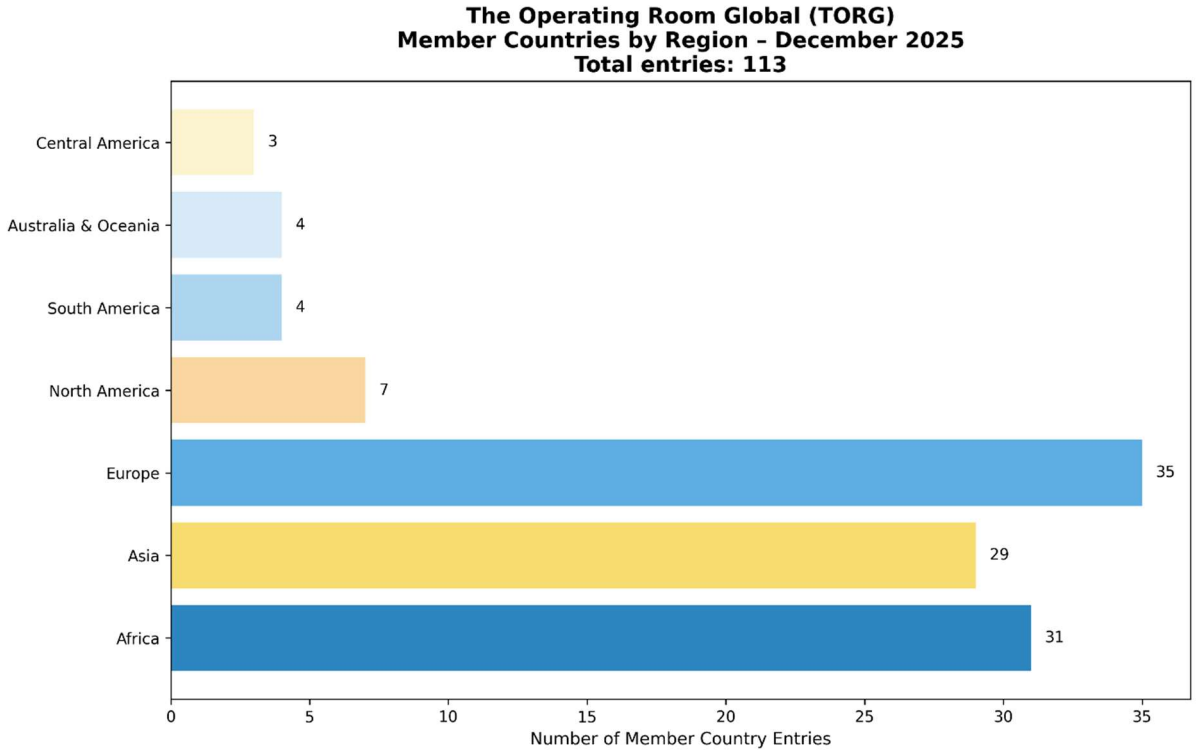


Figure 2. TORG Member Countries by Region (December 2025)

Regional distribution of TORG member country entries.

This total (113) reflects entries, not unique sovereign countries. Some entities are counted more than once due to transcontinental classification: Russia (Europe & Asia) & Azerbaijan (Europe & Asia) Total Member Countries: 111. A detailed list of TORG member countries by region is provided in ***Appendix A.***

3.0 Audience & Demographics

3.1 Membership Demographics: Women: **74.9%,** Men: **25.1%**

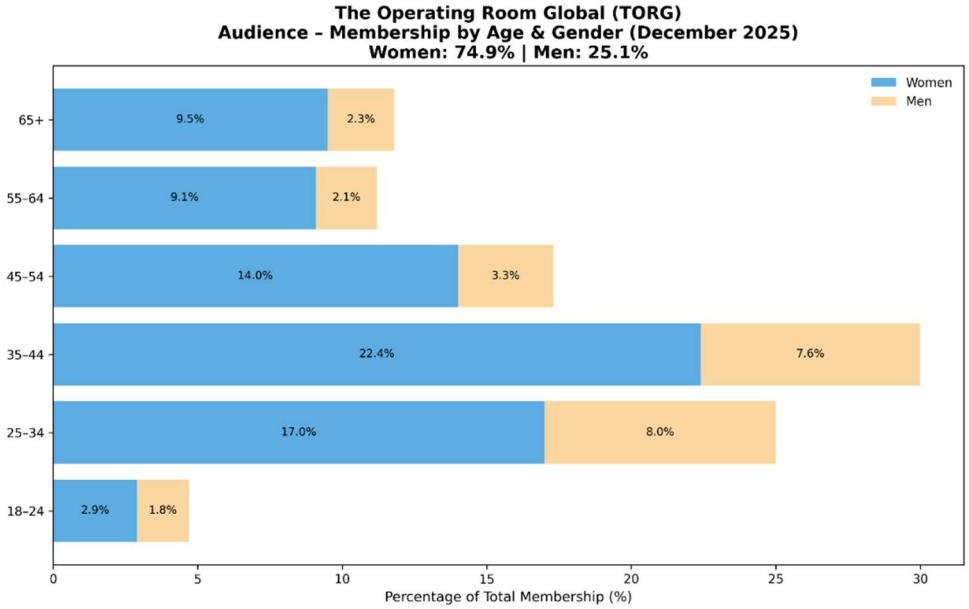


Figure 3. Membership Age and Gender Distribution (December 2025)

Age and gender distribution of registered TORG members.

3.2 Potential Audience Profile

- Estimated potential audience: **3.5-4.2 million professionals**
- Women: **55.1%,** Men: **44.9%**

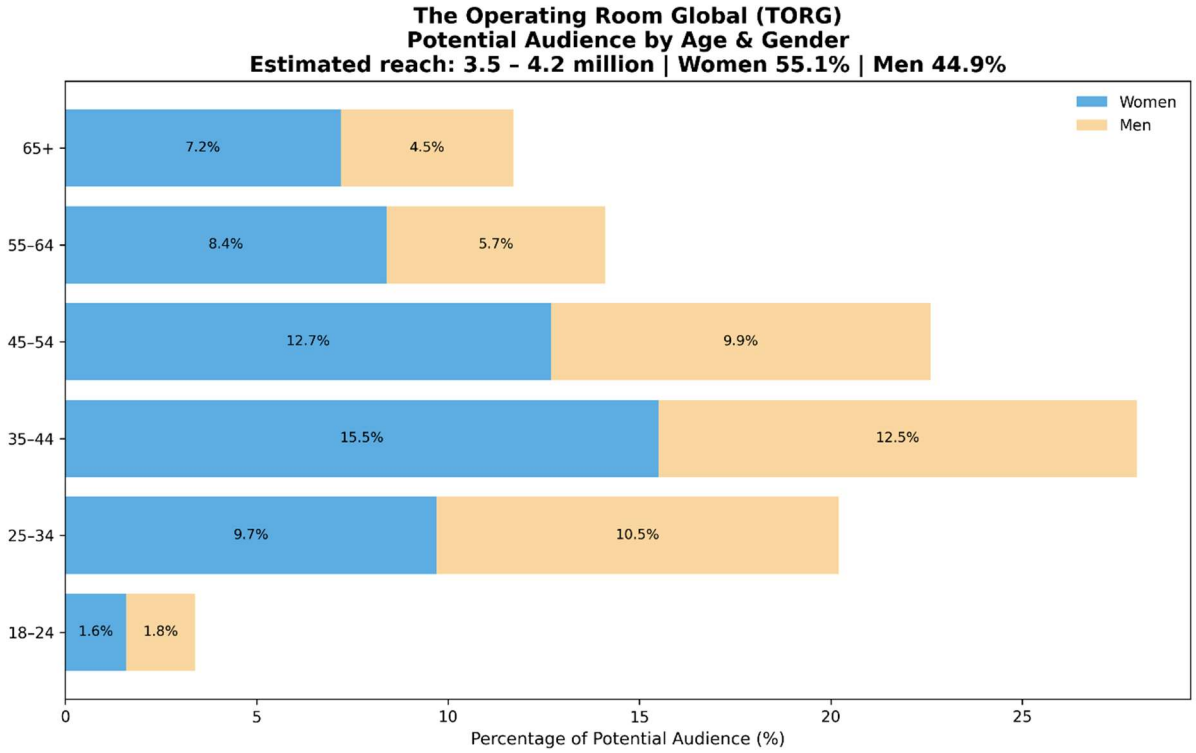


Figure 4. Potential Audience by Age and Gender

Estimated demographic profile of the global perioperative and surgical workforce aligned with TORG's mission.

4.0 Engagement Analytics

4.1 Top Countries by Engagement

Countries with the highest engagement in December 2025 included the United States, Philippines, India, United Kingdom, Canada, Australia, Nigeria, Iran, Indonesia, Malaysia, Brazil, Pakistan, and South Africa.

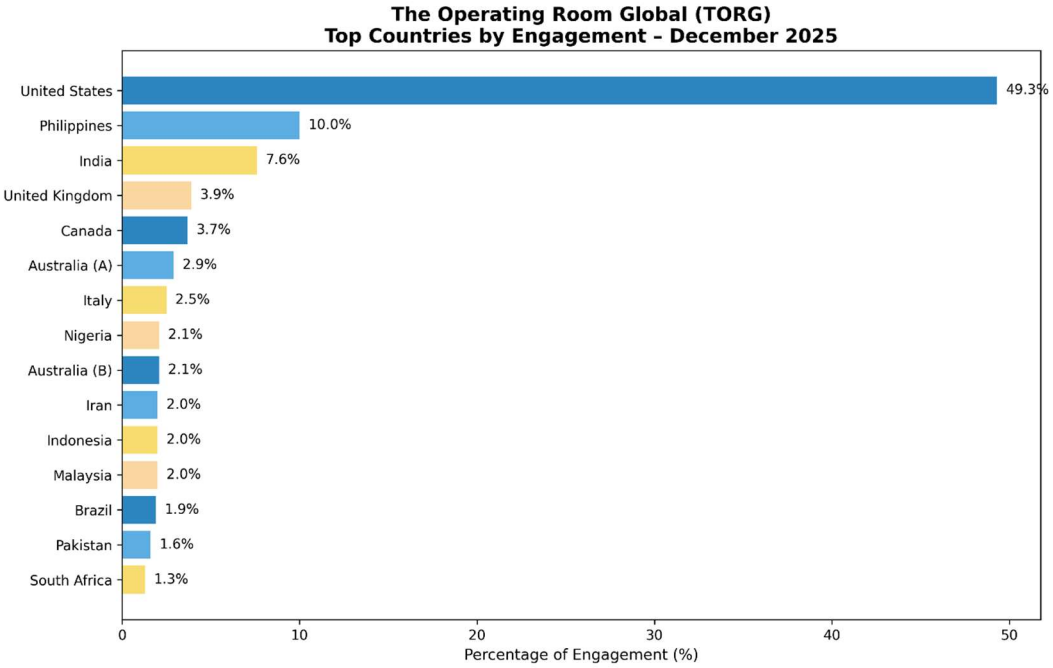


Figure 5. Top Countries by Engagement (December 2025)

Countries ranked by engagement metrics across TORG platforms.

4.2 Top Cities by Engagement

Figure 6 depicts Key cities contributing to engagement included **Sialkot**, **New York**, **Quezon City**, **Hong Kong**, **Los Angeles**, **Melbourne**, **Riyadh**, **Singapore**, **Tehran**, and **Dhaka**.

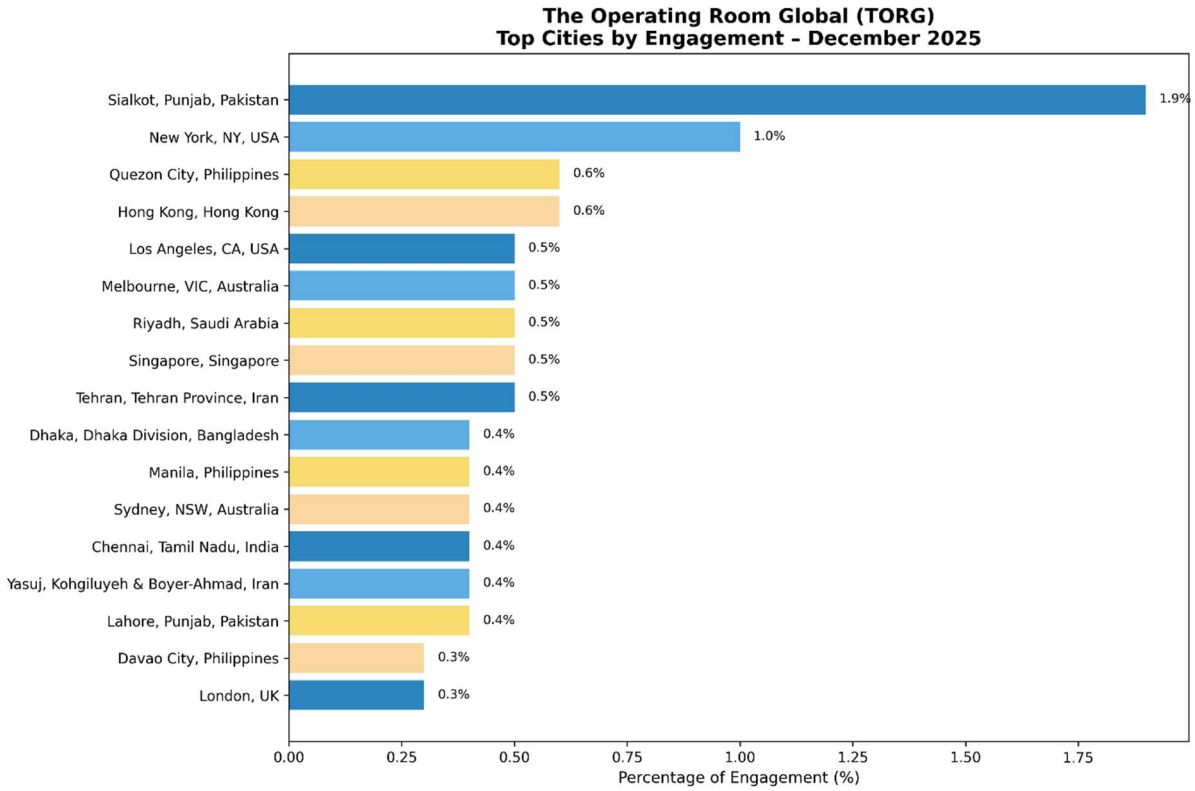


Figure 6. Top Cities by Engagement (December 2025)

City-level engagement hotspots reflecting global participation in TORG activities.

5.0 Digital & Social Media Performance

5.1 Social Media Performance - Last 28 Days (27 Nov-24 Dec 2025)

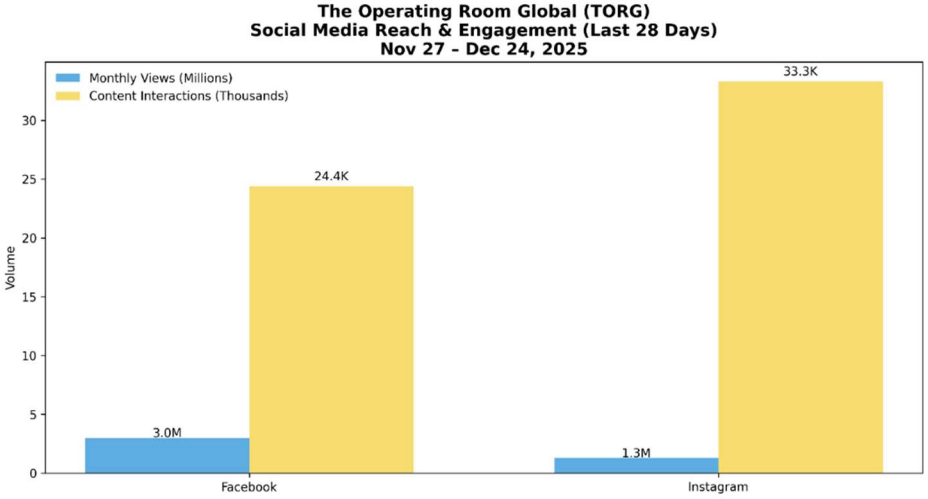


Figure 7a. Social Media Reach and Engagement (Last 28 Days)

Views and content interactions across Facebook and Instagram.

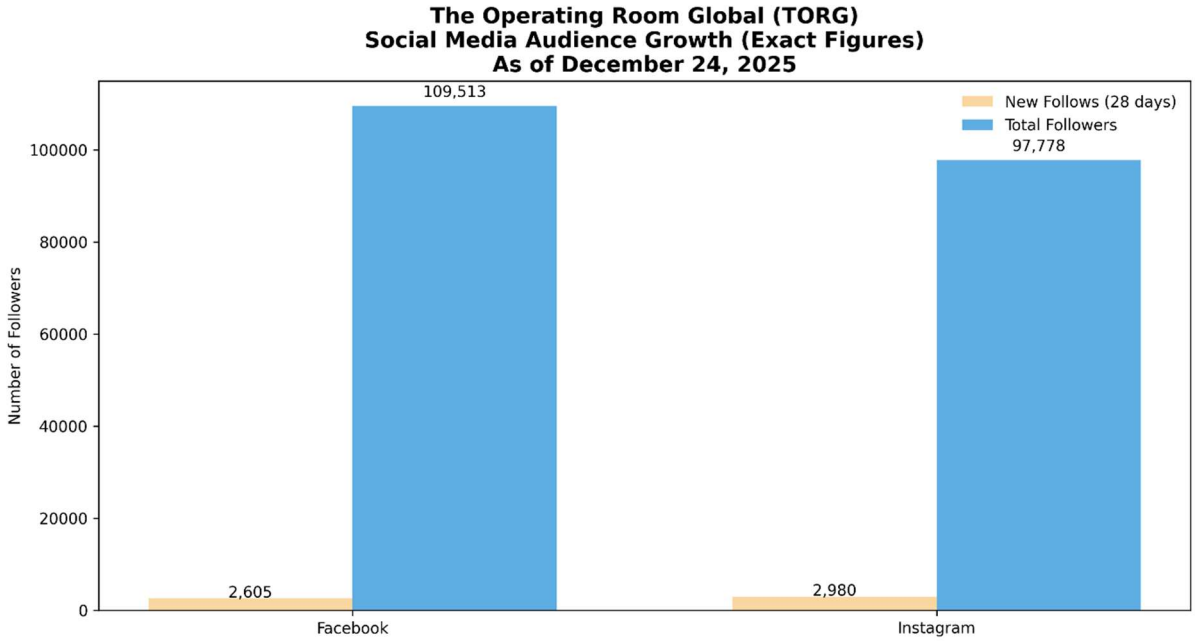


Figure 7b. Social Media Audience Growth (Last 28 Days)

New followers and cumulative audience size as of December 202

Figures 7a-7b. Social Media Reach and Engagement (Nov 27-Dec 24, 2025).

During the reporting period, TORG achieved strong digital engagement across platforms, recording over 4.3 million monthly views, 57,700 content interactions, and continued audience growth, with total followers reaching 109,513 on Facebook and 97,778 on Instagram.

5.2 Social Media Performance - Full Year 2025

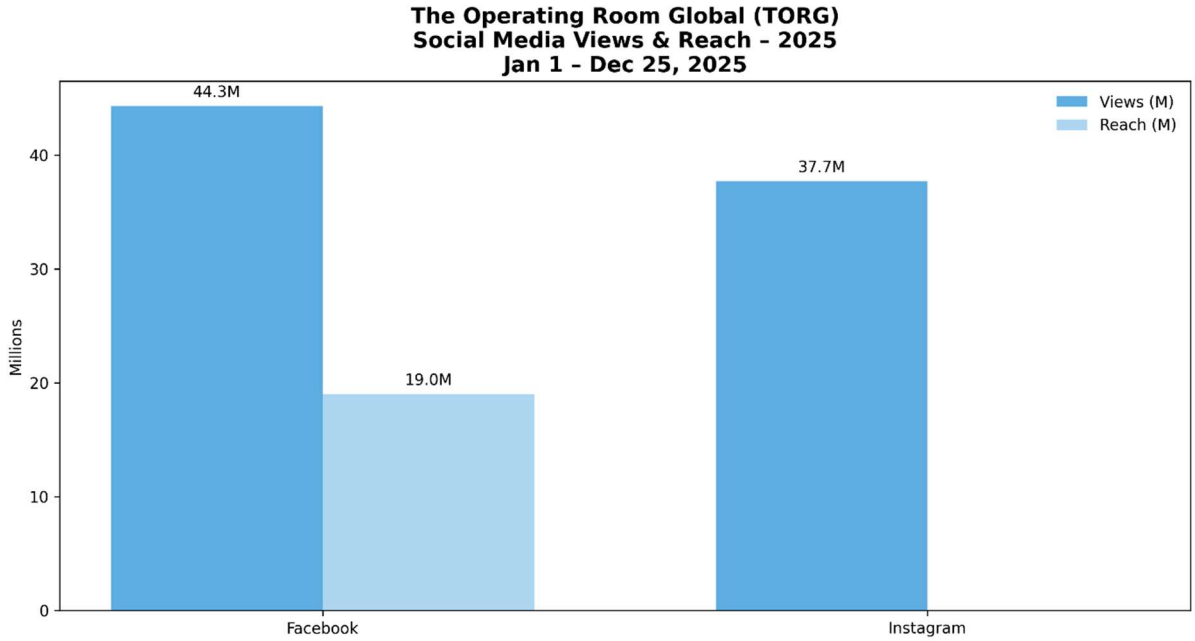


Figure 8a. Annual social media Views and Reach (2025)

Total annual views and reach across Facebook and Instagram.

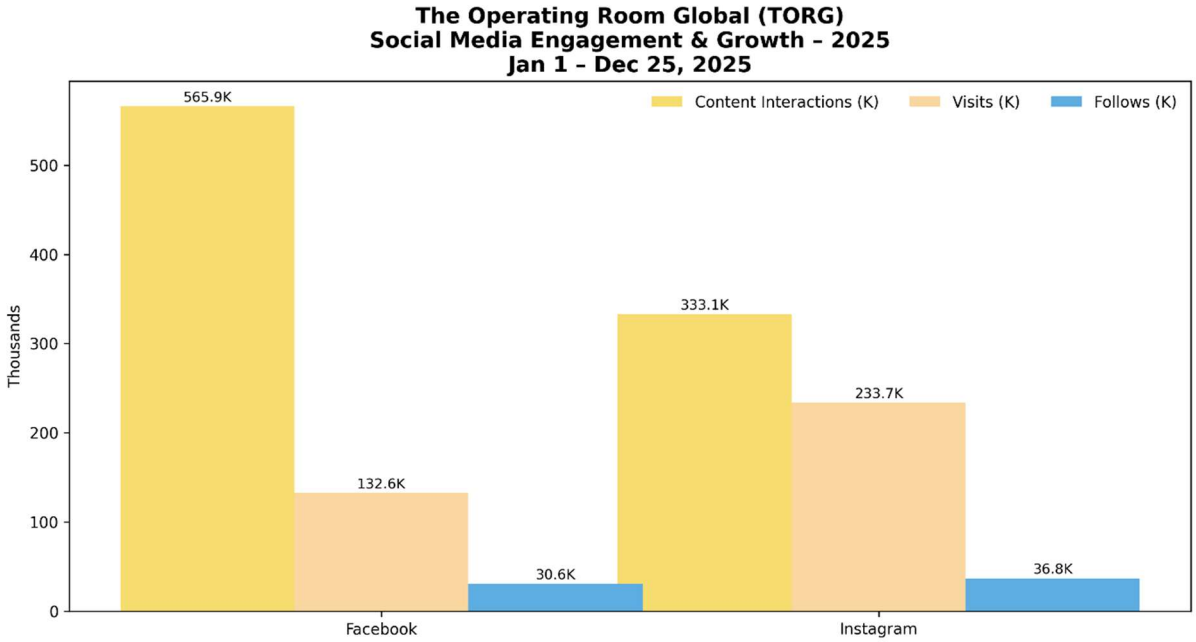


Figure 8b. Annual Engagement and Audience Growth (2025)

Annual content interactions, visits, and follower growth.

As per Figures 8a-8b, in 2025, TORG achieved extensive digital reach and engagement, generating over 82 million views, nearly 900,000 content interactions, and strong audience growth across Facebook and Instagram.

6. Education, Training & Capacity Building

6.1 Training Impact Overview

Total Number of Professionals Trained in 2025: 5,566 professionals (Figure 9).

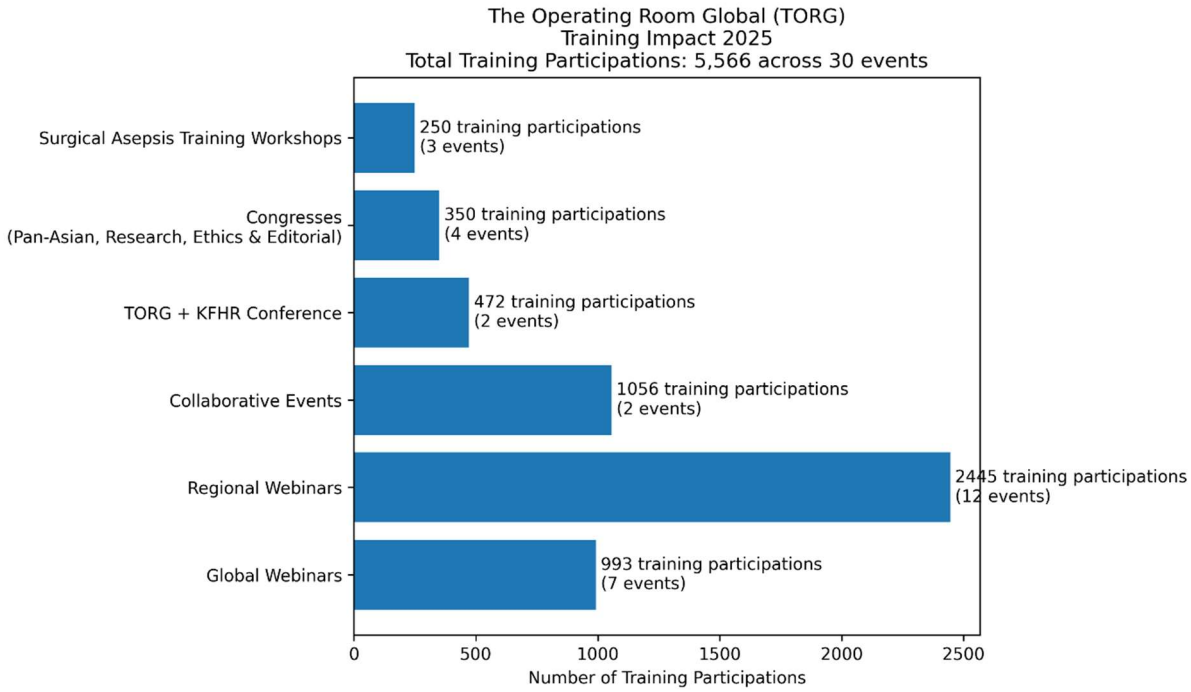


Figure 9. Training Impact 2025: Events, Modality, Dates, and Participation

Summary of training delivery by TORG in 2025, including number of events, delivery modality (virtual, in-person, hybrid), date ranges, and professionals trained.

6.2 Global Webinars (6 Events | 993 Trained)

Key global webinar topics and dates included (Table 1).

Event	Trained
Embracing our Destiny: Indications for Robotic Surgery and Advantages for Patients and Surgeons with Dr. Adel Abou-Mrad - TORG + TROGSS Webinar - March 9, 2025	256
Future of Surgery/ Surgery for Future with Amb./Prof./Dr. M. Mahir Özmen - TORG + TROGSS Webinar - May 4, 2025	224
Clinical Interview Masterclass: The STAR Technique for Surgical & Perioperative Roles with Amb./Prof./Dr. Adebusola Adenike Owokole - June 22, 2025	111
Standing Up for the World: The Global Orthopedic Crisis and Our Mission to Restore Mobility with Dr. Nicholas Ochieng Okumu - September 21, 2025	82
Building the Global Perioperative Workforce: Nurses, Anesthetists, and surgeons in Short Supply with Dr. Nikki Washington - October 05, 2025	125
Cyber threats in the OR: Evolving Risks and How to Safeguard Surgical Technology with DeJuan Kennedy - October 12, 2025	79
Neurosurgery Webinar: Topic 1: "Clinical Experience with Intracranial Tumors in Low-Resource Settings: Practical Insights and Lessons Learned" with Dr. Roland Nchufor Ndouh. Topic 2: "Building Capacity in Neurosurgery: Challenges and Opportunities in Resource-Limited Settings" with Dr. Charles Kachungungu - November 2, 2025	116
Subtotal - Global Webinars:	**993 trained**

Table 1. Global Webinars Delivered by TORG in 2025

6.3 Regional Webinars (12 Events | 2,445 Trained)

Regional webinars were delivered across Rwanda, Pakistan, Nigeria, Sierra Leone, Zimbabwe, and Ethiopia, addressing: Surgical safety and checklist implementation, Sterilization and infection control, Workforce wellbeing and ergonomics, Quality improvement in perioperative care and more (Table 2).

REGIONAL WEBINARS	Topics with Dates	TOTAL TRAINED
Rwanda	1. Awareness Under Anesthesia: Understanding, Preventing, and Managing Intraoperative Awareness with Dr. Justin Hagumimana (January 19, 2025, 188 Trained). 2. Surgical Safety Checklist in the Operating Room with Florence Furaha (February 9, 2025, 303 Trained) 3. Early Infant Male Circumcision (EIMC): Procedure, Benefits, and Complications Management" with Mr. Augustin Ntakirutimana (April 20, 2025, 104 Trained)	595
Pakistan	1. Essential Quality Assurance Standard in Central Sterile Supply Department (CSSD) with Mr. Muhammad Naveed (January 26, 2025, 186 Trained). 2. Workplace Satisfaction and Retention Strategies for OR Staff with Ms. Hira Salim (February 16, 2025, 141 Trained)	327
Nigeria	1. Reducing Musculoskeletal Injuries in Healthcare: Ergonomic Solutions and Best Practices with Oluwatoyin Akinlade (February 2, 2025, 176 Trained).	825

	2. Revolutionizing Sterilization: Exploring New Technologies, Environmental Impact, and Cost-Effectiveness in Healthcare with Jessie Lopez (March 2, 2025, 218 Trained). 3. Fostering a Safe and Respectful Workplace: Addressing Bullying, Harassment, and Violence with Mr. Sunday Ojekhekpen (April 13, 2025, 188 Trained). 4. Innovations in Sterilization and Surgical Instrument Maintenance: Enhancing Patient Safety through SHARP and STERI Programs with K. (Miles) Miles (May 11, 2025, 243 Trained).	
Sierra Leone	1. Implementation of Enhanced Recovery after Cesarean Section Protocol in Resource Limited Settings: A Quality Improvement Project from Evidence to Reality with Hailemariam Getachew Tesema (March 16, 2025, 188 Trained). 2. Perimortem Cesarean Section: A Life-Saving Procedure in Maternal Cardiac Arrest with Foday Daddy Mansaray (May 18, 2025, 112 Trained).	300
Zimbabwe	1. Comprehensive Perioperative Management: Enhancing Patient Safety and Surgical Outcomes" with Nothando Dube (April 27, 2025, 155 Trained).	155
Ethiopia	1. Safety Walk Rounds: A Leadership-Driven Journey to Patient Safety, Experience Sharing from Debre Birhan Comprehensive Specialized Hospital (DBCSH) with Dr. Nigussie Tefera Habiteyohannis (March 23, 2025, 108 Trained). 2. Pain Free Hospital Implementation: a Multidimensional Intervention to Improve Pain Management at University of Gondar Specialized Hospital, Ethiopia with Demeke Yilkal Fentie (May 5, 2025, 135 Trained).	243
Subtotal - Regional Webinars		**2,445 trained**

Table 2. Regional Webinars by Country, Topic, and Date (2025)

6.4 Conferences & Congresses

TORG + KFHR 2025 | 2nd Annual Scientific Conference & 10th Anniversary

The Operating Room Global (TORG), in collaboration with King Faisal Hospital (KFH), Kigali, Rwanda proudly celebrated the TORG+KFHR 2025 | 2nd Annual Scientific Conference & 10th Anniversary in the vibrant city of Kigali, Rwanda at IRCAD Africa.

- **Format:** Hybrid (In-person and Virtual)
- **Dates:** 26-28 August 2025
- **Professionals trained:** 472

Conference Modality	Date(s)	Trained
In-person	26 Aug 2025	176
Virtual	**26-28 Aug 2025**	**296**

Table 3. Participation by Conference Modality - TORG + KFHR Conference (August 2025)

Figure 10a: *TORG + KFHR 2025 | 2nd Annual Scientific Conference & 10th Anniversary*

Figure 10b: *TORG + KFHR 2025 | 2nd Annual Scientific Conference & 10th Anniversary*

Figures 10a & 10b highlight key moments from the TORG + KFHR 2025 | 2nd Annual Scientific Conference, commemorating TORG's 10th anniversary and showcasing multidisciplinary engagement and global collaboration.

6.5 Collaborative Events: Collaborative Regional Webinars & Global Health Dialogues (2025)

In 2025, The Operating Room Global (TORG) supported and co-delivered collaborative regional webinars and global health dialogue sessions focused on patient safety, multidisciplinary teamwork, and risk management in the operating room. These activities brought together surgeons, anaesthesiologists, perioperative nurses, surgical technologists, trainees, and students across Africa and Asia.

Through these initiatives, TORG-supported educational activities reached over 1,050 participants, spanning virtual and in-person engagement, and strengthened cross-regional collaboration in global surgical and perioperative care.

Date	Activity	Topic	Format	Participants Reached	Collaborating Organisations
20 July 2025	TORG-Ethiopia & TORG-Cameroon Collaborative Webinar	*Building Stronger Surgical Teams: Unity in Action*	Virtual Panel Discussion. Featuring 6 Panelists (2 Surgeons, 1 Anesthesiologist, 2 Perioperative Nurses, 1 Surgical Technologist) and 2 Session Chairs.	147 registered participants	TORG-Ethiopia Chapter, Cameroonian Medical Students' Association, InCiSioN Cameroon, Cameroon Nurses Association. Facilitated by Student Dr. Samuel Fodop, TORG Conference Fellow.
20 December 2025	Global Health Dialogue: Patient Safety & Risk Management in the Operating Theatre	*Patient Safety and Risk Management in the Operating Theatre*	Hybrid (In-person & Virtual)	727 in-person attendees; 182 online accounts (minimum 909 participants)	Emversity (India), TORG India Chapter. Facilitated by Dr. Zakir Hussain Parray.

Table 4: Summary of Collaborative Educational Activities

Table 4 summarises collaborative educational activities delivered in 2025, reaching a minimum of 1,056 multidisciplinary clinicians, trainees, and students through expert-led and interactive learning sessions.

6.6 Congresses (Pan-Asian, Research Ethics & Editorial Training), 4 Events | 350 Trained)

Activity	Trained
IRB Ethics Congress - 29 Jun. Theme: "Ethics in Global Surgery Research: Foundations, Challenges, and Best Practices" Featuring expert insights on: Global frameworks in surgical research ethics, Practical challenges with vulnerable populations, and Modern surgical paradigms and future perspectives.	89
TORGJ Editorial Forum - 3 Aug. Theme: "Publishing with TORGJ: Best Practices for Manuscript Preparation, Submission & Publication"	125
TORG-India Pan-Asian Congress - 23 Nov. Topic 1: "Surgical Asepsis: Foundations of Infection Prevention in the Operating Room" with Dr. Krunal Soni. Topic 2: "The Future of Orthopedic Surgery: Challenges, Opportunities, and Innovations" with Dr. Gratien Nzayikorera.	94
Global Research Fellowship (Cohort-wide teaching) - 6 Dec. Title: Development of Research Questions Addressing Pre- and Post-Operative Context with Dr. Elhadi Miskeen.	42

Subtotal - Research & Editorial Training	350 trained

Table 5. Participation in the Congresses (Pan-Asian, Research Ethics & Editorial Training).

Table 5 summarises participation across four congress-level educational activities in 2025, with a total of 350 participants trained in research ethics, academic publishing, surgical practice, and research capacity development.

6.7 Surgical Asepsis In-Person Training Workshops - TORG India (Apollo PROTECT Programme)

In 2025, the **TORG India Chapter** delivered a series of **three Surgical Asepsis Training Workshops** under the **Apollo PROTECT Orthopaedics Programme** at **Apollo Hospitals Ahmedabad**. Led by **Dr. Krunal Soni**, National Director, TORG India, the workshops focused on reinforcing core principles of surgical asepsis, infection prevention, patient safety, and operating theatre discipline for multidisciplinary operation theatre teams. Building on the success of the inaugural session, the subsequent workshops deepened participants' understanding of maintaining surgical asepsis, including proper scrubbing protocols, use of personal protective equipment, sterile field discipline, sterilisation indicators, and colour-coded safety systems. These repeat trainings were intentionally designed not as duplications, but as progressive reinforcements, contributing to a sustained culture of accountability, teamwork, and excellence in the operating theatre. The continued engagement of the surgical teams demonstrated a shared commitment to patient-centred, safe, and reliable surgical care.

Across the three workshops, **approximately 250 operating theatre professionals** were trained, reflecting significant institutional engagement and impact.

Key Training Focus Areas

- Surgical scrubbing and hand hygiene (5-7 minutes)
- Proper use of mask, cap, gown, and gloves
- Maintenance of sterile field and hand positioning
- Sterilisation indicators and compliance
- Colour-coded systems for infection prevention
- Team discipline and patient safety culture.

Table 6: Summary of Surgical Asepsis Training Workshops

Programme	Location	Organising Chapter	Lead Facilitator	Number of Workshops	Estimated Participants Trained	Key Focus
Apollo PROTECT - Surgical Asepsis Training Workshops	(In-Person) Apollo Hospitals, Ahmedabad, India	TORG India Chapter	Dr. Krunal Soni	3	~250 (approx.)	Surgical asepsis, infection prevention, OT discipline, patient safe

Table 6 summarises the delivery and focus areas of surgical asepsis training workshops, highlighting key infection prevention practices and patient safety principles reinforced across participating operation theatre teams.

Figure 11: Images from Surgical Asepsis In-Person Training Workshops - TORG India

6.8 Final Total - Trained In 2025

Category	Number of Events	Trained
Global Webinars	**7 events**	**993**
Regional Webinars	12 events	2,445
Collaborative Events	2 events	1,056
TORG+KFHR Conference	2 events	472
Congresses (Pan-Asian, Research Ethics & Editorial Training)	4 events	350
Surgical Asepsis Training Workshops	3 events	250
TOTAL TRAINED IN 2025	**30 EVENTS**	**5,566 TRAINING PARTICIPATIONS**

Table 7. Total Trained in 2025

In 2025, The Operating Room Global (TORG) delivered structured education and training activities reaching over 5,000 registered training participations across global and regional webinars, international congresses, conferences, and cohort-based research and ethics programmes.

7. Research, Innovation & Ethics

7.1 Global Research Projects

In 2025, The Operating Room Global (TORG) strengthened its research portfolio through the formal establishment and activation of the TORG Global Research Team, appointed in **January 2025** and officially inaugurated on **2 February 2025**. The team operates at the forefront of innovation, driving high-impact, multicentre research initiatives aligned with TORG's mission to enhance operating room practices, perioperative safety, and surgical systems globally.

The work of the TORG Global Research Team spans innovative research design, global data analytics, ethics and quality assurance, and knowledge dissemination, setting new benchmarks in perioperative research and education across diverse health system contexts.

7.1.1 TORG Global Research Projects (2025)

During the reporting period, five flagship research projects were initiated under the 2025 research portfolio. TORG contributed to and led several high-profile collaborative research initiatives in 2025:

- Ongoing Project D-25: *A Multinational Audit of WHO Surgical Safety Checklist Adherence in Low-Resource Settings.* Conducted across multiple sites and countries, this audit (initiated in April 2025) assesses compliance with the WHO Surgical Safety Checklist and identifies system-level barriers and facilitators to safe surgical practice.
- Onboarding WHO Operative Encounter Pilot (February 4, 2025): Participation in the WHO Clinical Registry Operative Encounter Module Pilot Project, developed under the guidance of the WHO Integrated Health Services Department, Clinical Services and Systems (CSY) Unit, with technical input from the G4 Alliance. The pilot involved multisites and supports global efforts to standardise operative data collection.
- Ongoing RAMPs Study - Regional Assessment of Lower Limb Amputations in Sub-Saharan Africa: A multinational, multidisciplinary collaborative project led by the University of Birmingham in partnership with TORG, launched through a call on 22 June 2025. The study assesses causes, care processes, and outcomes of lower limb amputations across sub-Saharan Africa.
- Ongoing - Geospatial Accessibility and Financial Protection for Bellwether Surgery in Resource-Limited African Communities: Led by the TORG-Ethiopia (TORG-ETH) Research Unit, this initiative (call issued 10 July 2025) examines geographic access to essential surgical services and financial risk protection for populations in resource-limited settings.
- Audit Project A-25: *Assessment of Safe Patient Handling Practices and Their Impact on Work-Related Musculoskeletal Injuries among Healthcare Workers in Nigerian Hospitals.* This study examines occupational health risks among healthcare workers, with a focus on ergonomics and injury prevention in perioperative and clinical settings.
- Ongoing Project F-25: Evaluating the Integration of Virtual Reality in Ophthalmology Surgical Training and Practice in Ireland: A Mixed-Methods Study. A doctoral-level mixed-methods research project inviting multidisciplinary collaborators to examine the educational, clinical, and implementation impact of Virtual Reality (VR) in ophthalmology surgical training and practice in Ireland. The study comprises a systematic literature review, semi-structured interviews with national and international stakeholders, a two-round Delphi consensus study, and the development of a national VR implementation framework.

7.1.2 Upcoming Projects:

- Project B-25: *Analyzing the Predictors of Knowledge Improvement in Endotracheal Intubation Training: A Secondary Analysis of Video-Assisted versus Hands-On Demonstration Data.* This project evaluates educational effectiveness in airway management training, comparing instructional modalities to inform evidence-based training strategies.

- Project E-25: *Identifying Novel Biomarkers for Postoperative Delirium in Older Surgical Patients After Major Non-Cardiac Surgery and Anesthesia.* Launched via a call in June 2025, this project explores the identification and validation of neuroinflammatory and neurodegenerative biomarkers (including GFAP, NfL, and IL-6) associated with postoperative delirium. The study aims to develop predictive models integrating clinical risk factors to improve perioperative outcomes in older surgical populations.

Figure 12: RAMPS Project Update, December 2025 and Multinational Audit Project Month 3 Update.

The images in Figure 12 highlight ongoing data collection, site engagement, and implementation progress across participating institutions in both research initiatives.

7.2 Institutional Review Board (IRB)

The **TORG Institutional Review Board (IRB)** plays a pivotal role in advancing ethical integrity, transparency, and excellence in global perioperative research conducted under the auspices of The Operating Room Global (TORG). Drawing on the collective expertise and commitment of its members, the IRB provides ethical oversight and guidance for innovative research studies aimed at enhancing patient safety, advancing clinical knowledge, and supporting sustainable global surgical development.

The TORG-IRB operates in accordance with internationally recognised ethical frameworks, including the Declaration of Helsinki, the Belmont Report, and applicable local and national regulatory requirements in countries where TORG-led research is conducted. Through this framework, the IRB ensures the protection of human subjects and the ethical conduct of research across diverse health system contexts.

Key Milestones and Activities (2025)

- **Inauguration:** The TORG-IRB was formally inaugurated on **19 February 2025**.
- **Proposal Submissions Opened:** Research ethics proposal submissions officially opened on **24 February 2025**.
- **IRB Expansion:** The IRB team was expanded on **20 April 2025**, strengthening its multidisciplinary and international capacity.
- **Inaugural Ethics Congress:**
  - **Date:** 29 June 2025
  - **Participants:** 89 registered professionals
  - **Theme:** *"Ethics in Global Surgery Research: Foundations, Challenges, and Best Practices"*
  - **Key focus areas:**
    - Global frameworks in surgical research ethics

- Ethical challenges in research involving vulnerable populations
- Emerging surgical paradigms and future ethical considerations

Regulatory Recognition and Assurance

Figure 13. Key IRB Milestones in 2025

In 2025, the TORG-IRB achieved significant regulatory milestones, further strengthening its governance framework:

- **Official Registration with the U.S. Office for Human Research Protections (OHRP):**
  - IORG Number: IORG0012466
  - IRB Number: IRB00014742
  - Registration Date: 28 April 2025
- **Federalwide Assurance (FWA):**
  - Issued by the U.S. Office for Human Research Protections (OHRP)
  - Date: 5 June 2025
  - FWA Number: FWA00035510

Impact and Strategic Significance

The establishment and formal recognition of the TORG-IRB significantly enhance the credibility and integrity of all research conducted under TORG. It ensures compliance with internationally accepted ethical standards, strengthens the protection of human research participants, and builds trust among partners, collaborators, and the communities served by TORG.

Furthermore, the IRB's governance framework positions TORG to expand global research collaborations, support scholarly publications, and deliver high-quality research training initiatives, reinforcing its leadership role in ethical research governance within global surgery and allied health fields.

8. Publications & Knowledge Dissemination

8.1 The Operating Room Global Journal (TORGJ), ISSN 3105-3262 (Online) | Quarterly | CC-BY 4.0 Licensed | Peer-Reviewed

In 2025, The Operating Room Global Journal (TORGJ) established a robust editorial governance structure to support high-quality scholarly publishing and knowledge dissemination in global surgery and perioperative care.

Key editorial milestones achieved during the reporting period included:

- Editorial Team Call: Conducted between February and April 2025, inviting experienced clinicians, researchers, and academics to contribute to the development of the journal.
- Editorial Team Appointment: The inaugural TORGJ Editorial Team was formally appointed on 27 May 2025.
- Editorial Team Inauguration: The TORGJ Editorial Team was officially inaugurated on 1 June 2025, marking the commencement of structured editorial operations.
- TORGJ Editorial Forum - *From Manuscript to Impact*:
  - Date: 3 August 2025
  - Participants Trained: 125
  - Focus: Best practices in manuscript preparation, peer review, submission processes, and publication ethics, aimed at strengthening research writing and publication capacity among global health professionals.

This structured approach to editorial governance and capacity building has strengthened the journal's academic integrity, supported authors from diverse settings, and reinforced TORGJ's role as a credible platform for disseminating high-quality research in global surgery and perioperative systems.

Publications.

In 2025, The Operating Room Global Journal (TORGJ) published two issues (Volume 1, Issues 1 and 2), featuring peer-reviewed original research, systematic reviews, audits, case reports, and policy-oriented analyses addressing surgical systems strengthening, patient safety, ethics, workforce performance, infection control, and access to surgical care in diverse global settings.

TORGJ - Volume 1, Issue 1 (2025)
10 Manuscripts, 36 Contributors
Theme: "*Strengthening Surgical Systems and Human Factors in Global Health*"
DOI: 10.64573/torgj0925001
This issue addressed surgical systems strengthening, workforce capacity, human factors, infection control, and patient safety across global contexts.

TORGJ - Volume 1, Issue 2 (December 2025)
10 Manuscripts, 37 Contributors
Theme: "*Advancing Safe, Ethical, and Sustainable Patient-Centred Care Across Surgical and Perioperative Systems*"
DOI: 10.64573/torgj1125001
Included original research, audits, systematic reviews, and case studies addressing sterilization safety, ethics, service access, clinical outcomes, and perioperative quality improvement.

8.2 TORG Magazine (TORG-MAG)

In 2025, The Operating Room Global Magazine (TORG-MAG) concluded its publication cycle, marking an important phase in TORG's knowledge dissemination strategy. All three issues of TORG-MAG were published on **Amazon in February 2025**, each featuring **eight manuscripts** addressing perioperative practice, innovation, and global surgical themes.

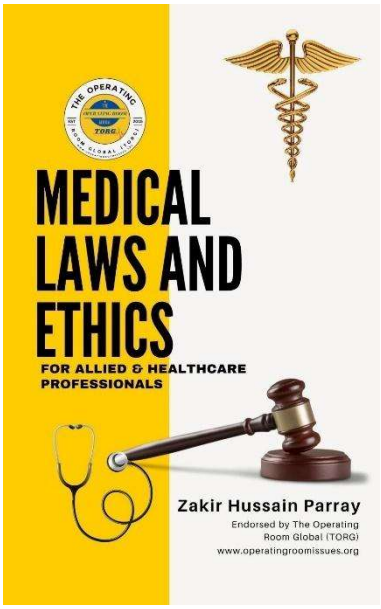
The issues published were:

- **Volume 1, Issue 1 -** ***Surgical Symphony*** (August 2024), Paperback ISBN: **9798311696913**
- **Volume 1, Issue 2 -** ***Innovating for Tomorrow*** (December 2024), Paperback ISBN: **9798311718851**
- **Volume 2, Issue 1 -** ***Bridging Borders, Saving Lives*** (March 2025), e-ISSN: **3078-5073**, ISBN: **9798313238302**

The **Inaugural Issue** (*Surgical Symphony*, August 2024) was printed and formally launched at the **TORG 2024 Inaugural Scientific Conference**, serving as a flagship publication for the organisation's early scholarly engagement. Following the establishment of **The Operating Room Global Journal (TORGJ)** as a peer-reviewed academic journal, the TORG-MAG was formally discontinued, reflecting a strategic transition toward a dedicated journal platform to support higher-impact scholarly publishing and academic indexing.

8.3 Official TORG Book Published

In **February 2025**, The Operating Room Global (TORG) published its first official book, ***Medical Laws and Ethics for Allied & Healthcare Professionals***, authored by **Dr. Zakir Hussain Parray**. The publication provides a comprehensive overview of legal and ethical principles relevant to allied health and healthcare professionals, supporting professional practice, patient safety, and ethical decision-making across diverse healthcare settings.



The book was released in multiple formats to enhance accessibility:

- **Kindle Edition:** ISBN **9798311593106**
- **Paperback Edition:** ISBN **9798311593106**
- **Hardcover Edition:** ISBN: 9798311600125

This publication represents a significant milestone in TORG's commitment to knowledge dissemination, professional education, and ethical practice within global healthcare and perioperative systems.

9. Strategic Partnerships

In 2025, The Operating Room Global (TORG) strengthened and expanded its strategic partnerships to advance education, training, research, and capacity building across surgical and perioperative disciplines globally.

9.1 Professional and Academic Partnerships

- **The Robotic Global Surgical Society (TROGSS) Partnership (Agreement signed: 19 April 2025).** In partnership with The Robotic Global Surgical Society (TROGSS), The Operating Room Global (TORG) supported intercontinental surgical training by facilitating and endorsing TORG members' applications to the TROGSS Intercontinental Training Program (ITP). Eligibility for observerships, fellowships, and visiting professorships in robotic surgery, advanced laparoscopy, and advanced endoscopy was restricted to TORG members, ensuring that programme access aligned with TORG's membership framework and professional development objectives.
- **Magister Chirurgiae (MCh), Association of Future Surgeons:** Partnership initiated on **13 January 2025** to support surgical education and early-career professional development.
- **ECAMS:** Celebrated **one year of partnership** on **1 February 2025**, providing TORG members with exclusive discounted access to aesthetic medicine and surgery training programmes.
- **UNICAF Scholarships:** Launched on **5 March 2025**, offering TORG members up to **85% scholarships** for online undergraduate, postgraduate, and doctoral programmes at partner universities, including University of California, Riverside Extension (UCR), UNICAF University, Liverpool John Moores University, University of Suffolk and University of East London.

9.2 Training, Innovation, and Capacity-Building Partnerships

- **Safe Surgery Innovation (STERI & SHARP):** Initiated on 27 January 2025 by the TORG-Nigeria Sterilization and Infection Control Committee in collaboration with Safe Surgery Innovation (SSI).
    - **STERI:** A globally recognised online certification programme in sterilization technology for LMIC healthcare settings.
    - **SHARP:** The world's first combined hands-on and e-learning programme for surgical instrument repair in LMICs.
- **IRCAD Africa:** In May 2025, TORG secured 50% discounted access for members to IRCAD Africa's minimally invasive surgery training programmes.

9.3 Research and Institutional Partnerships

- **RAMPs Study - University of Birmingham:** Memorandum of Understanding signed on 4 July 2025 to support a multinational study on lower limb amputations in sub-Saharan Africa.
- **International Bariatric Club (IBC), Oxford:** Partnership confirmed; Memorandum of Understanding signed in October 2025.
- **Murhesa Medical Center, Democratic Republic of Congo:** Initial engagement on 2 October 2025, with Memorandum of Understanding signed on 7 October 2025.

9.4 Upcoming Partnerships

- Borama Regional Hospital, Somaliland: Initial partnership meeting held on 29 November 2025.
- Max King Institute, Rwanda: Partnership initiated on 1 December 2025.

10. Chapter Growth & Leadership

Leadership Appointments (2025)

Between January and March 2025, leadership appointments were made to strengthen national and global leadership capacity:

- India x 2, Nepal x 1, Burundi x 1 Nigeria

Additional leadership appointments during the year included:

- June 2025: Cameroon, *Conference Media & Outreach Fellow*.
    - July 2025: New Zealand, Russia, Nigeria
- September 2025: India, *National Director*.
    - October 2025: New TORG Governing Board Members appointed for 2025/2026 Term.

11. Volunteer Engagement & Governance

In 2025, The Operating Room Global (TORG) strengthened volunteer participation and organisational capacity through structured calls, appointments, and leadership development initiatives across research, governance, and creative functions.

Key volunteer engagement milestones included:

- **Global Calls for Volunteers (January-April 2025):** Open calls issued for participation in the TORG Global Research Team, Institutional Review Board (IRB), and TORG Journal Editorial Team, supporting multidisciplinary and international representation.
- **Expansion of TORG-Nigeria Committees:** Committee structures within TORG-NG were expanded in January 2025 to enhance local programme delivery and operational effectiveness.
- **TORG Creative Design Team (TORG-CDT):**
  - Call for volunteers and appointments conducted in July 2025. Two additional expanded calls in the last quarter of 2025.
  - Promotions and structural reorganisation implemented in October 2025, resulting in the appointment of one Director and two Unit Heads.
- **TORG Research Mentors' Network (TORG-REM):** Calls and appointments for research mentors were completed in October 2025, supporting structured mentorship and research capacity building.
- **TORG Governing Board:** Calls and appointments were conducted between October and November 2025, with the formal inauguration held on 16 November 2025.

These volunteer engagement activities strengthened governance, expanded professional participation, and reinforced TORG's commitment to inclusive leadership and sustainable organisational growth.

12. Legal Incorporation in Ireland

In 2025, The Operating Room Global (TORG) reached a significant organisational milestone with the successful legal incorporation of The Operating Room Global Centre for Education, Research & Innovation Ltd in the Republic of Ireland. This incorporation represents an important step in strengthening TORG's legal and institutional foundation as a global organisation.

The establishment of a legally recognised entity enhances TORG's governance, transparency, and accountability, while expanding opportunities for international partnerships and collaboration. It also positions TORG to access international grant funding, research frameworks, and formal institutional engagements, supporting the organisation's long-term sustainability and impact in global surgical and perioperative education, research, and innovation.

13. TORG-Democratic Republic of Congo (DRC) Chapter

In October 2025, The Operating Room Global (TORG) formalised the establishment of its Democratic Republic of Congo (DRC) Chapter through the official signing of a Memorandum of Understanding (MoU) with Murhesa Neurosurgical Center, Bukavu, South Kivu, on 7 October 2025. This partnership designates Murhesa Neurosurgical Center as TORG's National Hub in the DRC, strengthening regional capacity for surgical education, innovation, and research.

As part of ongoing collaborative efforts, representatives from the TORG-DRC National Hub, Dr. Charles Kachungungu (Consultant Neurosurgeon and Head of Murhesa Neurosurgical Center) and Dr. Chris Kitumaini (Medical Advisor, Murhesa Neurosurgical Center)

undertook a strategic visit to IRCAD Africa. The visit supported knowledge exchange and collaboration in surgical training, research, and innovation.

14. TORG Global Research Fellowship - Mentorship Track

In October 2025, The Operating Room Global (TORG) inaugurated the TORG Global Research Mentors' Network (TORG-REM) and launched the Global Research Fellowship - Mentorship Track, a structured 12-month programme (December 2025-November 2026) designed to build research capacity among early-career clinicians, surgical trainees, medical students, and allied health professionals.

The inaugural cohort comprises 31 selected fellows representing 7 countries, reflecting the programme's global reach and commitment to inclusive research capacity development. The fellowship is supported by 10 globally selected, multidisciplinary research mentors with expertise across surgery, anesthesia, perioperative nursing, biomedical sciences, and health systems research.

Mentors provide structured guidance through monthly mentor-mentee meetings, targeted workshops on research methodology, manuscript development, and scientific presentation skills, and ongoing monitoring of project milestones. Fellows undertake research, audit, or quality improvement projects aligned with TORG's mission, with programme outputs culminating in abstract submission to scientific conferences, publication in The Operating Room Global Journal (TORGJ), and oral presentation at the Virtual TORG Global Research Symposium. Structured processes are in place to address underperformance, uphold academic standards, and foster international collaboration and professional development.

15. Establishment of the TORG Scholarship & Fellowship Support Fund

During the reporting period, **The Operating Room Global (TORG)** initiated the development of a unified funding mechanism to support education, fellowship completion, research, and capacity-building activities across its global programmes.

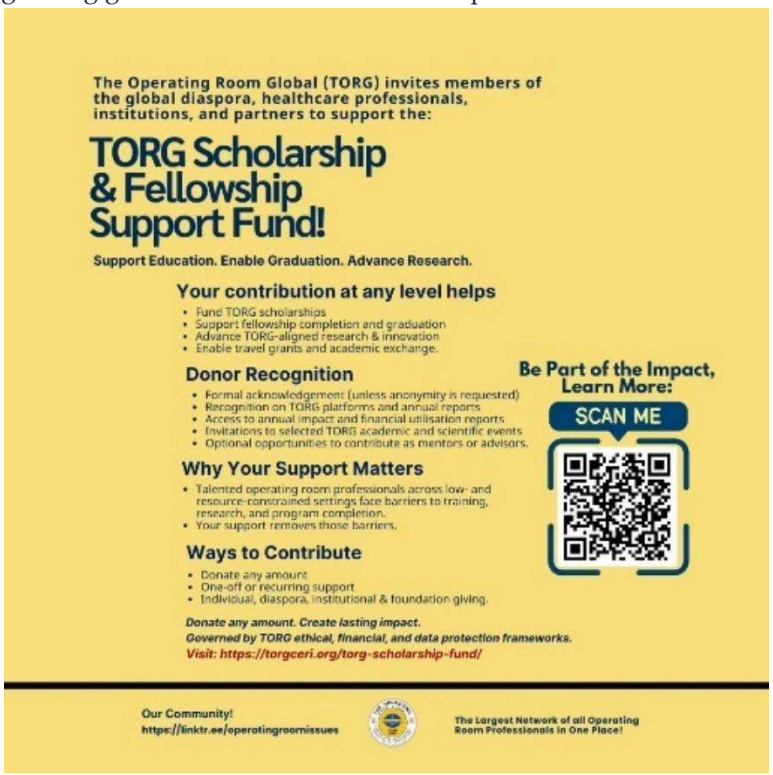
The **TORG Scholarship & Fellowship Support Fund** was conceptualised as a transparent, ethically governed fund through which members of the global diaspora, healthcare professionals, institutions, and partners may contribute **any amount** towards:

- TORG scholarships and structured educational programmes
- Fellowship completion and graduation support
- TORG-aligned research and innovation projects
- Travel grants and academic exchange opportunities

The Fund integrates fellowship support within the broader scholarship framework, ensuring flexibility, equity, and sustainability, while maintaining strong governance and academic independence.

A recognition-based donor framework was developed to acknowledge contributions ethically and non-commercially, with no donor influence over selection, training, or research outcomes. Provisions were also established for impact and financial utilisation reporting, donor recognition preferences (including anonymity), and optional invoicing or payment link requests to support institutional and diaspora contributors.

This initiative reflects TORG's continued commitment to strengthening global operating room education, research, and leadership development through accountable, inclusive, and sustainable resource mobilisation.



16. Milestones & Achievements

Organisational Growth & Visibility

- Surpassed major digital engagement milestones, reflecting sustained global reach and community growth:
  - 80,000 Facebook followers - January 13, 2025
  - 90,000 followers - May 2025
  - 95,000 followers - July 9, 2025
  - 100,000 followers - September 13, 2025
- Strengthened TORG's visibility and influence as a global convening platform for operating room professionals.
- In 2025, TORG achieved extensive digital reach and engagement, generating over 82 million views, nearly 900,000 content interactions, and strong audience growth across Facebook and Instagram.
- During the last 28 days (Nov 27-Dec 24, 2025), TORG achieved strong digital engagement across platforms, recording over 4.3 million monthly views, 57,700 content interactions, and continued audience growth, with total followers reaching 109,513 on Facebook and 97,778 on Instagram.

Governance, Leadership & Institutional Development

- Appointed the TORG Global Research Team in January 2025 and formally inaugurated the team on February 2, 2025, strengthening research leadership and coordination.
- Inaugurated the TORG Governing Board (2025-2026) on October 16, 2025, reinforcing governance, oversight, and strategic direction.
- Incorporated a new organisational arm in Ireland: The Operating Room Global Centre for Education, Research & Innovation - June 24, 2025, strengthening TORG's institutional and legal presence in Europe.

Education, Training & Capacity Building

- Successfully delivered the inaugural TORG-King Faisal Hospital Rwanda (KFHR) Clinical Observership Programme in March 2025, providing hands-on clinical exposure and skills enhancement for the first cohort of participants.
    - The programme contributed to clinical skill development and patient care at KFHR.
    - Call for the 2026 Cohort opened in October 2025, reflecting programme sustainability and growth.
- Advanced structured scholarship and fellowship pathways, including planning for the TORG Scholarship & Fellowship Support Fund, to support education, programme completion, and leadership development.

Research, Ethics & Academic Output

- Confirmed participation of 44 hospitals across multiple countries for the WHO Surgical Safety Checklist Audit - April 2025.
- Achieved key regulatory and ethical milestones:
    - Institutional Review Board (IRB) registration
    - Federalwide Assurance (FWA) secured between February and July 2025
- Published the first TORG book on February 21, 2025, marking a significant milestone in academic dissemination and knowledge leadership.
- Appointed the TORG Journal (TORGJ) Editorial Board on May 27, 2025, strengthening academic publishing capacity.

Partnerships & Global Collaboration

- Signed a Memorandum of Understanding (MoU) with the RAMPs Team, University of Birmingham on July 4, 2025, supporting collaborative research on lower limb amputations in sub-Saharan Africa.
- Strengthened partnerships with King Faisal Hospital Rwanda (KFHR) through education, observerships, and anniversary activities.
- Continued to expand regional and international collaborations across Africa, Europe, and Asia.

Chapters, Regional Expansion & Events

- Celebrated the 10th Anniversary of The Operating Room Global in Kigali, Rwanda in August 2025, marking a decade of impact in global operating room education, research, and advocacy.
- Inaugurated the TORG-Democratic Republic of Congo (DRC) Chapter at Muhesa Neurosurgical Center, Bukavu, South Kivu - October 2025, expanding TORG's regional footprint.
- Delivered the TORG-India Pan-Asian Congress 2025 on November 23, 2025, strengthening engagement across Asia and promoting cross-regional collaboration.

Strategic Sustainability & Resource Mobilisation

- Conceptualised and initiated the TORG Scholarship & Fellowship Support Fund as a unified, transparent mechanism to support:
    - Scholarships
    - Fellowship completion and graduation
    - Research and innovation
    - Travel grants and academic exchange
- Developed ethical donor recognition frameworks, opt-in donor engagement mechanisms, and impact reporting structures to support sustainable and accountable resource mobilisation.

Conclusion & Forward Strategy

The year 2025 strengthened TORG's foundations in education, research, governance, and global collaboration. In 2026, TORG will focus on scaling training delivery, expanding research outputs, deepening partnerships, and advancing ethical and innovative surgical systems worldwide.

APPENDIX A: TORG MEMBER COUNTRIES BY REGION (DECEMBER 2025)

This appendix presents the TORG member country entries by geographic region as of December 2025. Figures reflect country entries rather than unique sovereign states, as some entities are counted in more than one region due to transcontinental classification.

Africa (31 Country Entries):
TORG member countries in Africa include Nigeria, Tanzania, Swaziland (now Eswatini), Zimbabwe, Kenya, South Africa, Rwanda, Ghana, Cape Verde, Malawi, South Sudan, Namibia, Egypt, Mauritius, Zambia, Senegal, Botswana, Gambia, Angola, Ethiopia, Cameroon, Libya, Sierra Leone, Uganda, Somalia, Tunisia, Morocco, Democratic Republic of Congo, Burundi, Algeria, and Burkina Faso.
Asia (29 Country Entries):
In Asia, TORG member country entries include Malaysia, Philippines, Saudi Arabia, Pakistan, India, Indonesia, Nepal, Russia (partly in Europe and Asia), United Arab Emirates, Iraq, Iran, Jordan, Singapore, Palestine, Bahrain, Oman, Taiwan, Vietnam, Yemen, Japan, Hong Kong, Lebanon, Bangladesh, Sri Lanka, Kazakhstan, Azerbaijan (Eurasia), Maldives, Qatar, and Afghanistan.
Australia and Oceania (4 Country Entries):
TORG representation in Australia and Oceania includes Australia, Fiji, Papua New Guinea, and Kiribati.
Central America (3 Country Entries):
In Central America, TORG member country entries include Puerto Rico, Antigua & Barbuda, and St. Lucia.
Europe (35 Country Entries):
European TORG member country entries include Sweden, Greece, Denmark, Monaco, Germany, Wales, England, Scotland, Northern Ireland, North Macedonia, the Netherlands, Albania, Hungary, Russia (partly in Europe and Asia), Cyprus, Latvia, Lithuania, Republic of Ireland, Portugal, Spain, Poland, Croatia, Czech Republic, Austria, Liechtenstein, Finland, Norway, France, Belgium, Kosovo, Romania, Italy, Azerbaijan (Eurasia), Bulgaria, and Andorra.
North America (7 Country Entries):
In North America, TORG member country entries include the United States of America, Jamaica, Mexico, Bermuda, the British Virgin Islands (BVI), Dominica, and The Bahamas.
South America (4 Country Entries):
South American TORG member country entries include Brazil, Ecuador, Colombia, and Peru.
Appendix Note

- **Total country entries: 113**
- This total reflects entries, not unique sovereign countries.
- Some entities are counted more than once due to transcontinental classification, notably Russia (Europe & Asia) and Azerbaijan (Europe & Asia). Total Member Countries: 111.

APPENDIX B: DISSOLVED COMMITTEES AND LEADERSHIP STRUCTURES (2025)

The following committees, chapter executive teams, and organisational structures were formally dissolved in 2025 as part of TORG's governance review, restructuring, and strategic realignment processes. Dissolutions were undertaken to strengthen organisational effectiveness, streamline operations, and support sustainable growth.

- TORG Nigeria Chapter Executives: Created 1 August 2023; dissolved 3 February 2025.
- TORG-Nigeria Workplace Health and Safety Committee: Created 25 September 2024; dissolved 25 September 2025.
- TORG-Nigeria Sterilization and Infection Control Committee: Created 25 September 2024; dissolved 25 September 2025.
- TORG Global Education & Training Committee: Created 24 September 2024; dissolved 25 September 2025.
- TORG Pakistan Chapter Executives: Created 6 August 2023; dissolved 25 September 2025.
- TORG Magazine (TORG MAG): Created 26 August 2024; dissolved 25 September 2025.
- TORG Zambia Chapter Executives: Created 7 October 2024; dissolved 25 September 2025.
- TORG Rwanda Chapter Executives: Created 26 May 2024; dissolved 25 September 2025.
- TORG Executive Council: Created 14 November 2019; dissolved 26 September 2025.

APPENDIX C: TORG+KFHR 2025 - 2ND ANNUAL SCIENTIFIC CONFERENCE & 10TH ANNIVERSARY PROGRAMME

This appendix provides a detailed overview of the scientific programme and participation at the TORG+KFHR 2025 | 2nd Annual Scientific Conference & 10th Anniversary, held in Kigali, Rwanda, through a hybrid format combining in-person and virtual sessions.

Conference Overview

- In-Person Session: Date: 26 August 2025, Professionals Trained: 176
- Virtual Sessions: Dates: 26-28 August 2025, Professionals Trained: 296

(Virtual sessions are counted once per cohort across the three-day programme.)

In-Person Scientific Programme

Keynote Addresses

- **Dr. Menelas Nkeshimana**
  Workforce Development as a Catalyst for Global Health Equity: The Impact of Rwanda's 4×4 Strategy.
- **Amb./Prof./Dr. Adebusola Adenike Owokole**
  (Founder, President & CEO, The Operating Room Global)
  A Decade of Impact: Strengthening Surgical Systems Through Global Collaboration and Innovation - The Role of The Operating Room Global (TORG).

Invited Speaker Session

- **Dr. Daniel David Otobo**
  Strengthening Health Systems for Better Surgical Outcomes: The Role of Policy and Advocacy.

In-Person Oral Abstract Presentations

- **TORGxKFHR 2025-26080-1**
  Optimizing Perioperative Anesthesia Management for Patients with Non-Communicable Diseases, Rwanda.
  Presenter: Yves Kwihangana (Student, Department of Anesthesia, College of Medicine and Health Sciences, University of Rwanda)
- **TORGxKFHR 2025-26080-2:** *Surgical Characteristics of Appendectomy in the Eastern Region of the Democratic Republic of Congo: A Cross-Sectional Study.* **Presenters:** Dr. Aymar Akilimali, Dr. Daniel David Otobo, Dr. Jones Onesime, Excellent Rugendabanga
- **TORGxKFHR 2025-26080-3:** *An Obstructive Uropathy Revealing a Hydrometrocolpos in a 5-Month-Old Child: A Case Report.* **Presenter:** Samuel Ghislain Junior Fodop (School of Health and Medical Sciences, Catholic University of Cameroon)
- **TORGxKFHR 2025-26080-4:** *Assessment of Mental Health of Pregnant and Postpartum Women Attending Antenatal and Postnatal Services in Tertiary Health Institutions in Anambra State, Nigeria.*
  Presenter: Ada Esther Ozoemena (College of Nursing Science, Nnamdi Azikiwe University Teaching Hospital, Nnewi, Nigeria)
- **TORGxKFHR 2025-26080-5:** *Emergency Room Foley Catheter Retrieval of an Esophageal Foreign Body in a Low-Resource Setting: A Case Report.* **Presenter:** Dr. Wunde Njineck Ubraine (University of Yaoundé, Cameroon)
- **TORGxKFHR 2025-26080-6:** *Digital-First: Equipping the Next Generation of Health Leaders with Tech-Driven Problem-Solving Skills.* **Presenter:** Gaston Ndagijimana (Medical Student & Founder, MediGo Care Rwanda)

Virtual Panel Discussions

- **Anesthesiology:** *Advancing Anesthesia Care in LMICs: Innovations and Workforce Development.*
- **Perioperative Nursing:** *Strengthening Perioperative Nursing in Low-Resource Settings: Challenges and Strategies for Growth.*
- **Surgical Technology:** *Innovations in Surgical Technology and Sterile Processing: Enhancing Patient Safety.*
- **Surgery:** *The Journey to Surgical Excellence: Training, Mentorship, and Overcoming Barriers.*

Virtual Scientific Programme

Keynote Addresses

- **Prof. David J. O'Regan,** *A Journey of Mastery through Accessible and Sustainable Learning.*
- **Prof. Adel Abou-Mrad,** *Innovations in Surgery: New Techniques and Technologies.*

- **Prof. Rodolfo J. Oviedo,** *Ethics and Leadership in Global Surgery.*
- **Prof. Dr. Bhavneet Bhalla,** *Smarter Surgeries: The Role of Artificial Intelligence in Robotic Surgery.*

Speaker Sessions

- **Muhammad Naveed.** *The Environmental Impact of Sterilization and Sustainability in Sterile Processing.*
- **Dr. Raghav Bansal,** *The Journey of a Future Surgeon: Challenges, Opportunities, and Insights.*

Virtual Oral Abstract Presentations

- **TORGxKFHR 2025-28080-1**
  Exploring Challenges and Lessons Learned from Mass Casualty Management and Response: A Qualitative Phenomenological Research Design. **Authors:** Demeke Yilkal Fentie et al. (University of Gondar, Gondar, Ethiopia)
- **TORGxKFHR 2025-27080-2**
  Prevalence and Sex-Related Differences of the Thebesian Valve in a Black African Population: Autopsy Study in Kenya. **Authors:** Kiruka Kimani, Prof. Moses Obimbo, Dr. James Kigera (University of Nairobi, Kenya)
- **TORGxKFHR 2025-27080-4**
  A Miraculous Journey: Mother's Triumph over Two Episodes of Cardiac Arrest and Successful Peri-Mortem Cesarean Section in a Resource-Limited Setting. **Authors:** Unisa Kanu et al. (Koidu Government Hospital, Sierra Leone)

Appendix Note

This appendix provides a comprehensive academic and programme record of the **TORG+KFHR 2025 Conference**, complementing the high-level participation and impact summary presented in the main body of the Annual Report.

CITE THIS ARTICLE:

- **APA (7th edition):** Owokole, A. A. (2026, March 1). Institutional report: The Operating Room Global (TORG) annual report 2025. The Operating Room Global Journal (TORGJ), 2(1). https://doi.org/10.64573/torgj2602006
- **Harvard:** Owokole, A.A., 2026. Institutional report: The Operating Room Global (TORG) annual report 2025. The Operating Room Global Journal (TORGJ), 2(1). Published 1 March. Available at: https://doi.org/10.64573/torgj2602006
- **Vancouver:** Owokole AA. Institutional report: The Operating Room Global (TORG) annual report 2025. The Operating Room Global Journal (TORGJ). 2026 Mar 1;2(1). https://doi.org/10.64573/torgj2602006
- **MLA (9th edition):** Owokole, Adebusola Adenike. "Institutional Report: The Operating Room Global (TORG) Annual Report 2025." The Operating Room Global Journal (TORGJ), vol. 2, no. 1, 1 Mar. 2026, https://doi.org/10.64573/torgj2602006
- **Chicago (Author-Date):** Owokole, Adebusola Adenike. 2026. "Institutional Report: The Operating Room Global (TORG) Annual Report 2025." The Operating Room Global Journal (TORGJ) 2 (1), March 1. https://doi.org/10.64573/torgj2602006

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MONTH 5 UPDATE
735 PROCEDURES
TOP 5 COUNTRIES
1. ETHIOPIA
2. NIGERIA
3. TANZANIA
4. PAKISTAN
5. GHANA
Top 10 Hospitals
1. Global Maternity, Tanzania.
2. Debre Berhan Comprehensive Specialized Hospital, Ethiopia.
3. University of Gondar Comprehensive Specialized Hospital (UOG), Ethiopia.
4. Babcock University Teaching Hospital, Nigeria.
5. Indus Hospital & Health Network (IHHN) QF, NST & SMP Campus, Pakistan.
6. Federal Medical Centre Nguru, Nigeria.
7. District Headquarter Hospital, Parachinar, Pakistan
8. Aminu Kano Teaching Hospital, Nigeria.
9. FOCOS Orthopedic Hospital, Ghana.
10. Debre Tabor Comprehensive Specialized Hospital, Ethiopia.
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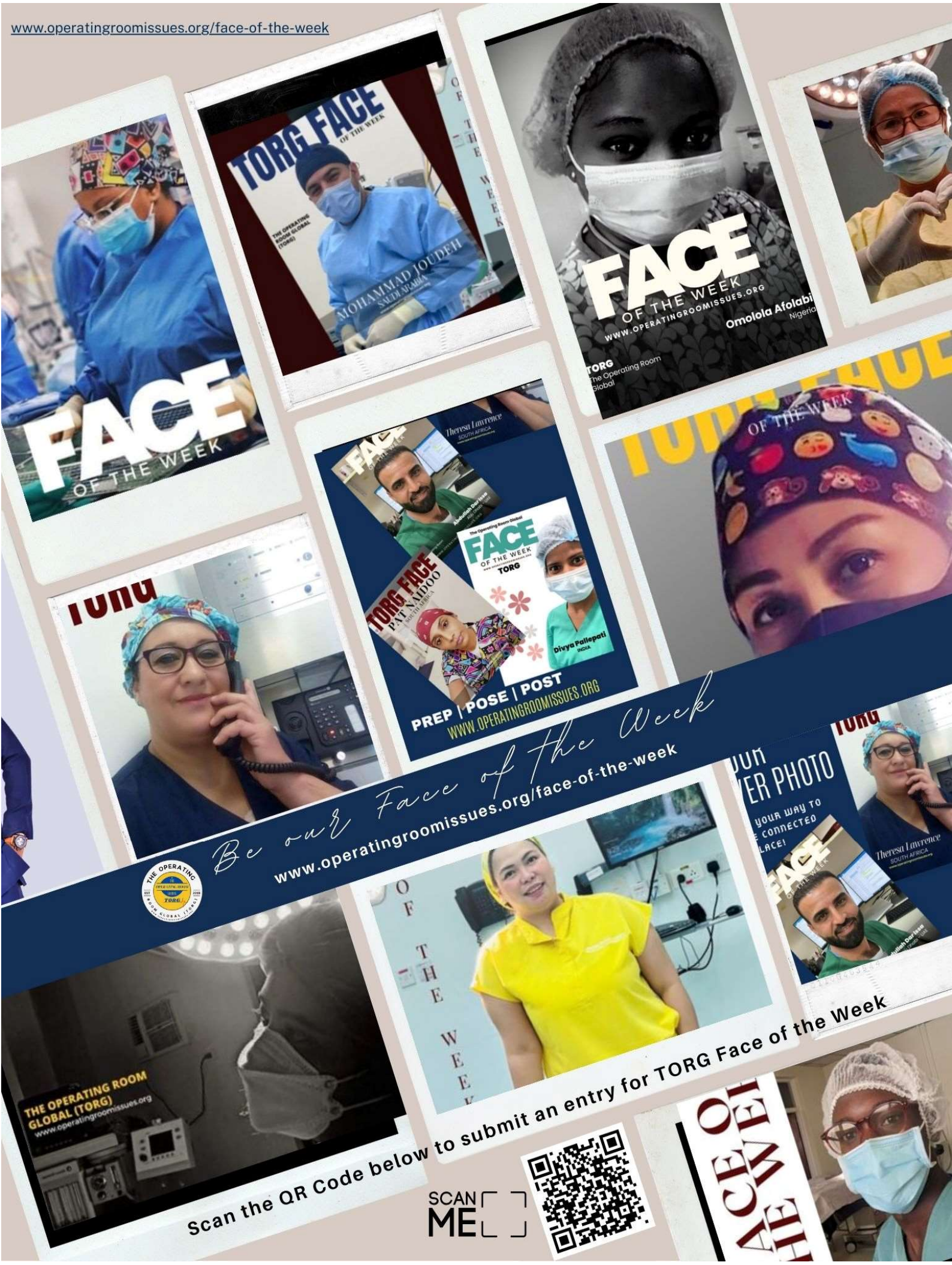

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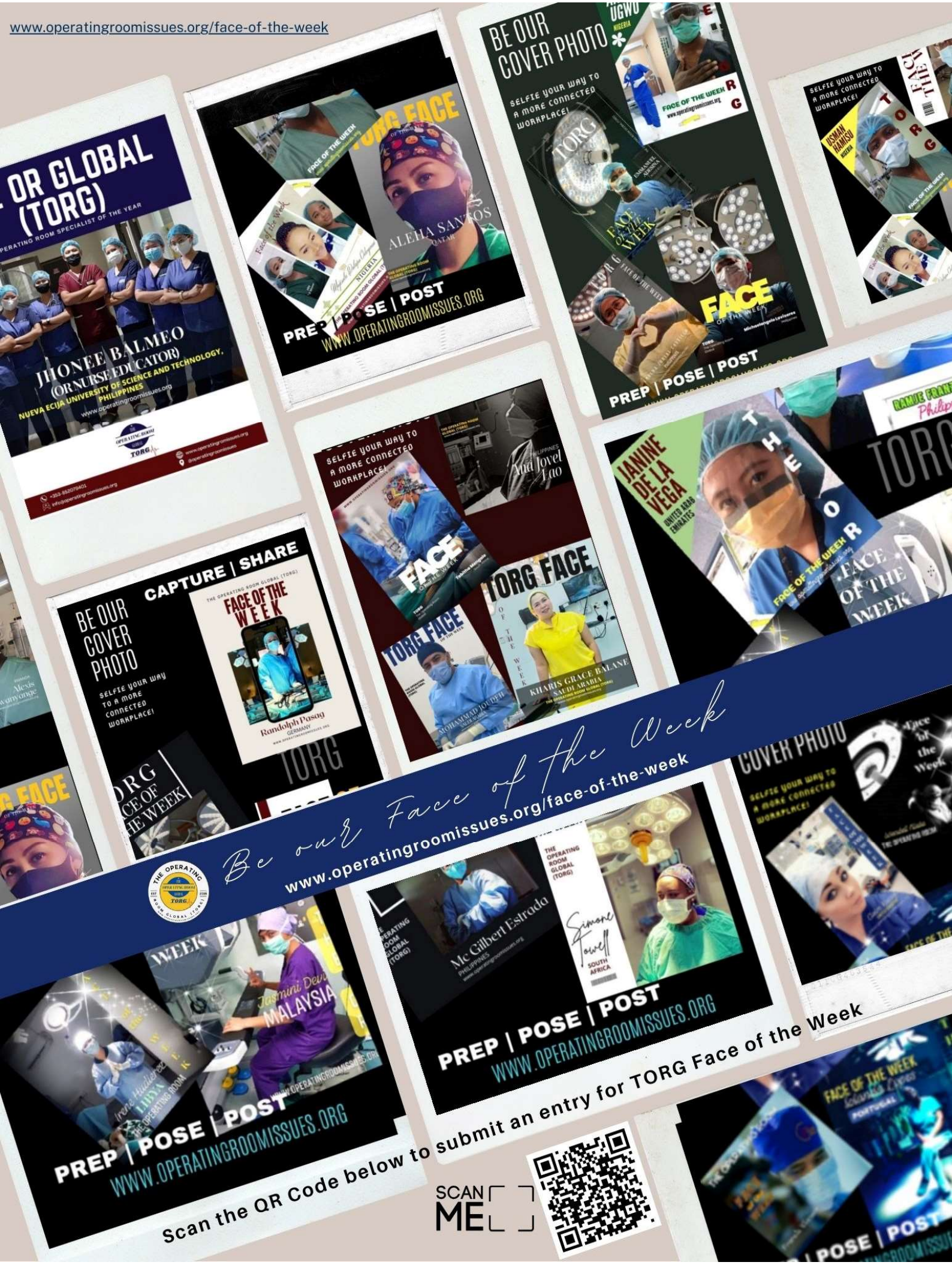

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