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The future of artificial intelligence in perioperative nursing

Artificial Intelligence (AI) stands poised at the forefront of health care innovation, promising transformative advances across multiple domains. In the field of perioperative nursing, where precision, efficiency and patient safety are paramount, the integration of AI holds immense potential to revolutionise clinical practice.

Defined as the imitation of human acumen, AI enables computers to perform tasks 'that typically require human intelligence, such as decision-making, problem-solving and learning'[1]. This editorial explores the current landscape of AI, future prospects for AI in perioperative nursing and the ethical imperatives that accompany this transformative paradigm shift.

As technology continues to evolve rapidly, perioperative nursing stands to benefit from AI-driven solutions that enhance diagnostic accuracy, optimise patient outcomes and streamline workflows. The possibilities for innovation are vast, from AI-assisted decision-making algorithms to predictive analytics and virtual reality training simulations. However, alongside these opportunities lie challenges that demand careful consideration, including privacy concerns, algorithm biases and the ethical implications of augmenting human expertise with AI.

Current landscape of artificial intelligence

Integration of AI is gaining momentum in the perioperative nursing landscape, albeit at varying degrees across different health care settings. Notably, robotic-assisted surgery has been widely used for some time[2]. Robotic surgical systems, equipped with advanced imaging and navigation capabilities, enable surgeons to perform minimally invasive procedures with enhanced precision and dexterity. Perioperative nurses play a crucial role in supporting these procedures, ensuring the seamless integration of robotic technology into the surgical workflow and optimising patient outcomes[2]. Other frontiers in robotic surgery include research into and development of autonomous surgical robots[3]. Some of these use AI models to give them the ability to solve problems, recognise words and objects, and make decisions.

Much work currently being undertaken using AI has significant application in the domain of pre-operative assessment for the identification of patients who are at risk[4]. AI leverages large datasets in predictive analytics and machine learning to provide practical solutions in the provision of proactive, patient-centred care.

'Predictive analytics' is used for forecasting based on previous history. 'Machine learning' is a subfield of AI and one type of modelling used in predictive analytics where engineers 'teach' the computer to associate data with specific outcomes[5]. Algorithms are applied to data and identify patterns that are used to create models that can be used to individualise patient management based on their personal profile[6]. While both

predictive analytics and machine learning have a basis in applied mathematics, predictive analytics is older and more likely to have a reporting purpose while machine learning focusses on modelling and has a wider range of purposes[7].

Using data such as patient demographics, medical history, diagnostic tests and electronic medical record (EMR) evidence, clinicians are able to make informed decisions and optimise surgical outcomes. Machine learning methods hold the potential for identifying frail patients and patients at risk of complications, mortality and admission to the intensive care unit (ICU)[8, 9].

Decision support systems powered by AI are being employed to assist perioperative clinicians in real-time clinical decision-making[5]. Machine learning models provide evidence-based recommendations regarding operating decisions, surgical procedures, modifiable risk factors and post-operative care protocols[5]. Further, this technology is being used to predict and prevent medication errors[6] and even predict prolonged lengths of stay for specific patient cohorts[10]. Augmentation of clinicians' expertise with AI-driven insights has the potential to enhance patient safety and streamline care delivery processes such as discharge planning and staffing.

In perioperative nursing education, preparation for rare events has paved the way for AI use across multiple platforms. Skills and knowledge have traditionally been acquired from the written form and supervised practice. Harnessing AI has led to advances such as tablet-based digital simulation for learning surgical instrumentation[11]. Here in Australia, a virtual reality simulation is in development for experiencing the instrument nurse role during a ruptured abdominal aortic aneurysm[12]. Participating in online simulation using AI-generated virtual patients is already embedded into clinical use. This platform provides an opportunity for immediate feedback to the clinician, as the virtual patient can learn and react to the nurses' decisions in real time[1].

Moving into the tertiary education sector, AI is also used in mannequins for simulation-based learning[13]. Generative AI is used by educators to create realistic patient scenarios[14] and devise novel educational activities. AI platforms such as ChatGPT (Chat Generative Pre-trained Transformer) may also be used by students, for example, if a student requires further information on a specific concept[15]. Some students also use AI when writing assignments, and this raises concerns about academic integrity[14].

Future directions

Incorporating AI is poised to revolutionise our profession. For nurses working at the patient-care interface, AI can streamline perioperative workflows allowing nurses to focus on higher-value activities. From administrative duties like scheduling and documentation to clinical tasks such as medication management and wound care, AI-driven automation tools could be developed to enhance efficiency, reduce errors and optimise resource allocation. Let us delve into some future predictions for AI that may impact perioperative nursing.

AI's potential extends to logistical support; for example, robots could retrieve items from Central Sterile Supply Services, eliminating the need for a circulating nurse to leave the operating room if an instrument is dropped[16]. Imagine a scenario where surgical setups are automated, and surgeon preference cards are instantly updated to reflect real-time activities. This could lead to a system with no missing instruments, thanks to micro-level tracking and management of sterile supplies. Such advancements could not only prevent supply service issues with instrumentation, but also eliminate intra-operative delays (such as the wait for a radiographer) and ensure no single-use items are ever 'on backorder'. The questions arise: Could robots assist with restocking? Could AI help triage phone calls for medical colleagues who are scrubbed in?

AI-driven automation tools could be developed to optimise resource allocation. Perioperative staff management could be revolutionised with an equitable request and rostering system, improving efficiency. Imagine an app that could approve a shift swap or annual leave in a matter of seconds[16].

Machine learning could be used to streamline case throughput and team performance, and have positive impact on theatre utilisation, staffing and associated expenditure[17]. Imagine a world where delays could be predicated and surgery cancellations do not occur. Imagine a world where all staff finish their shifts on time.

Moreover, AI-assisted diagnostic tools could empower perioperative nurses with real-time insights and predictive analytics. Machine learning models that aid in early detection and intervention may augment nurses' diagnostic capabilities. AI-driven decision support systems will support clinical judgment and enable personalised care plans tailored to each patient's unique needs.

By mainstream use of AI models, educational programs can tailor learning experiences to individual needs, providing personalised content and feedback to nurses. These platforms could enable

adaptive learning pathways across multiple modalities beyond the instrument nurse role, such as crisis resource management, ensuring nurses acquire the skills and knowledge required to excel in the dynamic perioperative environment. Virtual reality may even have a place in pre-registration programs, to lessen the significant gap between the need for exposure to the profession and available opportunities for student perioperative placement.

Challenges and considerations

Embracing AI technologies in perioperative nursing involves certain challenges and must be tempered with care. Patient privacy, data security management and algorithm bias must all be considered and human expertise and autonomy must be augmented by and not undermined by AI. Managing the impact of technology on the workload burden of nursing professionals is exigent[16]. Addressing these challenges is essential to harnessing AI's full potential in the perioperative setting and ensuring its ethical, effective and sustainable integration into clinical practice.

As perioperative nursing integrates AI technologies, ensuring patient privacy and data security is paramount[18]. Using algorithms on vast amounts of patient data to develop AI models arguably raises concerns about unauthorised access, breaches and misuse. Nurses must adhere to strict confidentiality protocols and system leaders must safeguard patient information with robust data encryption and access controls.

Algorithm bias poses a significant challenge in AI-driven perioperative care. As computer systems learn, biases inherent in their training data can lead to inaccuracies and disparities in the outputs given by the AI. Perioperative nurses must use their advanced critical thinking skills to evaluate AI outputs and recognise potential biases[19]. Human control must be retained over patient care decisions, with AI used to enhance, not supplant, clinical judgment and autonomy. AI cannot build a therapeutic relationship with a patient.

Introducing AI into perioperative nursing can contribute to technology-related stress, enhancing the dichotomy between provision of compassionate nursing care to vulnerable human beings and technical competence[20]. Nurses may experience anxiety or resistance due to concerns about job displacement, increased workload or fear of technology failures. It's imperative to address these concerns through comprehensive training, ongoing support and fostering a culture of technological literacy and resilience among nursing staff.

Opportunities for collaboration

The integration of AI in perioperative nursing presents a unique opportunity for interdisciplinary collaboration. It fosters partnerships between nurses, technologists, researchers and industry stakeholders to drive innovation and advance patient care.

One avenue for collaboration lies in developing and refining AI-driven technologies tailored specifically to the perioperative environment. By bringing together nurses with expertise in perioperative care, technologists skilled in AI development and researchers well-versed in health care analytics, interdisciplinary teams are well placed to co-design tangible and practical solutions to unique clinical challenges.

Furthermore, collaboration between academia and health care institutions can play a pivotal role in advancing the science and practice of AI in perioperative nursing. Academic institutions can provide the necessary infrastructure, resources and expertise to conduct cutting-edge research in AI-driven health care technologies, while health care institutions can offer real-world clinical insights and data for validation and implementation. By fostering mutually beneficial partnerships, the translation of AI research into clinical practice is accelerated.

Collaboration with regulatory agencies, professional associations and policymakers is critical in establishing the necessary frameworks and guidelines to govern AI's responsible and ethical use in perioperative nursing. Nurses must agitate for policies and regulations that promote transparency, accountability and patient safety in AI-driven health care environments.

In embracing these opportunities for collaboration, perioperative nurses can play a leading role in shaping the future of health care delivery, not only driving innovation but also improving patient outcomes through the responsible integration of AI-driven technologies into clinical practice.

Conclusion

The integration of AI in perioperative nursing represents a transformative paradigm shift with far-reaching implications for patient care, clinical practice and health care delivery. It is imperative to embrace the opportunities, address the challenges and collaborate across disciplines to harness the full potential of AI in shaping the future of perioperative care. As AI and human expertise converge,

perioperative nurses continue to uphold patient-centred care, compassion and professional excellence. Through innovation, collaboration and ethical advocacy, perioperative nurses will continue to advance the field, ensuring best-practice patient care now and into the future.

Conflict of interest declaration and funding statement

The authors of this manuscript declare no conflict of interest or affiliations with any organisation or entity with any financial interest (grants, membership, employment etc.) and non-financial interest in the subject matter or materials discussed herein.

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Letter to the Editor

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I would like to compliment Dr. Paula Foran and Nick Nijkamp for their publication of the effects of staffing practices related to safety and quality of care in perioperative nursing. This publication brings awareness to patient care and safety in the perioperative setting by highlighting direct correlation between patient outcomes and adequate staffing. The direct correlation between patient outcomes and adequate staffing is clearly presented in this publication and should continue to bring awareness of the issue.

The perioperative setting is one held to a high standard within my own practice for the three years of my career. This setting brings forward a series of emotions unlike other areas of nursing, often seeing patients at their most vulnerable. Many individuals experience a loss of control that can be an overwhelming and terrifying experience. The uncertainty of outcome and wellbeing is undoubtedly the driving factor for the array of emotions patients experience.

These mixed emotions do not come without substantial backing. According to Nijkamp and Foran[1], patients undergoing invasive procedures are highly vulnerable to potential adverse outcomes. Lapses in care and safety can occur at any time before, during or after a surgical procedure. Examples of this would include a missed critical lab value in the pre-operative setting. A wrong site surgery in the intra-operative location. Lastly a missed warning sign of a procedural complication such as post-operative lack of pulse in the operative extremity.

Furthermore, patient safety is of utmost importance in all aspects of patient care. The perioperative setting specifically holds patient safety to the highest standard. As described by Brooks and Nelson-Brantley[2], the perioperative setting can be one of the most challenging practice environments due to its complex culture and the challenges this creates for a culture of safety. Often the atmosphere is one with many moving parts. Multiple disciplines working in coordination with multiple tasks to accomplish during the time a patient is in the perioperative setting.

A series of checks and balances must be implemented to ensure nothing is overlooked or assumed while providing care with so many individuals directly involved. Often responsibilities are assigned to others working within the team. These actions can lead to oversite and error if not properly managed. These challenges must be addressed to provide a level of patient safety and increased quality of care. Roles and responsibilities must be defined for all staff attending to the patient and working in the perioperative setting to ensure safety is maintained. Continued awareness of patient safety needs to be elevated in staff education and continued training. Currently, nursing staffing ratios are a continual battle.

Undoubtedly improving staff-to-patient ratios will increase patient safety and overall wellbeing, but staff ratios are a separate challenge faced by all aspects of nursing. A more realistic approach would be to provide continuing education on the latest practices surrounding patient care and safety, specifically in the three stages of perioperative care. By educating nursing staff on the latest and best practice strategies, one would undoubtedly be aware of what safety considerations to remain alert to. The aim is to improve patient safety related to the range of factors surrounding staffing practices within the perioperative setting.

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Effectiveness of intra-operative gentamicin irrigation in reducing post-operative surgical site infections: A systematic review

Abstract

Aim: To evaluate and synthesise the effectiveness of intra-operative gentamicin in reducing post-operative surgical site infections compared to other irrigating solutions or no irrigation.

Background: Surgical site infection has posed challenges to health care providers around the globe. It is influenced by many risk factors, only a few of which are under the control of the surgeon and operating team. Wound irrigation is considered an essential part of the intra-operative process. It aims to minimise the risk of surgical site infection by thorough lavage of the operative site.

Design: Systematic review of effectiveness.

Review methods: The databases CINAHL, Scopus, Embase, Medline, PubMed, OpenGrey, Google Scholar and ProQuest Dissertations & Theses Global were searched with parameters set between 1 January 2013 and 31 July 2023. The review followed the Joanna Briggs Institute (JBI) methodology for systematic reviews of effectiveness and the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA 2020) guidelines. Two independent reviewers conducted the selection process, critical appraisal and data extraction. The eligible studies were critically appraised using JBI critical appraisal tools for randomised controlled trials and cohort studies. Data synthesis was performed through subgroup analysis and narrative synthesis, since meta-analysis was not possible.

Results: The impact of intra-operative gentamicin irrigation on surgical site infections was analysed across eight studies. The subgroup analysis favoured the gentamicin saline group over the saline group in reducing post-operative surgical site infections (RR=0.27 [0.13;0.55], P < 0.001.)

Conclusion: This systematic review shows that intra-operative gentamicin irrigation lowers the incidence of surgical site infections when compared to normal saline irrigation. However, there were contradictory results when intra-operative gentamicin irrigation was compared to alternative interventions such as no irrigation, diluted povidone iodine and combination antibiotic irrigation.

Keywords: gentamicin, irrigation, lavage, surgical site infection, post-operative infection

Background

Substantial resources and professional efforts are dedicated to reducing post-operative infections due to their significant impact on short- and long-term surgical outcomes[1]. Some of these outcomes are increased pain, prolonged antibiotic use and increased risk of mortality and morbidity[1]. The incidence of post-operative infection is influenced by many factors, including the type of surgery performed, patients' susceptibility to infection, antibiotic prophylaxis and the method of surveillance used for infection detection[2]. Post-operative infection develops in the surgical incision site, leading to a surgical site infection (SSI) or a more remote infection, such as pneumonia or catheter-associated urinary infection[2].

Health care providers around the globe face constant challenges that are associated with SSI[3]. The frequency of SSI has imposed a burden on health care institutions and posed a potential threat to the health of patients[3]. The Centers for Disease Control and Prevention (CDC) defines SSI as 'an infection that occurs after surgery in the part of the body where the surgery took place'[4, p.1]. An SSI can be a superficial infection confined to skin or progress to more severe infections affecting tissues beneath the skin, organs and implanted material[4]. SSI may have a negative effect on a patient's physical and mental health[3,5], and can lead to additional surgical procedures, increased pain, higher financial burden, risk of nosocomial infections and prolonged hospital stays[3,5,6].

There are various risk factors which influence the occurrence of SSI; however, only a few are within the control of the surgeon and surgical team. Numerous studies suggest that factors influencing the development of SSI include the host defence, the amount of microbes present at the incision site, and the virulence of those microbes[5,7]. The occurrence of SSI among patients who undergo inpatient surgical procedures is reported as being between 'two and four per cent'[8, p.1]. *Staphylococcus aureus,* coagulase-negative *Staphylococcus* and *Escherichia coli* are the most prevalent microorganisms associated with SSI[9, p.814].

The financial burden of post-operative SSI significantly impacts health institutions and patients[10]. From an Australian perspective, it has been estimated that the average incidence rate of SSI across all types of surgery is 3.3 per cent resulting in total direct expenses of around A$323.5 million[11]. From a patient perspective, SSI causes stress and anxiety from lengthy hospital stays and delayed wound healing, thereby lowering their quality of life. In addition, many patients face financial struggles as a consequence of unexpected medical expenses and lost income[11].

To eliminate bacterial contamination and lower the incidence of SSI, intra-operative wound irrigation is undertaken as a complementary approach to the intravenous (IV) antibiotic regime[12]. Using the antibiotic and directly on the operative sites reduces systematic exposure[13]. The concentration of the antibiotics is high and prolonged when applied to the targeted operative site, and the antimicrobial agents are used where they are most required[14]. Conversely, physiological changes may prevent the optimal efficacy of systematic antibiotics[14].

Wound irrigation is referred to as lavage, washout or wound washes and is an essential part of the intra-operative process[3]. Irrigation with normal saline (NS) is a generally established practice in the operating room[3]. Wound irrigation is performed by pouring the solution over the surface of the surgical wound to dilute and remove blood, tissue debris, metabolic waste, exudates and other body fluids and debris[6]. There are various solutions available for surgical irrigation, such as antibiotics, surfactants and antiseptics; and these vary in delivery availability, mechanisms, solution composition and the type of base solution[3,15].

The surgical intra-operative irrigation of interest for this systematic review is gentamicin irrigation. Gentamicin is a potent antibiotic from the aminoglycoside class used to treat gram-negative infections[16]. Its mode of action is to disrupt the structural integrity of the bacterial cell membrane, by targeting the bacterial ribosomes, which eventually leads to the inhibition of protein synthesis in the bacteria[16]. High doses and prolonged administration of aminoglycosides may cause toxicity in the kidneys and ears[14]; however, a single dose diluted in NS has not been associated with these toxicities[14]. Gentamicin irrigation is frequently used in orthopaedic procedures such total joint arthroplasty and open fracture[17]. It also has broad-spectrum capabilities and is cost effective[17].

Studies conducted over the last decade revealed conflicting evidence regarding the use of gentamicin in intra-operative wound irrigation. While some studies[16,18–20] indicate that gentamicin effectively reduces SSI, others have contrasting findings, especially when compared to other irrigating solutions[21–24]. Emile et al.[21] demonstrated that intra-operative wound irrigation with gentamicin–saline or NS decreased the risk of SSI in open appendectomy

procedures compared to no irrigation. Similarly, a meta-analysis by Fu et al.[25] revealed that irrigation using various antibiotics (such as clindamycin, gentamicin, lincomycin, rifampicin and others), alone or in combination, or aqueous PI solution significantly reduced the risk of SSI when compared to NS irrigation or no irrigation[25]. Meanwhile, Inojie et al.[22] compared the effectiveness of gentamicin and diluted povidone-iodine (PI) in intra-operative wound irrigation for preventing SSI in open spine surgery and found that, while both solutions effectively reduced SSI, diluted PI had a more significant effect than gentamicin[22].

A recent systematic review by Mo et al.[26] found that antibiotic wound irrigation during surgery resulted in a statistically significant decrease in the incidence of SSI; however, there was a moderate to high heterogeneity among the included studies[26]. In contrast, a systematic review by de Jonge et al.[6] found that intra-operative antibiotic wound irrigation did not significantly reduce the incidence of SSI.

Only a limited number of guidelines for preventing SSIs focus on intra-operative wound irrigation; and even among these, conflicting recommendations have been made[27]. Regulatory bodies such as the World Health Organization (WHO), the National Institute for Health and Care Excellence (NICE) and CDC have not been able to standardise perioperative procedures for intra-operative wound irrigation practices aimed at preventing SSI[27]. This is due to the heterogeneous nature of the available research evidence[27]. In Australia, very few investigations or studies have explored the benefits of antibiotic intra-operative irrigation.

The WHO[28], CDC[29] and NICE[30] published evidence-based guidelines for preventing SSI, in 2016, 2017 and 2019 respectively, that included the use of antibiotics for intra-operative wound irrigation. Since then, several studies have been carried out correlating gentamicin irrigation with SSI and numerous systematic reviews and meta-analyses have explored the effectiveness of various types of intra-operative wound irrigation to minimise SSI[6,15,25,26,31,32]. However, a systematic review focussing explicitly on gentamicin irrigation has not previously been carried out. Hence, this systematic review will explore current evidence of the potential efficacy, benefits, risks and limitations of using gentamicin for intra-operative wound irrigation to reduce SSI.

Aim

The aim of this review is to offer a thorough overview of the current knowledge about the effectiveness of gentamicin when used for intra-operative irrigation to reduce the incidence of SSI. This systematic review seeks to gather the existing evidence, evaluate the quality of

Table 1. Summary of PICO selection criteria

	Inclusion criteria details
Population	Patients undergoing surgery regardless of: • age • gender • type of surgery (all surgical specialities including emergency, elective, open and laparoscopic surgeries) • country of residence.
Intervention	Use of intra-operative gentamicin irrigation regardless of the dosage diluted in normal saline and the amount used for the washout.
Comparators	Intra-operative gentamicin irrigation was compared with: • standard irrigation (normal saline 0.9%) • no irrigation • other antibiotics • combination of gentamicin and other antibiotics.
Outcomes	Primary outcome: the incidence of post-operative SSI in surgical patients. Secondary outcomes: duration of hospital stay, factors that affected wound healing and post-operative complications (as a result of the surgery or SSI).

Table 2: Review concepts and search terms

Key concept	Search terms
gentamicin irrigation	gentamicin, therapeutic irrigation, lavage, wash, washout
post-operative infections	surgical site infection, surgical wound infection, post-operative wound infection

the relevant studies and synthesise findings. The review focuses on the following question: Is intra-operative gentamicin irrigation effective in reducing post-operative surgical site infections in comparison to other irrigating solutions or no irrigation?

Method

The review was conducted in accordance with the Joanna Briggs Institute (JBI) systematic reviews of effectiveness methodology[33] and followed the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) guidelines[34].

Study selection

The inclusion criteria were established based on population, intervention, comparator and outcomes (PICO) framework for study selection (see Table 1). Case studies, reviews and meta-analyses were excluded. As well as aligning with the PICO criteria, the selected studies had human subjects and were published in English between 1 January 2013 and 31 July 2023.

Search strategy

The search strategy was based on three steps to locate relevant published and unpublished studies (see Figure 1). The first step was conducted between 2018 and 2023 using identified keywords in a preliminary search on five databases – Cumulated Index to Nursing and Allied Health Literature (CINAHL), Scopus, Embase, Medline and PubMed. Keywords and search terms (see Table 2) were used to identify and assess the volume of results that met the review's inclusion criteria. In the preliminary search, only a few articles were identified; therefore, the time frame for article retrieval was expanded to ten years.

The second step involved consulting an experienced librarian to assist in formulating the logic grid according to the database requirements to conduct an extensive search for the potential articles. The Boolean terms 'AND' and 'OR' were used to retrieve relevant articles. The elaborated search results are attached as supplemental material. The databases were also searched with the following restrictions, wherever applicable: human subjects, English language, publication date between 1 January 2013 and 31 July 2023.

The third step was manually searching for articles through Google Scholar, Open Grey and ProQuest Dissertations & Theses. Additionally, the reference lists of the retrieved articles were checked for relevant and related studies.

A total of 52 studies were identified from the search of databases, grey literature and registers. These were uploaded into the Endnote 20.6/2022 (Clarivate Analytics) citation manager, and all duplicate entries were removed. The Joanna Briggs Institute System for the Unified Management, Assessment and Review of Information (JBI-SUMARI) was used to manage the review of articles[35]. Eighteen studies were imported into JBI SUMARI and these were screened for abstract, title and full text by the two reviewers, KK and ZS, independently.

Studies were excluded if they failed to meet the inclusion criteria. The reasons for exclusion after the screening phase were ineligible outcome, ineligible population, ineligible intervention and unavailability of full text. Whenever a conflict emerged, it was resolved through discussion between the two reviewers. Since these conflicts were managed by the two reviewers, a third reviewer was not required.

Methodological quality appraisal

The included studies were four cohort studies[14,16,18,23] and four RCTs[19–22]. The two reviewers used the standardised JBI critical appraisal checklist for cohort studies and randomised control trials (RCTs)[36] to assess the methodological quality of the eligible studies (see supplemental material).

Of the four cohort studies, three received an overall percentage score of 73 per cent (8/11)[16,18,23], the fourth[14] had an overall percentage score of 55 per cent (6/11). All the studies ensured that the recruited groups were similar (question 1), measured outcomes reliably (question 7) and used appropriate statistical analysis (question 11). There were notable gaps in strategies to deal with confounding factors (question 5), reasons for loss of follow-up (question 9) and strategies to address incomplete follow-up (question 10). This indicated that improvement is needed to address potential sources of biases.

Of the four RCTs, one received an overall percentage score of

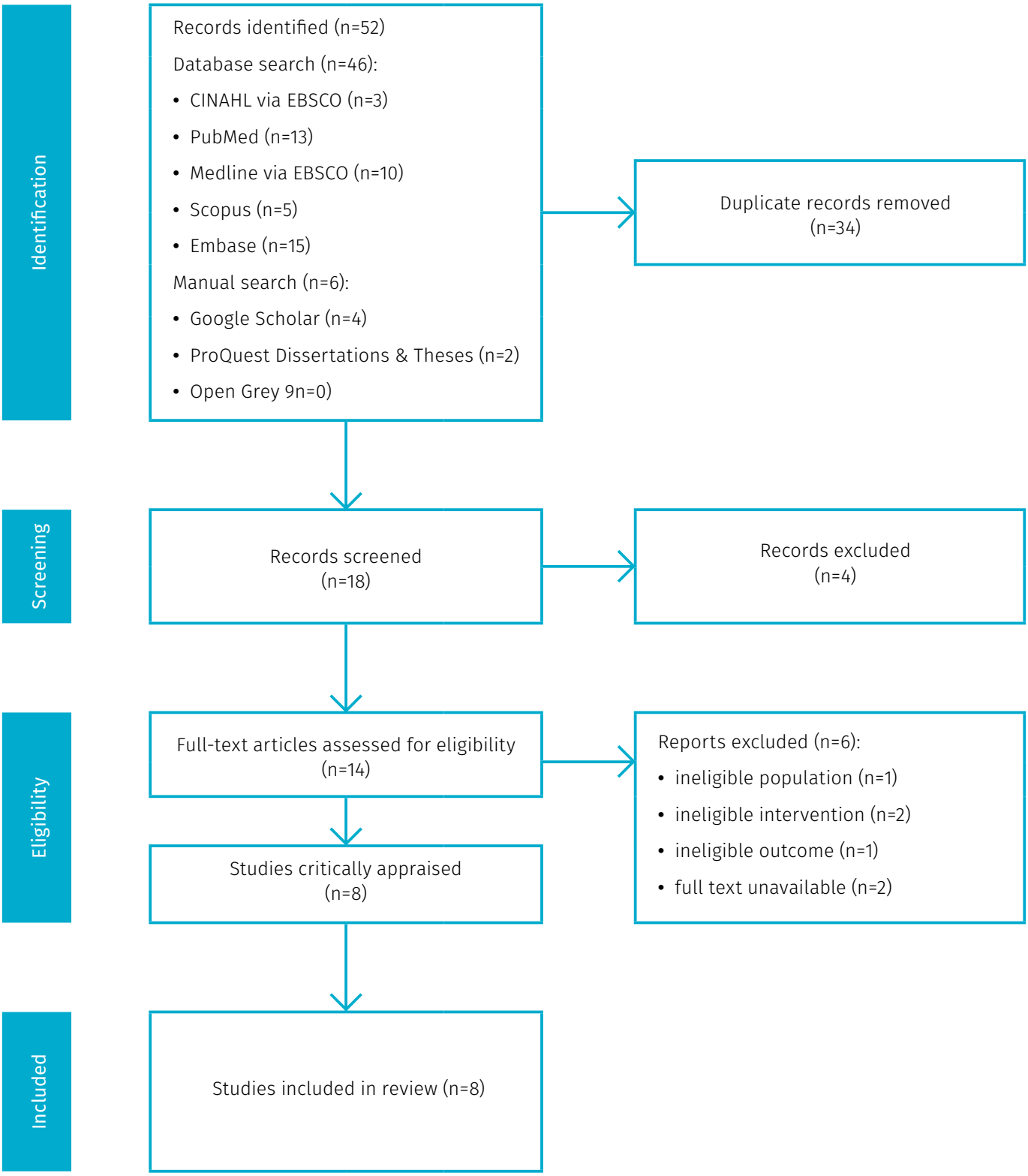

Figure 1: PRISMA flow diagram of paper selection process

100 per cent (13/13)[22], one received an overall percentage of 92 per cent (12/13)[21] and two received 69 per cent (9/13)[19,20]. All the studies used true randomisation to assign participants to treatment groups (question 1), had treatment groups similar at baseline (question 3), treated groups in an identical way apart from the intervention (question 7), analysed participants in treatment groups (question 9), measured outcomes in the same way for all treatment groups (question 10), measured outcomes in a reliable way (question 11), used appropriate statistical analysis (question 12) and used an appropriate trail design (question 13). Three studies[20–21] had concealed allocation to groups (question 2), while the concealment methods were not clearly reported in the fourth study[19]. There were notable gaps concerned with blinding – of participants (question 4), of those delivering treatment (question 5) and those assessing outcomes (question 6); in only one study[22] were all three roles blinded to treatment assignment.

Data extraction

Reviewer KK used the JBI data extraction tool for systematic data extraction for RCTs and cohort studies, and reviewer ZS verified the data extracted. The extracted data included details such as articles' authors, year, country, settings/context, participant characteristics, risk factors of SSI, groups (intervention and control), outcomes and description of the main results. Extraction of unnecessary data was avoided as it would have been time-consuming. Disagreements did not occur during the data extraction process; therefore, a third reviewer was not required.

Synthesis

Subgroup analysis was performed as meta-analysis was not possible due to the heterogeneity in study types and outcome measures. The studies were pooled for subgroup analysis based on the characteristics of the studies using JBI SUMARI[35] whenever possible. Effect measures were expressed as relative risk (for dichotomous data), and confidence intervals (95%) were calculated for the analysis. Statistical analyses were performed using fixed effects and the Mantel-Haenszel statistical method. The heterogeneity of the studies was assessed statistically by standard Chi-square and I^2 tests. Additionally, the findings were presented in the narrative form, wherever statistical pooling was not possible.

Results

Characteristics of included studies

Sample size and setting

The total number of participants from the eight included studies was 3622. The study samples of individual studies ranged from 80 to 1464 participants. The geographical locations of the included studies were Africa[22], China[16], Czech Republic[14], Egypt[20,21], Iran[18,19] and the United States of America (USA)[23]. Six studies[16, 18-22] identified the setting as a tertiary hospital, the remaining two studies[14,23] did not specify the setting.

Participant characteristics

Only four studies[16,20–22] established the criteria for age range, while the remaining studies[14,18,19,23] provided the mean age range. Seven studies[14,16,18,19,21–23] involved participants of both genders; one study[20] had an intake of only female participants as the surgery performed was elective caesarean section. Some studies reported the presence of comorbidities such as diabetes mellitus[16, 21–23], obesity[18,19,20,22,23], and chronic obstructive pulmonary disease[23].

Surgical speciality

The surgical specialties of the selected studies varied, with three being gastroenterology[14,21,23], two neurosurgery[16,22], two orthopaedic[18,19] and one obstetric[20].

Comparator and intervention group

All of the included studies compared gentamicin irrigation with one or two comparators. Six studies[14,16,18–20,22] had two study groups – one group received gentamicin irrigation while the other received a comparator – no irrigation[14], saline irrigation[16,18–20] or PI solution[22]. Two studies[21,23] had three groups – the first group received gentamicin irrigation and the second group received no irrigation. In one study the third group received NS irrigation[21], in the other study the third group received a combination of gentamycin (240mg) and clindamycin (600mg)[23].

Concentrations and dosages of gentamicin

All the studies used NS as a diluent although the concentration and dosage of gentamicin used for intra-operative irrigation varied between the studies. Four studies[16,18,19,22] used a gentamicin concentration of 80 mg/L, although three studies[16,18,19] used a volume of three litres while one[22] used one litre. The concentrations used in the remaining four studies were 1 mg/kg of gentamicin in 200 ml of NS[20], 160 mg of gentamicin in 400 ml of NS[21], 80mg of gentamicin in 10mls of NS[14] and 240mg gentamicin mixed with 500ml of NS[23].

Technique for intra-operative irrigation

Four studies[14,16,21,22] specified the technique used for intra-operative wound irrigation. Emile et al.[21] irrigated each wound layer separately, during open appendectomy, before the layer was closed. In the study by Bayer et al.[14] irrigation was directly into the 'submucosal tunnel'[14, p.301] during peroral endoscopic myotomy (POEM) procedure. In the study by Inojie et al.[22], the surgeons filled the wound cavity up to the level of the skin without solution spillage around the operative site. Subsequently, they drained the irrigating solution within the predetermined duration.[22] Surgeons in the study by Wang et al.[16] used one of two techniques, depending on type of surgery – a 50 mL syringe was used for irrigation during open procedures, such as craniotomies and burr holes, and continuous wound irrigation was used for endoscopic procedures.

Outcome measures

Seven of the studies[16,18–23] investigated surgical site infection as the primary outcome; the eighth study[14] investigated infectious adverse events including SSI. Six studies[14,18–21, 23] reported on secondary outcomes related to the length of the stay (LOS) in the hospital, and two studies[21,22] focused on wound dehiscence.

Surgical site infection

Gentamicin versus normal saline

Three RCTs[18,20,21] and two cohort[16,19] studies, with a total of 2527 participants, compared gentamicin to NS irrigation. Across the five studies there were 1775 participants who received gentamicin irrigation and 752 who received NS irrigation. Four of the five studies[16,18–20], reported that irrigating with gentamicin decreased the incidence of SSI compared to irrigating with NS.

Wang et al.[16] conducted a cohort study with 444 participants, above the age of 18, who underwent neurosurgery. Of these, 265 patients received intra-operative irrigation with gentamicin 240 mg IV diluted in three litres of NS (the gentamicin–saline group) while 179 patients received intra operative irrigation with three litres of NS with no additives (the NS group). It was found that the SSI rate in the neurosurgeries was lower in the gentamicin–saline group (1.1%) when compared to the NS group (8.3%) with a P value of 0.001.

The retrospective cohort study by Yazdi et al.[19] investigated the effects of using gentamicin in intra-operative irrigation to prevent post-operative joint infections. This study had 1464 participants, comprising 1287 patients in the gentamicin–saline group and 177 patients in the NS group who underwent arthroscopic anterior cruciate ligament (ACL) reconstruction surgery. The gentamicin–saline group had 240mg IV gentamicin diluted in three litres of NS (80 mg/L) as intra-operative wound irrigation. In comparison, the NS group had three litres of NS without additives for irrigation. This study showed a lower incidence of septic arthritis in the gentamicin–saline group (0.23%) compared to the NS irrigation group (2.2%) with a statistical significance of $P < 0.05$.[19]

An RCT by Maaty et al.[20] compared the SSI rate between gentamicin–saline and saline irrigation of the subcutaneous tissue in obese patients having elective caesarean section (CS). There were 132 participants in this study, 66 in the gentamicin–saline study group and 66 in the saline control group. The participants in both groups ranged in age from 20 to 35 years, with body mass indexes of 30–40kg/m^2. The study group had 1mg/kg IV gentamicin diluted in 200ml of saline (0.9%) as the irrigation solution, while the control group had 200ml of saline (0.9%) as the irrigation solution. The SSI rates in the gentamicin–saline group were lower (3%) than in the saline irrigation group (4.5%). However, the difference was not statistically significant as indicated by the P value of 0.999. The relative risk (95% CI) that represented the effective size was 0.67 (0.12–3.86).

The prospective RCT by Yazdi et al.[18], had a total of 351 participants who underwent arthroscopic ACL reconstruction surgery. There were 174 patients in the gentamicin–saline group, and 177 patients in the NS group. The gentamicin–saline group received intra-operative irrigation with 240 mg IV gentamicin diluted in three litres of NS (0.9% sodium chloride). The NS group received three litres of NS (0.9% sodium chloride) without any additives. Yazdi et al.[18] found a lower risk of septic arthritis in the gentamicin–saline group (0.57%) compared to the NS group (2.2%); however, this was not statistically significant ($P = 0.4$)[18].

Emile et al.[21] conducted a prospective RCT study that examined the effect of 'layer-by-layer' wound irrigation on incisional SSI in open appendectomy. In the study, 69 patients received irrigation with 160mg IV gentamicin diluted in NS (0.9%) and 67 patients received irrigation with NS (0.9%). In contrast to the other four studies[16,18–20], Emile et al.[21] reported that the rate of SSI was greater (4.3%) in the group receiving gentamicin–saline irrigation than it was in the NS irrigation group (2.9%).

Gentamicin versus diluted povidone iodine

One study[22] compared gentamicin with diluted PI. Inojie et al.[22] conducted a prospective comparative RCT study with 80 participants who underwent non-instrumented open spine surgery (that is, spinal procedures that did not involve the use of implants and prostheses[22]). Participants were randomly assigned to two equal groups – the gentamicin group (n = 40) received wound irrigation with 80 mg IV gentamicin diluted in a litre of NS and the PI group (n = 40) received wound irrigation with a litre of dilute PI (3.5%). The overall SSI rate was higher in the gentamicin group (17.5 %) compared to the PI group (2.5%). The incidence of SSI varied significantly between the groups (P = 0.025), which is statistically significant. The SSI was further categorised into deep SSI and superficial SSI. The incidence of SSI was higher in the gentamicin group than the PI group for both deep SSI (5% compared to 2.5%, P = 0.556) and superficial SSI (12.5% compared to 0%, P = 0.025)[22].

Gentamicin alone versus gentamicin with antibiotics

Fatula et al.[23] conducted a retrospective cohort study of participants who underwent open ventral hernia repair (OVHR) with mesh. In the study, 263 patients received irrigation with 240 mg of gentamicin in 500 ml of NS (the gentamicin–saline group) and 299 patient received irrigation with 240 mg gentamicin and 600mg clindamycin diluted in 500 mL of NS (the G+C group). The incidence of SSI was significantly lower (P < 0.001) in the G+C group (5.35%) than the gentamicin–saline group (15.21%)[23].

Gentamicin irrigation versus no irrigation

One RCT[21] and two cohort studies[14,23] compared wound irrigation with gentamicin to no irrigation, with a total of 785 participants, 392 who received irrigation with gentamicin and 393 who received no irrigation. Emile et al.[21] conducted a prospective RCT study of open appendectomy patients in which 69 patients received irrigation with 160mg IV gentamicin diluted in 400ml NS (0.9%) and 69 patients received no irrigation. The gentamicin–saline group had significantly lower SSI rates than the no-irrigation group (respectively, 4.3 % and 17.4%)[21]. The retrospective cohort study by Fatula et al.[23] involved patients who had OVHR with mesh – 263 patients received irrigation with gentamicin and 260 patients received no irrigation. The SSI rate in the no-irrigation group was slightly higher than in the gentamicin group (respectively, 16.54% and 15.21%)[23].

In a retrospective cohort study of 124 patients who underwent a POEM procedure, by Bayer et al.[14], 60 patients received 80mg of IV gentamicin diluted in 10 ml of NS as intra-operative submucosal lavage and 64 patients did not. In contrast to Emile et al.[21] and Fatula et al.[23], Bayer et al.[14] found that the incidence of infectious adverse events was higher in patients who received gentamicin lavage than in patients who did not (2% compared to 0%); however, the results were not statistically significant (P = 0.48).

Length of hospital stay

The length of hospital stay (LOS) is a challenging outcome to measure due to the presence of confounding factors in the studies. Six studies reported LOS as a secondary outcome. In the study by Bayer et al.[14], the group that received gentamicin irrigation had a longer LOS than the group with no irrigation (respectively, 2.6 +/- 1.4 and 1.9 +/- 0.8, P < 0.01). Emile et al.[21] reported the average LOS for the three study groups – no irrigation 1.14 (SD 0.3), gentamicin–saline irrigation 1.1 (SD 0.26) and NS irrigation 1.05 (SD 0.24), with a P value of 0.18. The average LOS in the study by Fatula et al.[23] was three days for the group that received no irrigation, four days for the group that received gentamicin–saline irrigation and four days for the group that received irrigation with a combination of gentamicin and clindamycin (P < 0.001).

Maaty et al.[20] reported a shorter average LOS in the gentamicin group (1.3 +/- 0.5) than the saline group (1.4+/-0.7); however, the difference was insignificant (P = 0.302). The LOS for the NS group in the earlier study by Yazdi et al.[18] was from 8 to 14 days; however, the LOS of one patient in the gentamicin–saline group who developed deep infection post-operatively was not specified. In their later study, Yazdi et al.[19] found that the LOS for the NS group ranged from 8 to 14 days, while the LOS for the gentamicin–saline group was 13 to 30 days.

Wound dehiscence

Two studies[21,22] included wound dehiscence as one of the secondary outcomes. The study by Emile et al.[21] reported that the no irrigation group had a higher wound dehiscence rate than both the gentamicin–saline group and the NS group (respectively (2.8% (n=2), 0% and 0%, P = 0.22). On the other hand, Inojie et al.[22] reported that wound dehiscence was higher in the gentamicin–saline group (n=6) than in the diluted PI group (n=1).

Study	Gentamicin-saline		Normal saline		Weight	M-H,	Relative Risk
	Events	Total	Events	Total			Fixed, 95% CI
Emile et al.[21]	3	69	2	67	6.01%	1.46	[0.25, 8.44]
Maaty et al.[20]	2	66	3	66	8.88%	0.67	[0.12, 3.86]
Wang et al.[16]	2	179	22	265	52.53%	0.13	[0.03, 0.57]
Yazdi et al.[18]	1	174	4	177	11.74%	0.25	[0.03, 2.25]
Yazdi et al.[19]	3	1287	4	177	20.83%	0.10	[0.02, 0.46]
Total (95% CI)		**1775**		**752**	100.00%	0.27	[0.13, 0.55]

Heterogeneity: x^2=7.06, df=4 (P=0.133) 1^2=43
Test for overall effect: Z=-3.63 (P<0.001)

Favours [Gentamicin-saline] Favours [Normal saline]

Figure 2: Forest plot of gentamicin–saline irrigation versus normal saline irrigation

Subgroup analysis

The subgroup analysis of two cohort studies[16,19] and three RCTs[18,20,21] (including a total of 2527 participants) favoured the gentamicin–saline group over the saline group in reducing post-operative SSI (see Figure 2). The relative risk (RR) of 0.27 (95% confidence interval between 0.13 to 0.55) and Z value of -3.93 (P < 0.001) indicated that there is a statistically significant difference. Therefore, the null hypothesis is rejected, suggesting that there is a lower rate of post-operative SSI with gentamicin–saline irrigation than with normal saline irrigation. The analysis also revealed moderate heterogeneity (x^2 = 7.06, df = 4 (P = 0.133), I^2=43) implying some variability across the studies.

Discussion

The primary purpose of this systematic review was to determine whether intra-operative gentamicin irrigation effectively reduced the incidence of SSI. The review comprised eight papers (four cohort studies[14,16,18,23] and four RCTs[19–22]) comparing the efficacy of gentamicin irrigation with other comparators. Several studies in the review provided consistency by controlling the variables to some degree, such as the same surgeon, or surgeons with similar experience[16,18,21]; pre-operative preparation[18] and surgical techniques[18,21]. Participants in seven of the eight selected studies were administered the same pre-operative and post-operative antibiotics[14,16,18–22]. However, this review found conflicting results in relation to the effect of intra-operative gentamicin wound irrigation on SSI incidence.

Overall, intra-operative gentamicin irrigation reduced the incidence of SSI when compared to NS irrigation. This is consistent with the findings of Ruiz-Tovar et al.[37] who reported a substantial decrease in contamination when lavage was performed with gentamicin solution compared to when lavage was performed with normal saline. Similarly, a study by Ma et al.[38] investigated the effect of intra-operative gentamicin irrigation (in surgical solution) on the incidence of endophthalmitis following cataract surgery. They found a lower incidence of endophthalmitis in patients who received intra-operative gentamicin irrigation than patients who did not receive this (respectively 0.2% (n=5 of 21 469) and 0.8% (n=8 of 16 395), P = 0.016)[38].

The results of the reviewed studies varied when gentamicin–saline irrigation was compared with diluted PI irrigation, no irrigation, and irrigation with a combination of antibiotics. These findings align with a study by van Herwijnen et al.[24] into intra-operative irrigation in adolescent idiopathic scoliosis surgery. van Herwijnen et al.[24] reported that wound irrigation with diluted PI dramatically reduced the SSI rate by around 20 per cent when compared to gentamicin irrigation. Meanwhile, a univariable analysis by Hemmingsen et al.[39] revealed that intra-operative gentamicin wound irrigation significantly reduced deep infections compared to no irrigation. However, intra-operative gentamicin wound irrigation was not statistically significant in the multivariable analysis compared to other factors influencing the risk of infection[39]. Moreover, a

recent scoping review of 17 articles suggested that vancomycin, gentamicin and streptomycin were the most efficacious antibiotics for using in intra-operative antibiotic irrigation to decrease SSI rates[12]. In contrast, a meta-analysis by de Jonge et al.[6] discouraged the use of antibiotic agents for intra-operative irrigation as no benefits in reducing SSI were found.

As well as discussing the potential benefits of gentamicin use, it is essential to address potential adverse effects, namely toxicity and resistance. Two studies[14,18] in this review mentioned that participants in their study did not have renal failure, which is one of the potential effects of gentamicin toxicity. However, no studies discussed gentamicin resistance in study participants. There is potential for gentamicin resistance to occur due to inadequate drug–microbe interaction periods and systemic absorption of antibiotics at subtherapeutic levels[5]. A World Health Organisation (WHO) expert panel also concluded that the possibility of antibiotic resistance may be linked to using antibiotics for wound irrigation[40]. Moreover, a study by Lee et al.[41] showed systematic absorption of gentamicin in surgical patients undergoing joint replacement surgeries with intra-operative gentamicin irrigation. They further concluded that this could lead to toxicity if used repeatedly or in large amounts[41].

Several factors have contributed to variability in the findings of the studies in this review. The efficacy of intra-operative gentamicin irrigation in reducing SSI may vary depending on the operative site and the nature and complexity of the surgical procedure.[16,19,21] This review included studies with different surgical procedures because of limited publications about intra-operative gentamicin irrigation in a specific speciality or procedure. Moreover, across the studies, the patient population was heterogeneous with varying demographics, comorbidities and overall health status. This diversity may have affected how participants responded to intra-operative gentamicin irrigation. Furthermore, the dosage and concentrations of gentamicin and the volume of the NS as diluent also varied across the studies. The duration of exposure to gentamicin also differed depending on the surgical context, and this may have affected the effect of the gentamicin on SSI. Lastly, the findings of included studies would have been influenced by the approach to methodology, data reporting and analysis that was used.

The WHO's Global guidelines for preventing surgical site infection[28] advocate against antibiotic use for intra-operative wound irrigation prior to closure to prevent SSI. The reason for this is the low quality of evidence supporting this practice in the published literature[28]. Similarly, CDC guidelines[29] do not recommend intra-operative antibiotic irrigation due to low-quality evidence of its harm or benefit in SSI prevention. However, CDC guidelines do recommend using diluted PI for intra-operative wound irrigation[29]. The NICE guidelines[30] also advise against wound irrigation or intracavity lavage to prevent SSI; however, they have suggested using antibiotics on the wounds before the closure for research purposes only[30]. The Australian Commission on Safety and Quality in Health Care (ACSQHC) also states 'avoid routine use of wound irrigation or intracavity antibiotic lavage'[42, p. 179] as there is a lack of evidence suggesting that these practices lowers SSI risk.

Recommendations for future research

This systematic review highlights the need for more primary studies exploring the effect of intra-operative gentamicin wound irrigation on SSI rates to strengthen existing findings. Future studies must include well-designed RCTs with a large sample and consider various surgical specialisations. Investigating the intra-operative use of gentamicin irrigation in neurosurgery, orthopaedic surgery, gastrointestinal surgery and other surgical specialisations may yield important information about the efficacy of the practice in different surgical contexts. This may produce more accurate results, address confounding variables and biases and contribute to more in-depth insights into the effects of intra-operative gentamicin irrigation on SSI and patient outcomes.

Strengths and limitations

A comprehensive search strategy captured articles and publications pertinent to the review topic. The PRISMA guideline was used to show that this review was conducted and reported in a structured and consistent manner, increasing its transparency and credibility. The included studies were characterised in detail, which assisted in comprehending the significance and relevance of the results. Conversely, this review was limited by flaws in the included studies. The sample size for most studies was small, diminishing their external and internal validity and potentially predisposing the studies to failure to discover a true effect[43]. It is important to note that studies were not excluded based on the quality, and differences in the methodological quality of the included studies may have

caused potential biases. Hence, it is necessary to recognise that some studies had drawbacks due to how they managed confounding factors, dealt with insufficient follow-up and handled blinding techniques. Additionally, none of the studies compared different irrigation volumes nor evaluated the possible toxic effect of gentamicin on the surgical patient.

Implications for practice

While some of the findings of this review point to the benefits of intra-operative wound irrigation, they also indicate ambiguous or conflicting evidence. This is consistent with the position regulatory bodies, such as the WHO, CDC and NICE, have taken in not recommending that antibiotics be used for intra-operative wound irrigation because of lack of conclusive evidence. The ambiguity in the results could contribute to the lack of standardisation of intra-operative antibiotic wound irrigation. The findings of the study may also enlighten and provide valuable insight to perioperative personnel who still use intra-operative gentamicin irrigation during surgical procedures.

Conclusion

The outcome of this systematic review indicates that intra-operative gentamicin irrigation lowers the incidence of SSI when compared to NS irrigation. However, there were contradictory results when intra-operative gentamicin irrigation was compared to other alternative interventions such as irrigation with diluted PI, irrigation with a combination of antibiotics and no irrigation. The variations in surgical specialities, patient demographics, gentamicin dose, volume of dilution and surgical technique affect the efficacy of gentamicin irrigation in reducing SSI. The moderate heterogeneity across the studies indicates the need to standardise the intra-operative gentamicin irrigation protocols. Furthermore, future research should investigate potential issues associated with intra-operative gentamicin irrigation, including toxicity and resistance, to better understand its effects on patients and SSI prevention.

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Effectiveness of intra-operative gentamicin irrigation in reducing post-operative surgical site infections: A systematic review

Supplement 1: Critical appraisal of included studies

Table 1: Critical appraisal of cohort studies using Joanna Briggs Institute cohort study checklist

Study	Q1: Were the two groups similar and recruited from the same population?	Q2: Were the exposures measured similarly to assign people to both exposed and unexposed groups?	Q3: Was the exposure measured in a valid and reliable way?	Q4: Were confounding factors identified?	Q5: Were strategies to deal with confounding factors stated?	Q6: Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	Q7: Were the outcomes measured in a valid and reliable way?	Q8: Was the follow up time reported and sufficient to be long enough for outcomes to occur?	Q9: Was follow-up complete, and if not, were the reasons to loss to follow-up described and explored?	Q10: Were strategies to address incomplete follow-up utilised?	Q11: Was appropriate statistical analysis used?	Score
Bayer et al.[1]	Y	U	U	U	U	Y	Y	Y	Y	N/A	Y	6/11
Fatula et al.[2]	Y	Y	Y	Y	Y	Y	Y	U	U	U	Y	8/11
Wang et al.[3]	Y	Y	Y	Y	U	U	Y	Y	Y	U	Y	8/11
Yazdi et al.[4]	Y	Y	Y	Y	U	Y	Y	Y	N	N	Y	8/11
Percentage	100	75	75	75	25	75	100	75	50	0.0	100	

Y = yes, N = no, U = unclear, N/A = not applicable

Table 2: Critical appraisal of randomised controlled trials using Joanna Briggs Institute appraisal tool for randomised controlled trials

Study	Q1: Was true randomisation used for assignment of participants to treatment groups?	Q2: Was allocation to treatment groups concealed?	Q3: Were treatment groups similar at baseline?	Q4: Were participants blind to treatment assignment?	Q5: Were those delivering treatment blind to treatment assignment?	Q6: Were outcome assessors blind to treatment assignment?	Q7: Were treatment groups treated identically other than the intervention of interest?	Q8: Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?	Q9: Were participants analysed in the groups to which they were randomised?	Q10: Were outcomes measured in the same way for treatment groups?	Q11: Were outcomes measured in a reliable way?	Q12: Was appropriate statistical analysis used?	Q13: Was the trial design appropriate, and any deviations from the standard RCT design (individual randomisation, parallel groups) accounted for in the conduct and analysis of the trial?	Score
Emile et al.[5]	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	12/13
Inojie et al.[6]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	13/13
Maaty et al.[7]	Y	Y	Y	U	N	U	Y	U	Y	Y	Y	Y	Y	9/13
Yazdi et al.[8]	Y	U	Y	U	U	U	Y	Y	Y	Y	Y	Y	Y	9/13
Percentage	100	75	100	50	25	50	100	75	100	100	100	100	100	

Y = yes, N = no, U = unclear, N/A = not applicable

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Effectiveness of intra-operative gentamicin irrigation in reducing post-operative surgical site infections: A systematic review

Supplement 2: Characteristics of selected studies

Authors (year) Country	Procedure	Study design Setting/context	Participant numbers and characteristics	Risk factors	Groups (sample size)	Outcomes measured	Description of main results
Bayer et al.[1] (2018) Czech Republic	peroral endoscopic myotomy (POEM)	cohort study IKEM Centre	124 patients with dysphagia: • 68.5% had achalasia • 89.6% had regurgitation • 87.9 % occasional chest pain • Mean age: 46.4 years	Leak during the procedure	Group 1 (n=60): gentamicin lavage (80mg gentamicin in 10 mL NS) Group 2 (n=64): no lavage	• infectious adverse events • length of hospital stay (LOS)	Group 1 had more infectious adverse events than Group 2 (n=1 (2%) compared to n=0 (0%), P=0.48) but this was not statistically significant. Group 1 had longer LOS than Group 2 (2.6 (+/- 1.4) compared to 1.9 (+/-0.8), P<0.01).
Emile et al.[2] (2020) Egypt	open appendectomy	RCT General surgery department, Mansoura University Hospital	205 patients with acute appendicitis Age: 16–65 years	Age Diabetes mellitus (DM)	Group 1 (n=69): irrigation with 160 mg gentamicin in 400 ml 0.9% NS Group 2 (n=67): irrigation with 0.9% NS Group 3 (n=69): no irrigation	• SSI incidence • LOS (in days) • wound dehiscence	Groups 1 and 2 had significantly lower rates of incisional SSI than Group 3 (G1: n=3 (4.3%), G2: n=2 (2.9%), G3: n=12 (17.4%), P=0.005). Groups 1 and 2 had similar SSI rates (n=3 (4.3%) and n=2 (2.9%)). There was no significant difference in average LOS between the groups (G1: 1.1(SD 0.26), G2: 1.05(SD 0.24), G3 1.14 (SD 0.3), P=0.18). There was no significant difference in wound dehiscence between the groups (G1: n=0 (0%), G2: n=0 (0%), G3: n=2 (2.8%), P=0.22)
Fatula et al.[3] (2018) United States of America	open ventral hernia repair (OVHR)	cohort study Data from databases of: • Greenville Health System Hernia Center database (2008–2013) • Americas Hernia Society Quality Collaborative (AHSQC) (2013–2017)	822 patients who had OVHR with Mesh Age: • Group 1: 56.5 +/- 12.4 years • Group 2: 56.7 +/- 13.8 years • Group 3: 57.9 +/- 14.0 years	Age Body Mass Index (BMI) >25 DM Smokers	Group 1 (n=260): no antibiotic Irrigation Group 2 (n=263): irrigation with 240 mg gentamicin in 500 mL NS Group 3 (n=299): irrigation with 240 mg gentamicin and 600mg clindamycin in 500 mL NS	• SSI incidence • LOS (in days)	Group 3 had significantly lower SSI incidence than groups 1 and 2 (G1: n=43 (16.54%), G2: n=40 (15,21%), G3: n=16 (5.35%), P>0.001). There was no significant difference in average LOS between the groups (G1: 3 days, G2: 4 days, G3: 4 days, P<0.001).
Inojie et al.[4] (2023) Nigeria	neurosurgical spine surgery	RCT Memfys Hospital for Neurosurgery	80 patients who had non-instrumented surgery (Class 1 wounds) Age: 18 years and older	Age BMI >25 DM	Group 1 (n=40): irrigation with 80 mg of IV gentamicin in 1L NS Group 2 (n=40): irrigation with 1L 3.5% diluted PI	• SSI incidence • wound dehiscence	The overall SSI rate was significantly higher in Group 1 than Group 2 (n=7 (17.5%) compared to n=1 (2.5%), P=0.025). SSI was additionally divided into two categories: deep SSI and superficial SSI. The SSI rate was higher in Group 1 than Group 2 for both deep SSI (n= 2 (5%) and n=1 (2.5%)) and superficial SSI (n=5 (12.5%) and n=0 (0%)). Wound dehiscence was higher in Group 1 (n=6) than in Group 2 (n=1).

Authors (year) Country	Procedure	Study design Setting/context	Participant numbers and characteristics	Risk factors	Groups (sample size)	Outcomes measured	Description of main results
Maaty et al.[5] (2021) Egypt	elective caesarean section (C/S) – primary or repeated	RCT Ain Shams University Maternity Hospital	132 patients Age: 20–35 years BMI: 30-40 kg/m2 Single viable foetus, term pregnancy Hb level: >10 gm%	Obesity	Group 1 (n=66): irrigation with 200ml 0.9% saline Group 2 (n=66): irrigation with 1mg/kg gentamicin in 200ml 0.9% saline	• SSI incidence • LOS	Group 1 had higher SSI incidence than Group 2 but the difference was not statistically significant (n=3 (4.5%) compared to n=2 (3.0%), P=0.999). LOS was shorter in Group 2 than Group 1 but the difference was not statistically significant (1.3 +/- 0.5) compared to 1.4+/-0.7, P=0.302).
Wang et al.[6] (2021) China	Emergency neurosurgeries such as: • craniotomy • neuro-endoscopic procedures • Burr holes.	cohort study Emergency Centre operating theatre at Shenzhen People's Hospital	444 patients Age: >18 years Not allergic to gentamicin Not pregnant	Age DM	Group 1 (n=265): irrigation with 3L NS Group 2 (n=179): irrigation with 80mg/L gentamicin (240 mg gentamicin in 3L NS)	• SSI incidence	Group 1 had higher SSI incidence than Group 2 (n= 22 (8.3%) compared to n=2 (1.1%), P=0.001). The use of gentamicin irrigation reduced SSI incidence in Group 2 by 86.7% compared to the incidence in Group 1.
Yazdi et al.[7] (2019) Iran	arthroscopic anterior cruciate ligament (ACL) reconstruction – primary procedure	cohort study Orthopaedic department of Firoozgar Hospital	1464 patients requiring a simultaneous partial meniscectomy No pre-existing infections Mean age: • Group 1: 27.20 years • Group 2: 25.75 years	Age BMI >25	Group 1 (n=177): irrigation with 3L NS Group 2 (n=1287): irrigation with 80mg/L gentamicin (240 mg gentamicin in 3L NS)	• post-operative deep infections • post-operative septic arthritis (SA) • LOS	Group 1 had higher post-operative infection rates than Group 2 n=4 (2.2%) compared to n=3 (0.23%), P<0.05). LOS in Group 1 ranged from 8 to 14 days, and in Group 2 from 13 to 30 days.
Yazdi et al.[8] (2014) Iran	arthroscopic ACL reconstruction – primary procedure	RCT Firoozgar Hospital	351 patients requiring a simultaneous partial meniscectomy No skin lesions or pre-existing infection Mean age: • Group 1: 27.2 years • Group 2: 25.9 years	Age BMI >25	Group 1 (n=177): irrigation with 0.9% NS Group 2 (n=174): irrigation with 80mg/L gentamicin (240 mg gentamicin in 3L NS) Age and gender distributions were similar in the two groups.	• post-operative septic arthritis (SA) • LOS	Post-operative SA was higher in Group 1 than in Group 2 but the difference was not statistically significant (n=4 (2.2%) compared to n=1 (0.57%), P=0.4). The LOS in group 1 ranged from 8 to 14 days. The LOS of one patient who developed post-operative deep infection in group 2 was not specified.

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Supplement 3: Database logic grids

Table 1: CINHAL

Gentamicin irrigation	Post-operative infections
(MH "Therapeutic Irrigation+" AND MH "Gentamicins+") OR TI ((Lavage* OR wash* OR wash out OR irrigat*) AND (Gentamicin* OR gentamycin*)) OR AB ((Lavage* OR wash* OR wash out OR irrigat*) AND (Gentamicin* OR gentamycin*))	MH "Surgical Wound Infection+" OR TI ("Surgical site infection*" OR "post-operative infection*" OR "postoperative infection*" OR "postoperative wound infection*" OR "post-operative wound infection*") OR AB ("Surgical site infection*" OR "post-operative infection*" OR "postoperative infection*" OR "postoperative wound infection*" OR "post-operative wound infection*")

Table 2: Scopus

Gentamicin irrigation	Surgical site infections
((Lavage* OR wash* OR wash out OR irrigat*) AND (Gentamicin* OR gentamycin*))	"Surgical site infection*" OR "post-operative infection*" OR "postoperative infection*" OR "postoperative wound infection*" OR "post-operative wound infection*"

Table 3: PubMed

Gentamicin irrigation	Surgical site infections
((Lavage*[tiab] OR wash*[tiab] OR wash out[tiab] OR irrigat*[tiab]) AND (Gentamicin*[tiab] OR gentamycin*[tiab])) OR ("Therapeutic Irrigation"[mh:noexp] AND "Gentamicins"[mh])	"Surgical Wound Infection"[mh] OR Surgical site infection*[tiab] OR post-operative infection*[tiab] OR postoperative infection*[tiab] OR postoperative wound infection*[tiab] OR post-operative wound infection*[tiab]

Table 4: Embase

Gentamicin irrigation	Surgical site infections
((Lavage* OR wash* OR wash out OR irrigat*) AND (Gentamicin* OR gentamycin*)).ti,ab OR ((lavage.sh OR stomach lavage.sh OR peritoneum lavage.sh) AND Gentamicin.sh)	Surgical infection.sh OR (Surgical site infection* OR post-operative infection* OR postoperative infection* OR postoperative wound infection* OR post-operative wound infection*).ti,ab

Table 5: Medline

Gentamicin irrigation	Surgical site infections
((Lavage*[tiab] OR wash*[tiab] OR wash out[tiab] OR irrigat*[tiab]) AND (Gentamicin*[tiab] OR gentamycin*[tiab])) OR ("Therapeutic Irrigation"[mh:noexp] AND "Gentamicins"[mh])	"Surgical Wound Infection"[mh] OR Surgical site infection*[tiab] OR post-operative infection*[tiab] OR postoperative infection*[tiab] OR postoperative wound infection*[tiab] OR post-operative wound infection*[tiab]

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Evaluation of pain levels and pain management in patients after elective total knee replacement surgery

Abstract

Objective: The aim of this study was to evaluate early pain management outcomes in patients undergoing total knee arthroplasty.

Materials and methods: This descriptive cross-sectional study was conducted between 1 March and 30 September 2022. The sample consisted of 112 patients who underwent total knee replacement surgery. Data was collected during face-to-face interviews in the first 24 to 48 hours after surgery, using a patient information form and the revised American Pain Society patient outcome questionnaire (APS-POQ-R). One-way analysis of variance (ANOVA), independent-samples t test, Kruskal-Wallis test and Mann-Whitney test were used in statistical analyses. Ethical approval, institutional approval and written informed consent from the patients were obtained.

Results: The mean age of the patients was 65.11 (±7.108) years, and 92.9 per cent of the patients were female. All patients received combined opioid and nonopioid analgesic and cold application therapy for pain management. In the 24 hours after surgery, the mean mildest pain score was 1.29 (±0.79), the mean most severe pain score was 9.25 (±1.086) and the mean perceived percentage of time in severe pain was 70.54 per cent (±13.546). The highest emotional effect caused by pain was anxiety with a score of 4.55 (±2.543). The patient level of satisfaction with the results of pain treatment was 8.87 (±1.663) points. It was determined that female patients and patients under 65 years of age had more severe pain and experienced more sleep and emotional effects ($p<0.05$).

Conclusion: It was observed that patients experienced pain and related anxiety in the early period after total knee arthroplasty. We recommend the use of other nonpharmacological methods along with cold application for effective management of pain and that health professionals should be supported with in-service training in order to better encourage patients.

Keywords: total knee replacement, pain, pain management, nursing

Introduction

Knee replacement surgery, total knee arthroplasty (TKA), is one of the most common orthopaedic surgeries performed today. TKA surgery is performed for the surgical treatment of osteoarthritis, especially in elderly individuals. It has been reported that 60 per cent of TKA patients experience severe post-operative pain and 30 per cent experience moderate post-operative pain[1,2]. In 2020, the International Association for the Study of Pain revised the definition of pain as 'an unpleasant sensory and emotional experience associated with or similar to actual or potential tissue damage'[3]. It is known that pain arising from

a certain location in the body may be a warning sign indicating a condition that threatens the organism[4,5]. The perception of pain varies between individuals and is influenced by factors including age, gender, education, culture, race, past experiences and genetics[6,7 8].

Post-operative pain is an acute, usually local, pain of relatively short duration that begins with the surgical incision and ends with wound healing[9,10]. Post-operative pain is a condition that can be predicted and prevented. With advancing technology, knowledge about the diagnosis and treatment of pain has increased, and new drugs and new methods have been introduced to monitor and manage pain. Examples include wearable devices, smart infusion pumps, virtual reality applications for pain management and robotic-assisted analgesia[11]. Nevertheless, surgical procedures still play an important role in the development of pain in individuals.

Orthopaedic surgery is thought to be the type of surgery where post-operative pain is most difficult to manage[12,13,14]. If pain cannot be controlled effectively, it causes a range of adverse effects in patients including immobility, sleep problems, prolonged opioid use, depression, anxiety, social isolation, delayed recovery and prolonged hospitalisation[15,16]. Effective pain control is important in preventing these complications.

Pain management interventions are carried out by a multidisciplinary team of health care professionals[17] including nurses. Nurses are of great importance in pain management since they play an active role in patient care not only after surgery but also before and during surgery. What makes the role of the nurse different from that of other team members is that the nurse spends longer time with the patient and, therefore, can learn the patient's previous pain experiences and coping strategies and use them when necessary. At the same time, the nurse is a health professional who educates the patient, implements the planned treatment and monitors the results of the treatments[9,18,19].

Patient satisfaction with post-operative pain control is closely related to the quality of care provided[20]. Studies have shown that the surgical patient group still experiences severe pain[21] and that pain assessment must be performed correctly if pain is to be managed effectively in the post-operative period[22]. However, measurable evaluations of post-operative pain interventions are quite limited in the literature. This study evaluated early pain management outcomes in total knee arthroplasty patients.

Materials and methods

Study design

The study is descriptive and cross-sectional in design.

Sample

The study population consisted of patients who underwent total knee replacement surgery between March and September 2022 in a public hospital in Turkey. A simple random sampling method was used in sample selection. Based on the information that the number of patients in the last year was 157, the number of participants was calculated as 112 when the 95 per cent confidence interval was calculated with 5 per cent. Patients over the age of 18 who had total knee replacement surgery and volunteered to participate were included in the study.

Data collection

Data was collected by face-to-face interviews between March and September 2022. Patients were interviewed when they felt best in the first 24 to 48 hours after surgery. The patient information form created by the researchers and the revised American Pain Society patient outcome questionnaire (APS-POQ-R) were used as data collection tools.

Patient information form

The patient information form includes questions about demographic characteristics such as age, gender, educational status, history of surgery, surgical site, anaesthesia and pharmacological and nonpharmacological methods used for pain relief. These were retrieved from the patient's medical file.

Revised American Pain Society patient outcome questionnaire (APS-POQ-R)

The APS-POQ-R (see supplemental material) was developed by the American Pain Society in 1991 and revised by Gordon et al. in 2010 for use in quality improvement[23]. The questionnaire consists of 12 questions aimed at assessing the patient's pain and satisfaction with the treatment and care provided for pain. Three of the questions have four sub-questions so there are 23 items in total. The items can be grouped into five sub-dimensions:

1. pain severity and its effect on sleep (5 items; 1, 2, 3, 4c, 4d)
2. effect of pain on activity (2 items; 4a, 4b)
3. emotional impact of pain (4 items; 5a, 5b, 5c, 5d)
4. side effects of pain management (4 items; 6a, 6b, 6c, 6d)
5. perception of care (3 items; 7, 8, 9).

The total score of the questionnaire is not used, evaluation uses the mean scores of the sub-dimensions[23,24]. Items 10, 11 and 12 are not included in the sub-dimensions and are evaluated outside the sub-dimensions of the scale. Item 10 addresses information received by patients about pain treatment options and how helpful they were, item 11 addresses use of nonpharmacological methods in pain treatment), and item 12 addresses whether use of nonpharmacological methods were encouraged by health care professionals.

Gordon et al.[23] reported the overall Cronbach's alpha value as 0.86[23]. In this study, the overall Cronbach's alpha value was 0.71.

Data analysis

Data evaluation was performed in the SPSS 26.00 program. In data analysis, descriptive statistical methods in the form of numbers, percentages and averages were used, as well as the Kolmogorow Smirnov test of normality. One way ANOVA test, independent-samples t test, Kruskal-Wallis test and Mann-Whitney test were used for comparisons between variables. Significance level was accepted as $p < 0.05$.

Ethical approach

Written permission was obtained from Bartın University Social and Human Sciences Ethics Committee (Decision No: E-71504618-600-2200022254) and Bartın Provincial Health Directorate for the conduct of the study. Permission to use the scale for the study was obtained from the scale developer. The study's participants were informed, and written informed consent was obtained.

Findings

The demographic and clinical characteristics of participants in the study are shown in Table 1. Of the 112 participants, 92.9 per cent were female, 50.9 per cent had primary school education and the mean age was 65.11 (±7.108) years.

Nearly all participants (99.1%) were anaesthetised with spinal anaesthesia. All patients received combined opioid and nonopioid analgesics as pharmacologic treatment in the post-operative, 24-hour period. Cold compress and elevation methods were used as nonpharmacological treatments.

Table 1: Demographic and clinical characteristics of the participants

Variable		Number of participants (%)
Age (in years)	Range: 46–85	
	Mean (SD): 65.11 (±7.108)	
	under 65 years old	56 (50.0%)
	65 years and older	56 (50.0%)
Gender	female	104 (92.9%)
	male	8 (7.1%)
Education	illiterate	52 (46.4%)
	primary school	57 (50.9%)
	middle school-high school	3 (2.7%)
Surgical site	right knee	55 (49.1%)
	left knee	57 (50.9%)
Applied anaesthesia	spinal	111 (99.1%)
	general	1 (0.9%)
Pharmacological treatment	opioid and nonopioid	112 (100%)
Nonpharmacological treatment	cold compress and elevation	110 (98.2%)
	cold compress	2 (1.8%)
History of surgery	yes	92 (82.1%)
	no	20 (17.9%)
Gonarthrosis experience	yes	43 (38.4%)
	no	69 (61.6%)

The majority of participants (82.1%) had a history of surgery, and 38.4 per cent had total knee arthroplasty.

The pain experiences and pain management results of the patients in the first 24 hours after surgery are shown in Table 2. The mean score for the least pain was 1.29 (±0.790) and the mean score for the worst pain was 9.25 (±1.086) where 0 indicated no pain and 10 indicated worst pain possible. The mean perceived amount of time in severe pain was 70.54 (±13.546) on a scale from 0 to 100 per cent of the time. When the effect of pain on sleep was evaluated, it was found that the mean score for effect on falling asleep was 3.63 (±3.269) and for effect on staying asleep was 3.61 (±3.261) where 0 indicated does not interfere and 10 indicated completely interferes.

When the effect of pain on activity was evaluated, it was found that the mean score for effect on activities in bed was 9.34 (±0.973) and for effect on activities out of bed was 8.21 (±1.363) where 0 indicated does not interfere and 10 indicated completely interferes. Regarding the emotional inpact of pain, anxiety had the highest mean score of 4.55 (±2.543) where 0 indicated did not experience the emotion at all and 10 indicated extreme emotion was experienced. Nausea was the side effect with the highest mean score of 4.96 (±4.658) where 0 indicated no side effect experienced and 10 indicated severe side effect experienced.

In relation to perception of care the mean score for pain relief was 8.71 (±0.801), on a scale from 0 (no relief) to 100 per cent (complete relief); the mean score for permission to participate in pain treatment decisions was 9.34 (±1.443), where 0 indicated not at all and 10 indicated very much so; and the mean score for satisfaction with pain treatment results was 8.87 (±1.663), where 0 indicated extremely dissatisfied and 10 indicated extremely satisfied.

Table 3 shows the distribution of responses to items 10, 11 and 12 that were not included in a sub-dimension. Nearly all participants (93.8%) stated that they received

Table 2: Scores for items in the five sub-dimensions

Sub-dimension	Item	Minimum	Maximum	Mean (X)	Standard deviation (SD)
Pain severity and its effect on sleep	least pain	0	3	1.29	0.790
	worst pain	5	10	9.25	1.086
	time in severe pain	40	90	70.54	13.546
	effect on falling asleep	0	10	3.63	3.269
	effect on staying asleep	0	10	3.61	3.261
Effect of pain on activity	effect on activities in bed	6	10	9.34	0.973
	effect on activities out of bed	3	10	8.21	1.363
Emotional impact of pain	anxious	0	10	4.55	2.543
	depressed	0	10	1.09	1.631
	frightened	0	10	1.58	1.844
	helpless	0	8	1.37	1.693
Side effects of pain management	nausea	0	10	4.96	4.658
	drowsiness	0	10	2.81	2.086
	itching	0	2	0.09	0.393
	dizziness	0	10	2.27	3.587
Perception of care	pain relief	7	10	8.71	0.801
	permission to participate in pain management decisions	4	10	9.34	1.443
	satisfaction with pain treatment outcomes	2	10	8.87	1.663

information about pain treatment, and the mean score for the helpfulness of the information was 8.62 (±1.47) where 0 indicated not at all helpful and 10 indicated extremely helpful. All participants used nonpharmacological pain relief methods; the most frequently used were cold application, walking, relaxation exercises, breathing exercises, distraction, prayer and massage. Nearly all participants (92%) reported that a nurse or doctor often encouraged them to use nonpharmacological pain relief.

Table 4 shows the effect of independent variables on the five sub-dimensions. It was found that women were significantly more affected by pain than men in terms of pain severity and effects on sleep, emotional impact of pain and side effects of medication, and women's perception of care was significantly lower than men's ($p<0.05$). It was also observed that partaicipants under 65 years of age were significantly more affected by pain than participants 65 years and older in terms of pain severity and effects on sleep, and emotional impact of pain ($p<0.05$). Education level and gonarthrosis experience were not found to have a significant effect on any of the sub-dimensions.

Discussion

Post-operative pain management is an important aspect of providing quality health care, and monitoring patient-related outcomes is a recommended quality improvement practice. There are a limited number of studies in the literature in which measurable evaluations of patients' pain experience after total knee arthroplasty were made. This descriptive and cross-sectional study evaluated patients' pain levels and pain management outcomes in the early post-operative period. In addition, the effect of independent variables on participants pain levels was examined.

The mean scores for the sub-dimensions of pain severity and its effect on sleep and side effects of pain management found in this study were consistent with the study by Özdemir[7]. More specifically, while the mean score for least pain (1.29) was similar to those of other studies[25–27], the average score for worst pain (9.25) was found to be high. This indicates that the participants in this study experienced severe pain.

Table 3: Distribution of responses to APS-POQ-R items 10, 11 and 12

Item	Response	Number of participants (%) (or score range, mean and standard deviation)
Received information about pain management	yes	105 (93.8%)
	no	7 (6.3%)
	helpfulness of the information received	Score range: 4–10 Mean (SD): 8.62 (1.47)
Use of nonpharmacological methods	yes	112 (100%0
	no	0 (0%)
	cold application	111 (99.1%)
	walking	100 (89.3%)
	relaxation exercises	93 (83.0%)
	breathing exercises	79 (70.5%)
	diversion of attention	68 (60.7%)
	prayer	47 (42.0%)
	massage	5 (4.5%)
Encouragement to use nonpharmacological methods	frequently	103 (92.0%)
	sometimes	7 (6.3%)
	never	2 (1.8%)

Table 4: The effect of independent variables on sub-dimensions

Variable		Pain severity and its effect on sleep			Effect of pain on activity			Emotional impact of pain			Side effects of pain management			Perception of care		
		X	SD		X	SD		X	SD		X	SD		X	SD	
Gender	female	5.08	1.52	**p=0.01**	17.5	1.90	p=0.73	9.01	6.21	**p=0.00**	10.6	7.32	**p=0.00**	8.92	0.92	**p=0.02**
	male	3.52	1.18	t=2.82	17.7	1.75	M-U=387.0	3.00	2.00	M-U=140.5	3.87	3.83	M-U=169.0	9.58	0.68	M-U=221.0
Age group (in years)	<65	5.29	1.59	**p=0.03**	17.6	2.05	p=0.22	10.2	7.23	**p=0.01**	10.4	6.98	p=0.41	8.86	0.94	p=0.07
	≥65	4.65	1.45	t=2.23	17.4	1.70	M-U=1365.5	6.89	4.43	M-U=1137.5	9.78	7.71	M-U=1428.5	9.07	0.90	M-U=1267.5
Education level	illiterate	4.79	1.48		17.6	1.55		7.90	5.90		9.17	8.00		8.94	1.55	
	primary school	5.06	1.62	p=0.23	17.3	2.15	p=0.21	9.24	6.59	p=0.59	11.2	6.67	p=0.13	8.97	0.83	p=0.90
	middle and high school	6.26	0.46	f=1.48	19.0	0.00	x2k-w=3.115	8.00	3.00	x2k-w =1.024	6.33	4.93	x2k-w =4.086	9.33	0.33	x2k-w =0.210
Gonarthrosis experience	yes	4.76	5.10	p=0.26 t=1.12	17.4	1.80	p=0.60 M-U=1398.0	7.44	6.11	p=0.08 M-U=1192.5	12.4	7.26	p=0.05 M-U=1014.5	9.03	0.82	p=0.18 M-U=1264.0
	no	5.10	1.49		17.5	1.94		9.30	6.20		8.66	7.03		8.93	0.98	

t = independent-samples t test, f = One way ANOVA test, X 2K-W = Kruskal-Wallis test, M-U = Mann-Whitney test

The mean score for the sub-dimension of emotional impact of pain in our study was lower than that reported by Özdemir[7] and Keskin[24]. However, the results of this study in relation to the most commonly experienced emotion and side effects of pain management are consistent with other studies. In this study, it was found that the most common emotional effect caused by pain was anxiety. Similarly, Polanco-Garcia et al.[25] found that the most common negative effect in patients after orthopaedic surgery was anxiety, with a rate of 58.5 per cent. Özdemir[7] also concluded that the most common emotional effect was anxiety.

Nausea was found to be the side effect with the highest mean score in our study. Nausea was also found to be the most common side effect in the study by Özdemir[7]. In the study by Polanco-Garcia et al.[25] the rate of nausea in patients was reported to be 36.4 per cent.

The mean score for satisfaction with pain treatment in the sub-dimension of perception of care in our study was 8.87 (± 1.663), which is consistent with the results of Özdemir[7]. In contrast to this, 93.8 per cent of participants in our study reported being informed about pain treatment while Polanco-Garcia et al.[25] reported a rate of 63.3 per cent.

In our study, all participants used nonpharmacological pain relief methods while the rate was only 69.7 percent in the study by Özdemir[7], 62 per cent did in the study by Gordon et al.[23] and 48.9 per cent in the study by Zoega et al.[27]. The most frequently used nonpharmacological method was cold application (99.1%). In the literature, cold application (39.4%) and deep breathing (21.6%) are the most common nonpharmacological methods used to relieve post-operative pain[7,27]. Cold application is a widely preferred method for reducing oedema and relieving pain in orthopaedic surgery.

Most participants (92%) in our study reported that the health care team often encouraged them to use nonpharmacological treatment. This is higher than the rates of 10.1 per cent[7] and 27.7 per cent[27] reported in other studies. Keast et al.[28] also found that the communication between the health care team and patients affected patient participation in nonpharmacological treatment.

In our study, it was found that gender had a significant relationship with pain severity and its effect on sleep, the emotional impact of pain and side effects of medication. It was observed that the mean scores of items in these sub-dimensions were significantly higher in female participants than in male participants and, accordingly, the women's perception of care was lower than the men's. This is consistent with research by Özdemir[7]. Our study also found a significant correlation between age and both pain severity and its effect on sleep and the emotional impact of pain – participants under 65 years of age were found to have significantly higher mean scores for these sub-dimensions than participants aged 65 years and older.

Similarly, Liu et al.[29] reported that female gender and younger age were positively correlated with pain severity[29]. These results support the idea that the perception of pain may differ according to age and gender.

Limitations and strengths

The study was conducted in a single health facility and cold application was encouraged more than other nonpharmacological pain relief methods. These limit the generalisability of the research results. A strength of the study was the data collection form which provided not only data about participant pain levels but also data about the effect of pain on sleep, activity and emotional state, and data about side effects of pain management and participant perceptions of care.

Conclusions and recommendations

Evaluation of pain levels and pain management of patients in the post-operative period directly affects the quality of care given to patients. In the post-operative period, opioid and nonopioid analgesia and pain medications have an important place in pain control but they may also cause various side effects. In this sense, the application of nonpharmacological methods is extremely important. However, the literature reveals that these methods are used in a limited way. Health professionals should be supported with in-service training in order to overcome the lack of knowledge about nonpharmacological methods and to better encourage patients to use nonpharmacological methods.

Declaration of conflicting interests

All of the authors declare that they have all participated in the design, execution and analysis of the paper, and that they have approved the final version. Additionally, there are no conflicts of interest in connection with this paper, and the material described is not under publication or consideration for publication elsewhere.

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Evaluation of pain levels and pain management in patients after elective total knee replacement surgery

Supplement: Revised American Pain Society patient outcome questionnaire (APS-POQ-R)

The following questions are about pain you experienced during the first 24 hours in the hospital or after your operation.

1 On this scale. please indicate the least pain you had in the first 24 hours:

0 1 2 3 4 5 6 7 8 9 10

no pain — worst pain possible

2 On this scale. please indicate the worst pain you had in the first 24 hours:

0 1 2 3 4 5 6 7 8 9 10

no pain — worst pain possible

3 How often were you in severe pain in the first 24 hours? Please circle your best estimate of the percentage of time you experienced severe pain:

0 10 20 30 40 50 60 70 80 90 100

never in severe pain — always in severe pain

4 Circle the one number below that best describes how much pain interfered or prevented you from:

a Doing activities in bed such as turning. sitting up. repositioning.

0 1 2 3 4 5 6 7 8 9 10

does not interfere — completely interferes

b Doing activities out of bed such as walking. sitting in a chair. standing at the sink.

0 1 2 3 4 5 6 7 8 9 10

does not interfere — completely interferes

c Falling asleep

0 1 2 3 4 5 6 7 8 9 10

does not interfere — completely interferes

d Staying asleep

0 1 2 3 4 5 6 7 8 9 10

does not interfere — completely interferes

5	**Pain can affect our mood and emotions. On this scale. please circle the one number that best shows how much the pain caused you to feel:**										
a	**Anxious**										
	0	1	2	3	4	5	6	7	8	9	10
	not at all										extremely
b	**Depressed**										
	0	1	2	3	4	5	6	7	8	9	10
	not at all										extremely
c	**Frightened**										
	0	1	2	3	4	5	6	7	8	9	10
	not at all										extremely
d	**Helpless**										
	0	1	2	3	4	5	6	7	8	9	10
	not at all										extremely
6	**Have you had any of the following side effects? Please circle '0' if now; if yes. please circle the one number that best shows the severity of each.**										
a	**Nausea**										
	0	1	2	3	4	5	6	7	8	9	10
	none										severe
b	**Drowsiness**										
	0	1	2	3	4	5	6	7	8	9	10
	none										severe
c	**Itching**										
	0	1	2	3	4	5	6	7	8	9	10
	none										severe
d	**Dizziness**										
	0	1	2	3	4	5	6	7	8	9	10
	none										severe

7 **In the first 24 hours. how much pain relief did you receive? Please circle the one percentage that best shows how much relief you have received from all of your pain treatments combined (medicine and non-medicine treatments):**

0 1 2 3 4 5 6 7 8 9 10

no relief — complete relief

8 **Were you allowed to participate in decisions about your pain treatment as much as you wanted to?**

0 1 2 3 4 5 6 7 8 9 10

not at all — very much so

9 **Circle the one number that best shows how satisfied you are with the results of your pain treatment while in the hospital:**

0 1 2 3 4 5 6 7 8 9 10

extremely dissatisfied — extremely satisfied

10 **Did you receive any information about your pain treatment options?** ☐ **No.** ☐ **Yes.**

a **If yes. please circle the number that best shows how helpful the information was:**

0 1 2 3 4 5 6 7 8 9 10

not at all helpful — extremely helpful

11 **Did you use any non-medicine methods to relieve your pain?** ☐ **No.** ☐ **Yes.**

If yes. please check all that apply:

- ☐ cold pack
- ☐ deep breathing
- ☐ distraction (Such as watching TV. reading)
- ☐ heat
- ☐ other (please describe)
- ☐ imagery or visualisation
- ☐ massage
- ☐ meditation
- ☐ listen to music
- ☐ prayer
- ☐ relaxation
- ☐ walking

12 **How often did a nurse or doctor encourage you to use non-medication methods?**

☐ never ☐ sometimes ☐ often

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Product stewardship in health care: The importance of minimising the environmental and health impacts of plastic products

Abstract

Increased waste in health care is a widespread problem. Currently, modern clinical practices favour single-use products and pre-packaged supply kits. Many of these consist of various types of plastics. By weight, up to 25 per cent of total hospital waste is plastics. Common plastics used are polyethylene terephthalate, polypropylene, polyethylene, polyvinylchloride and polyurethane. Polyethylene terephthalate represents the highest volume, and accounts for 40 per cent of the plastics used in operating rooms.

Health care has an enormous ecological footprint. Around the world, health care waste management strategies and clinician activities are starting to address how health care affects our planet and public health. Recovery of valuable waste, or product stewardship, is one of these strategies.

In many countries, product stewardship in health care is still non-existent or unregulated. Clinicians and health service organisations must make product stewardship in health care an integral part of sustainable procurement and health care business activities. In addition, sustainable solutions require the engagement of suppliers of plastic packaging who can contribute to reducing waste in health care and minimising the impact of plastics on the environment and public health.

Keywords: product stewardship, extended producer responsibility, sustainability, health care, plastics, public health

Introduction

The United Nations have developed 17 inter-related 'sustainable development goals'. Sustainable Development Goal 3 (SDG3) is 'good health and well-being', and SDG13 is 'climate action'[1]. Medical organisations such as the Australian Medical Association and Doctors for the Environment Australia have highlighted the detrimental effects of climate change to human health[2] and the recent Health Care Without Harm green paper Health Care's Climate Footprint reports that health care contributes to greenhouse gas (GHG) emissions and global warming[3]. One of the key findings of the report is that 4.4 per cent of net global emissions are from health care[3]. Australia has the tenth highest GHG emissions from health care and is among the top emitters per capita (1.29 tons of CO^2 per capita)[3]. In addition, seven per cent of Australia's total GHG emissions can be attributed to health care[4].

There is a need for health practitioners to address climate change and work towards reducing health care GHG emissions[5]. Health care providers are encouraged to be vigilant and active in reducing the carbon footprint and pollution generated by health care itself. Clinicians need to be in the forefront of highlighting the environmental crisis that has both direct and

indirect adverse effects on the public's health[6].

Manufacture, distribution and disposal of products used in health care all result in GHG emissions. This has created a need for health care facilities to review their waste management strategies. A review of waste management strategies in hospitals by Fletcher et al.[7] reported that most strategies caused environmental harm and more innovative solutions are needed. World-wide, eight per cent of GHG emissions related to health care can be attributed to the use of rubber and plastic products[2]. Although plastics have transformed the health care industry, it is very important to reduce the negative environmental impacts of plastic products – such as plastic packaging – by improving recovery and recycling of these materials.

Table 1 shows common plastics used in health care and their properties. Due to their favourable properties, common plastics used in health care are polypropylene, polyethylene, polyethylene terephthalate, polyethylene terephthalate glycol, polyvinyl chloride and polyurethane[8,9].

McGain et al.[10] estimated that, by weight, between 20 and 25 per cent of total hospital waste is plastic. This is comparable to the proportion of plastic waste generated in operating rooms (ORs) where plastic packaging, in particular, has increased since the introduction of laparoscopic and interventional procedures. Around 40 per cent of OR plastic waste is polyethylene terephthalate (PET)[11,12].

PET is one of the most often used plastics in health care due to its high strength barrier and versatility[13]. It is thermoformed to fit the shape of different medical instruments and used in sterile barrier medical device packaging (see Figure 1).

Table 1: Types of plastics used in health care

Type of plastic	Use in health care	Properties	Sterilisable	Recyclable
polypropylene (PP)	• orthotics • prosthetics • non-absorbable sutures • prescription bottles • disposable syringes • disposable warming blankets	• resistant to impact and corrosion • highly durable • stable with acids and other chemicals	yes	yes
polyethylene (PE)	• medical implants • personal protective equipment	• biocompatible • durable • resistant to impact and chemicals • low moisture absorption	yes	yes
polyethylene terephthalate (PET)	• packaging • instrument wraps • vascular prostheses	• transparent • durable	yes	yes
polyethylene terephthalate glycol (PETG)	• food preparation trays • sterilisation trays	• transparent • durable • safe to use in contact with food	yes	yes
polyvinyl chloride (PVC)	• infusion bags • catheters • tubing • face masks • surgical gloves	• resistant to corrosion • flame retarding	no	yes, as single plastic only
polyurethane (PUR)	• medical implants • surgical drains • tubing	• high compressive strength • impact resistant	yes	yes

Current situation of plastics recovery in Australia

In metropolitan and regional areas of Australia, recyclable materials such as hard plastics, paper and cardboard, glass and metal are collected in comingled waste bins by waste contractors. The bins are transported to material recovery facilities (MRFs) where their contents are separated into different streams of recyclable material. MRFs typically separate plastics into PET, high-density polyethylene (HDPE) and mixed plastics.

Collecting recyclable waste in comingled bins is a valuable solution for households and industries but faces some challenges. These include confusion about which items are allowed, contamination of recyclables by non-recyclables, degradation of recyclable materials and inclusion of small uncollectable items.

In Australia, the overall recycling rate of plastics in 2018–2019 was 11.5 per cent. Of all the types of plastic, PET had the highest recovery rate at 21.0 per cent followed by high-density polyethylene (HDPE) at 19.7 per cent[14]. In Australia, 363 200 tonnes of PET were consumed in 2018–2019 but only 76 400 tonnes were recovered. The Australian government estimates the economic loss from insufficient recovery of PET and HDPE at A$419 million per year[15]. However, in the health care setting, no guidance about which clinically used PET and HDPE products are recyclable is available. Health care

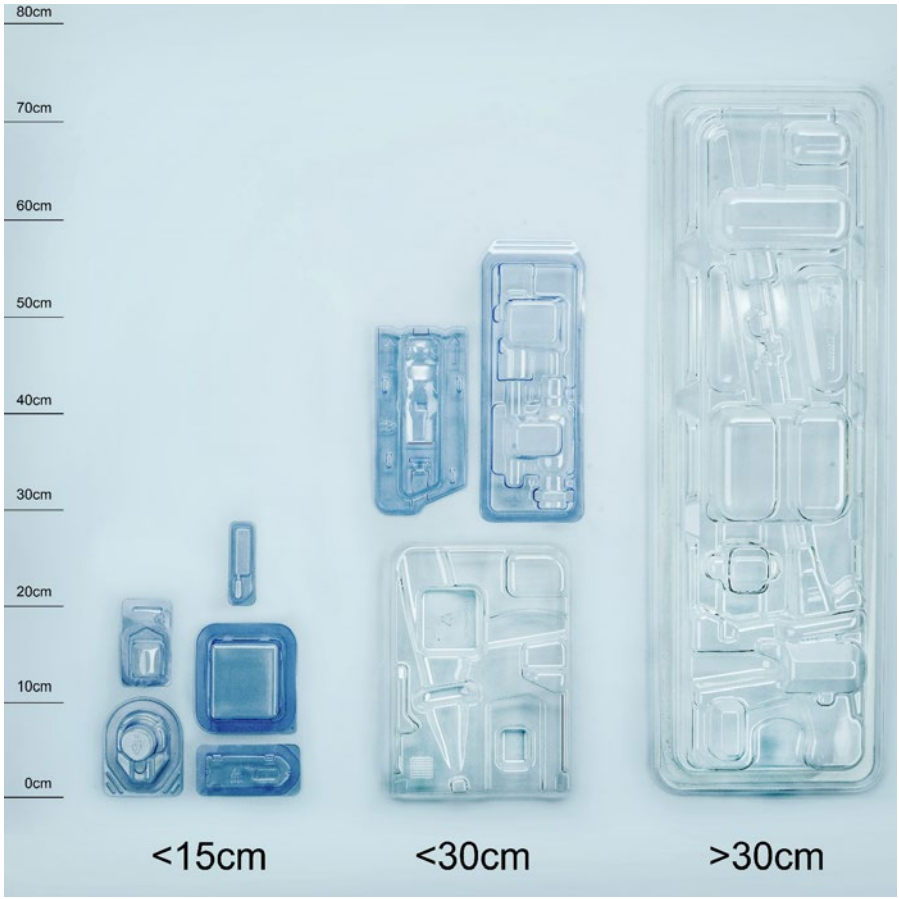

Figure 1: Typical shapes and sizes of PET packaging for medical instruments
(Source: Royal Brisbane and Women's Hospital)

plastic waste differs vastly in size and shape from household plastic waste. Additionally, plastics used in health care may contain toxins such as phthalates which can have a detrimental effect on health[6].

Product stewardship and extended producer responsibility

Product stewardship and extended producer responsibility offer a practical and widely proven model for cost-effective measures that minimise the impact of products and packaging on the environment and human health. The health care industry as producer of recyclable products is required to engage with their customers to provide sustainable solutions.

Product stewardship

Product stewardship is a widely utilised and applicable framework for managing products, packaging and other resource streams[16]. It underpins the global movement towards a circular economy for materials and resources. Product stewardship acknowledges the shared responsibility of participants throughout the product lifecycle – from raw material production to product manufacture, sale, use and recovery or disposal.

Product stewardship is based on several key principles:

- End users recycle their products and packaging through easily accessible pathways.
- Manufacturers are encouraged to develop products and packaging that can easily be recycled according to local remanufacturing capacity.
- Manufacturers can create end-markets for recovered materials by using recycled content in their products and packaging.

In 2011, the Australian government introduced the *Product Stewardship Act 2011* to manage the environmental and health and safety impacts of products. Australia has a range of voluntary, co-regulated and mandatory product stewardship schemes[16] that may be aimed at recovering problematic materials not covered by conventional resource recovery systems.

Voluntary schemes are typically funded through membership or subscription fees that are used to support the creation of a circular model for the targeted materials. Mobile Muster and Drum Muster are voluntary schemes.

Co-regulated schemes, such as the Australian Packaging Covenant[17], are delivered in collaboration by industry and government. They are typically voluntary and often funded by levies agree to and managed by industry. Participants pay the levy voluntarily to participate in the scheme, enabling accreditation and providing a financial base for recovery and recycling of targeted materials along the value chain. For example, container deposit schemes (CDSs), funded by the beverage industry, have been implemented across Australian states and territories and aim to minimise littering and recover resources used in the production of beverage containers.

Mandatory schemes are generally underpinned by regulatory frameworks that oblige all product

manufacturers that place the targeted materials into the market to contribute to the recovery and recycling of these materials at the product end-of-use.

Product stewardship of plastics in health care

In 2023, the Minister for the Environment listed plastics in health care products in hospitals on the product stewardship priority list. With up to 25 per cent of all hospital waste being plastics[10], product stewardship programs are innovative options for all plastics generated in health care.

A product stewardship program, led by health care manufacturers, has established PVC separating at the point of generation and collects PVC products from hospitals across Australia and New Zealand. The program, PVC Recycling in Hospitals, is supported by the Vinyl Council of Australia. To our knowledge, there are currently two product stewardship programs related to health care in Australian hospitals – PVC Recycling in Hospitals and Wrapback™, that collects polypropylene blue wrap from hospitals in Australia.

Extended producer responsibility

Extended producer responsibility (EPR) is perhaps the most complex of the product stewardship models currently operating around the world. It requires collaborative efforts of producers, government and consumers, with financial responsibility formally placed on producers through legislative and regulatory instruments. EPR programs such as CDS, have been shown to work successfully when governments regulate and monitor industries and producer strategies for waste product disposal, mandate or provide incentive for environmental targets to be met and assist with funding research and development.

Used packaging materials in Australia are regulated under the *National Environment Protection (Used Packaging Materials) Measure 2011* (NEPM). The NEPM establishes compliance obligations for brand owners responsible for placing packaging on the Australian market, and engages with participants along the circular packaging value chain. Obligated businesses must provide annual public reporting and planning for the delivery of improved sustainability outcomes for their packaging. These obligations can be met by becoming a signatory to the Australian Packaging Covenant, a co-regulatory product stewardship agreement based on shared responsibility principles. Among other measurable outcomes, signatories to the covenant commit to delivery of the 2025 National Packaging Targets. The aim is that by 31 December 2025:

1. all packaging will be recyclable, reusable or compostable
2. most (70%) of plastic packaging will be recycled or composted
3. packaging will be made from, on average, half recycled material
4. problematic and unnecessary single-use plastic packaging will be phased out.

The NEPM also compels state and territory governments to establish a corresponding statutory basis for non-signatories to the covenant, to ensure compliance obligations are met by all organisations placing packaging on the Australian market.

Until recently, a lack of enforcement for non-signatories to the covenant has resulted in challenges with free-riders and poor compliance.

However, a rapidly growing global awareness of the environmental and health impacts of plastic packaging is seeing increased focus on improving sustainability outcomes. In the Australian context, this shift is visible through the Australian government's National Waste Policy Action Plan 2019 and the National Plastics Plan 2021 as well as significant investment through the Recycling Modernisation Fund and National Product Stewardship Investment Fund, among others[14,18,19]. State and territory governments are providing similar support to build onshore capacity for resource recovery and remanufacture. Manufacturers are moving to deliver on increasingly ambitious commitments to packaging sustainability, reflective of the increased pressure from consumers to take responsibility for packaging waste.

Ten years ago, Hopewell et al.[20] reported that around four per cent of the world's oil and gas, both non-renewable resources, are used as raw materials for plastics and a further 34 per cent is expended to provide energy for plastics manufacture. They propose that with the combined efforts of the public, industry and government it may be possible to divert most plastics from landfill to recycling over the next decade[20].

It is widely accepted that approximately 80 per cent of all environmental impacts are determined during the design phase of a product[21]. In Japan, the Container and Packaging Recycling Law introduced in 1995 was the first law reflecting the EPR idea. Under this law, responsibility was partially shifted from municipal councils to producers. As a result of EPR laws, Japan's automobile manufacturers began to use one type of recyclable

thermoplastic instead of composite materials for ease of recovery for recycling[22].

This strategy has great potential when applied to single-use packaging of operating theatre instruments. The task of recycling packaging would be greatly simplified for the busy health care worker if all theatre instrument packaging was guaranteed by producers to be PET. This could help to overcome cultural barriers to recycling that are present in health care work environments[23,24]. Currently, only clear or translucent PET is considered circular (i.e. recyclable back to the same application again, for example, bottle-to-bottle) or of competitive market value once recycled[25,26]. If EPR laws provided incentive to producers to ensure all packaging of theatre instruments was clear PET, this could make recycling of plastic packaging waste coming from hospitals less resource intensive for recycling companies. It could also result in recycled products of higher quality without the need for extra investment to improve recycling facilities.

Conclusion

In a carbon footprinting study in three health systems, MacNeill et al.[27] described the impact of surgery and surgical products on climate change and public health. The study also highlighted the importance of health care practitioners in all areas of health care being proactive about promoting sustainability.

We call on industry to engage with the health care sector to establish sustainable product stewardship programs. We also call on governments to support such sustainable activities in hospitals to support clinical and waste management staff.

Establishing product stewardship schemes in health care settings for a variety of plastic products, such as PET packaging, would provide resources to segregate and collect plastics at source and prevent contamination. It could contribute to making subsequent segregation in MRFs obsolete and enable the recovery of plastics that cannot be recovered in MRFs due to their material type or size.

Recovery of high value plastic products and packaging resources will contribute to a reduction in the size of health care's ecological footprint, both GHG emissions and the environmental impact of waste. Bespoke product stewardship schemes and commitment to producer responsibility for plastic products used in health care would contribute to an increase in the recycling rate and reductions in waste going to landfill and GHG emissions.

Such approaches may also result in budgetary benefits through capturing the value of resources that currently contribute to the waste management costs of health care.

The health care sector is a dynamic and steadily increasing industry that is challenged to lower their detrimental impact on the environment and prevent harm. Addressing climate change and offering solutions is a professional responsibility for clinicians.

Key takeaways for clinical practice

Why did we do this project?

- Around one quarter of the waste generated in operating rooms is plastics; most of these end up in landfill due to limited recovery or recycling strategies.

What did we find?

- We found that around 40 per cent of all operating room plastic waste is made of polyethylene terephthalate (PET).
- Specifically, single-use surgical instruments are packaged in high grade PET.
- In contrast to community-based PET bottle recycling schemes, there is currently no recovery process for PET generated in health care.

How can health care professionals use these results?

- Policy makers: Governments and health care institutions should establish product stewardship schemes for plastics in health care to provide resources and strategies that support health care workers and hospital waste management staff.
- Health care Industry: The health care Industry should continue to increase their commitment to product stewardship and embrace producer responsibility for their products.
- Clinicians: Clinicians have a professional responsibility to address climate change and to contribute to a reduction in greenhouse gas emissions from health care.

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Advancing perioperative nursing education and surgical skills acquisition: A comprehensive approach

Abstract

Postgraduate nursing education serves as a crucial connection between theoretical knowledge and clinical practice, playing an important role in enhancing the competencies of nurses in specialised fields, such as perioperative nursing. The delivery of higher education has undergone a transformation, focussing on online and blended learning, making higher education more accessible and more flexible to adult learners than traditional face-to-face education programs. However, acquiring hands-on surgical skills poses a potential challenge for online education.

The expanding need for surgical service delivery from Perioperative Nurse Surgical Assistants (PNSAs) is increasing the demand for novice practitioners to acquire surgical skills. Simulation-based learning is an effective way to enhance skills in learners, and cost-effective solutions using innovative methodologies, that are explored in this discussion, pave the way for immersive learning experiences that enhance proficiency in surgical skills and ensure patient safety.

Keywords: perioperative nurse, Perioperative Nurse Surgical Assistant (PNSA), surgical skills, online education, digital health, digital technologies

Introduction

Postgraduate nursing education serves as a crucial bridge between theoretical knowledge and clinical practice, playing a pivotal role in enhancing the competencies of nurses in specialised fields. Baxter and Edvardsson[1] highlight the significance of evidence-based theory in nursing education, aiming to address the theory–practice gap prevalent in the profession, while Sonneborn et al.[2] emphasise its role in fostering critical thinking skills among nurses, ultimately leading to improved patient care and outcomes.

Higher education has undergone significant transformation in how education is delivered, with a global appetite for technology-enhanced learning design to complement the technological revolution in the 21st century[3,4,5]. Adult learners often prefer online learning, as a more flexible schedule allows students to manage professional, personal and educational demands more easily than with traditional face-to-face education programs[6,7]. Online and blended learning allows tertiary, higher education to be more accessible and flexible, and learning technologies can provide innovative opportunities to engage students in higher education[6].

This discussion paper explores postgraduate nursing education, particularly focusing on the Master of Nursing program with a perioperative practice specialisation offered by La Trobe University, to investigate its role in advancing perioperative nursing knowledge and skills.

It addresses the integration of evidence-based theory into clinical practice and examines the challenges of acquiring hands-on surgical skills in online education settings. By highlighting the significance of active learning strategies and innovative approaches, the aim is to improve perioperative nursing education and ultimately enhance patient care outcomes.

Discussion

The changing role of the perioperative nurse

In recent years, the role of the perioperative nurse has undergone significant transformation, driven by a myriad of factors including advancements in technology, evolving patient demographics and increasing complexity of surgery. Once viewed as a support figure in the operating room, perioperative nurses now find themselves at the forefront of patient care, wielding an array of technological tools and needing specialised knowledge to navigate the intricacies of modern surgical procedures[8].

The landscape of perioperative care has shifted dramatically, with patients presenting increasingly complex medical conditions and surgical needs. This shift is paralleled by advancements in medical technology, with operating suites now resourced with state-of-the-art equipment ranging from robotic surgical systems to advanced imaging modalities. These technological advancements have revolutionised surgical practices, offering greater precision, efficiency and safety in the operating room. However, they also pose new challenges for perioperative nurses, who must continually update their skills and knowledge to adapt to these evolving technologies[9,10,11].

Moreover, the changing demographics of patients undergoing surgery further compound the challenges faced by perioperative nurses. Aging populations, coupled with the rising prevalence of chronic diseases, have led to an increase in the acuity and complexity of and demand for surgery. As a result, perioperative nurses are tasked with caring for patients with a multitude of comorbidities, necessitating a comprehensive understanding of diverse medical conditions and their implications for surgical management[12,13].

Against this backdrop of change and complexity, the role of the perioperative nurse has expanded to encompass a broader scope of practice. Beyond their traditional responsibilities of pre-operative preparation and intra-operative assistance, perioperative nurses now play a pivotal role in coordinating multidisciplinary care, advocating for patient safety and implementing evidence-based practices to optimise patient and surgical outcomes[14,15]. This heightened level of responsibility underscores the need for perioperative nurses to possess advanced clinical skills, critical thinking abilities and a commitment to lifelong learning.

Considering these developments, postgraduate perioperative nursing education has emerged as a vital component in preparing nurses for the demands of modern surgical care. By equipping perioperative nurses with specialised knowledge, advanced skills and proficiency in cutting-edge technologies, postgraduate programs play a crucial role in ensuring the delivery of high-quality, patient-centred care in the perioperative setting. However, as the field continues to evolve, so too must nursing education, with a renewed emphasis on active learning strategies, innovative teaching modalities and integration of evidence-based practice into curricula[16,17].

Perioperative nursing education

The Master of Nursing (Perioperative practice) program taught at La Trobe University integrates two subjects tailored specifically for Perioperative Nurse Surgical Assistants (PNSAs) within an online Learning Management System (LMS). This platform combines written and visual content with interactive elements like images, activities, discussion forums and videos. Guided by the four phases of inquiry-based learning (IBL), students engage with relevant and credible information, summarise data, ask pertinent questions to drive self-directed inquiry and design actions driven by curiosity[18–20]. Additionally, synchronous online sessions facilitate communication and engagement among students, perioperative nurses and PNSAs nationwide, as well as with specialist presenters.

The curriculum encompasses clinical research, national and state health policies and standards, and professional competencies aimed at fostering reflection on quality improvement implications for clinical practice and patient outcomes[21,22]. Aligned with the Australian Qualifications Framework (AQF) criteria for postgraduate programs, the Master of Nursing subjects at La Trobe University meet an AQF level 9 standard, ensuring graduates acquire specialised theoretical and technical knowledge, research skills, and cognitive, technical and communication abilities for professional or highly skilled work[23]. Notably, the program emphasises the integration of theoretical knowledge with practical skills,

necessitating continued clinical practice within the perioperative environment to translate theory into practice, aligning with industry standards.

Engagement strategies in online learning for perioperative nurses

Ensuring active engagement in online education presents a significant challenge. Diep et al.[16] highlight the importance of social connectedness and a sense of belonging in online learning environments. To address this challenge, the curriculum at La Trobe integrates various strategies aimed at promoting student engagement, including interactive activities and synchronous online sessions. These measures are designed to foster a supportive learning community and enhance the overall learning experience for students.

Effective student engagement has become a focal point in higher education, particularly in online and blended learning formats. Research by Groccia[24], Pedler et al.[25] and Bouilheres et al.[26] emphasises the critical role of student engagement in the success of teaching and learning methods. Active involvement in learning activities is vital for sustaining engagement, as opposed to passive, lecture-based approaches that may lack universal effectiveness or not be engaging for students[16,27–29]. The Master of Nursing (Perioperative Practice) program at La Trobe University employs active, multisensory learning techniques in its online delivery. These methods, as highlighted by Kotsis and Chung[30], focus on visual, interactive and engaging learning approaches to enhance students' retention of online learning materials.

Surgical skills acquisition

Acquiring hands-on surgical skills poses a unique challenge in online education. While Welch et al.[31] emphasise the effectiveness of simulation-based learning in enhancing surgical skills among learners, the associated cost of simulation resources can hinder accessibility for both students and institutions. To address this challenge, innovative approaches such as homemade tools and readily available materials have been proposed[32]. These cost-effective solutions enable learners to practice surgical skills in simulated environments, thereby enhancing their proficiency before applying these skills in clinical practice. Additionally, active participation in learning activities fosters student engagement.

Schlegl[32] introduced a novel training approach for acquiring basic surgical skills through distance education that used homemade tools and readily available materials for practising suturing, knot tying and basic laparoscopic skills. Students expressed satisfaction with this distance education method for teaching surgical skills, with the majority (79%) of students meeting the curriculum's learning objectives[32]. Although materials like synthetic foam, animal meat and commercial boards are often used by students learning to suture, their expense or limited availability in resource-constrained settings poses challenges[33]. Readily available items can be used for practicing suturing and tying knots, such as banana peels for simple suturing techniques or synthetic animal skin for subcuticular suturing skills, and this facilitates development of psychomotor skills in novice clinicians [34].

Comparative studies of one-on-one surgical skills practice with an instructor compared to self-guided video-based practice have shown both strategies to be equally effective in teaching surgical skills and enhancing learners' performance[32]. These findings suggest that surgical skills can be effectively acquired through online distance education methods, creating a bridge between evidence-based theory and practical clinical application. Traditionally, hands-on psychomotor surgical skills training has been facilitated by surgeons in perioperative settings, where trainees or novice learners receive mentoring and supervision as they develop surgical assisting skills. Research by Kim et al.[35] and Jensen et al.[36] indicates no significant difference in basic surgical skill performance between training provided by surgeons and skilled non-surgeons, regardless of learners' prior surgical experience.

Efficient learning occurs when students actively engage in the learning process, as the retention of information is higher in multisensory and active learning activities[30]. However, there is a concern that patient safety may be compromised when inexperienced clinicians practice skills on patients due to inadequate knowledge, experience and supervision[30]. The Royal Australasian College of Surgeons (RACS) outlines ten surgical competencies for surgical trainees, highlighting the importance of safely and effectively performing surgical procedures for optimal patient care[37]. Novice clinicians benefit from gaining foundational surgical skills through online delivery methods and refining their surgical psychomotor skills using innovative technologies or accessible surgical skill methods before applying these skills on patients.

This skill acquisition approach aims to better prepare novices before undertaking surgical procedures on patients under the supervision of senior surgeons.

Conclusion

In the dynamic landscape of perioperative nursing, postgraduate education emerges as a method of empowerment, equipping nurses with the knowledge and skills vital for modern surgical care. The Master of Nursing (Perioperative Practice) exemplifies this commitment, integrating evidence-based theory and active learning strategies to bridge the theory–practice gap. Through innovative approaches like inquiry-based learning and engagement strategies tailored for online platforms, perioperative nurses, and PNSAs are prepared to navigate the complexities of surgical care with confidence.

As digital health and technologies continue to shape the future of health care, the significance of hands-on surgical skills acquisition in online education cannot be overstated. Cost-effective solutions and innovative methodologies, as explored in this discussion paper, pave the way for immersive learning experiences that enhance proficiency and ensure patient safety. By fostering a culture of lifelong learning and embracing advancements in perioperative practice, postgraduate nursing education remains pivotal in driving excellence and innovation in surgical care.

Declaration of conflicting interests

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Triggering change in perioperative pressure injury risk assessment: A project report

Abstract

Introduction: Hospital-acquired pressure injuries (HAPIs) are generally preventable, yet continue to be common adverse events in Australian hospitals, resulting in significant hospital expense and unnecessary harm to patients. Nurses use an appropriate assessment tool to assess patient pressure injury risk, such as the Braden Scale. Despite it being a commonly used tool in ward environments, the Braden Scale is considered by many to be unsuitable to assess patient risk during the intra-operative period. This project trialled using an additional pressure injury risk assessment tool that considers specific intra-operative factors, prior to the patient entering the operating theatre, to determine patient risk.

Method: The aim of this project was to trial the Scott Triggers® tool to assess pressure injury risk in patients undergoing surgery. Patients identified as high risk using the Scott Triggers® tool had additional preventative measures implemented in the form of a 'pressure injury prevention bundle' for the duration of their surgery. The desired outcome for this project was to see a reduction in perioperative pressure injuries and an increase in staff knowledge and awareness of pressure injury risk assessment and prevention.

Results: The Scott Triggers® tool successfully identified 37 patients as high risk for pressure injury development, whereas only one was identified using the Braden Scale. Participating perioperative nurses gave positive feedback about using the Scott Triggers® tool and implementing the pressure injury prevention bundle. Participating nurses also reported an increase in knowledge and awareness of perioperative pressure injury risk.

Conclusion: The Scott Triggers® tool was found to be more reliable for assessing pressure injury risk during the intra-operative phase. Perioperative nurses should consider the unique risk that the intra-operative period poses and use a suitable tool, such as the Scott Triggers® tool, to identify patients who are at high risk of developing a pressure injury.

Identified problem

A pressure injury, also known as a pressure ulcer or pressure sore, is defined by the Australian Commission on Safety and Quality in Health Care as a 'localised injury to the skin and/or underlying tissue, usually located over a bony prominence. As a result of pressure, shear and/or friction or a combination of these factors damage occurs to the skin, muscle and/or bone'[1, p.5]. Hospital-acquired pressure injuries (HAPIs) cause significant adverse effects for patients, including pain, physical deformities, decreased quality of life and an increased risk of morbidity and mortality[2]. Pressure injuries also have substantial impact on the health care system, resulting in increased length of hospital stays and associated treatment costs[2,3]. Kimsey[4] found patients who sustained a HAPI also had significantly higher rates of re-admission, and mortality rates of 11.2 per cent.

Although often preventable, pressure injuries continue to be one of the leading adverse events in Australian public hospitals, resulting in an annual cost of $9.11 billion[5,6]. Therefore, strategies toward pressure injury prevention are crucial to ultimately reduce the burden for patients, families and Australian hospitals.

The risk of developing a pressure injury in the operating theatre is significantly higher than other clinical areas, due to several unique risk factors linked with the surgical environment[7]. Examples of these risks include prolonged periods of immobility, impaired sensory perception, hypothermia and blood pressure fluctuations due to anaesthesia[2,8–10]. In their systematic review of literature, Haisley et al.[3] determined statistically significant results in risk factors for perioperative pressure injury development, including surgery length, low haemoglobin, diabetes and respiratory and cardiac disease. With this considered, surgical patients are found to be two to three times more likely than non-surgical patients to develop a HAPI[9]. Despite the inability to modify some of the surgery-related risk factors, perioperative nurses have a crucial role in identifying high-risk patients and implementing preventative care.

Experts suggest an essential step in the identification of high-risk patients is the use of an appropriate risk assessment tool[3,8,9]. Two of the most commonly used tools for pressure injury risk assessment are the Braden Scale and the Waterlow Scale; however, there is much debate around their suitability for perioperative patient assessment as they were not designed for operating theatre use and fail to recognise the unique risks of the operative environment[2,3,11]. In their meta-analysis of perioperative use of the Braden Scale He, Liu and Chen[10] deemed the Braden Scale unsuitable for sole assessment of surgical patients, due to its low predictive validity for perioperative pressure injury risk, and suggested a new assessment tool be developed to suit the patient demographic. The Waterlow pressure ulcer risk assessment tool has also been analysed for its perioperative validity and reliability, with Charalambous et al.[12] finding it also unsuitable as the only tool used for risk assessment of the perioperative patient due to the scale's limitations. In summary, both assessment tools have been found to be unsuitable for identifying pressure injury risk during surgery[3,8].

The Royal Adelaide Hospital (RAH) was one of many Australian hospitals using the Braden Scale to assess risk for perioperative patients developing a pressure injury, despite suggestions that it is not suitable for use in the operating theatre environment[9,10]. The incidence of pressure injuries associated with surgery at the RAH continued to be an ongoing problem, with 17 pressure injuries reported in perioperative patients between July 2020 and July 2021[13]. Furthermore, anecdotal evidence revealed that the implementation of pressure-reducing strategies was inconsistent, solely based on experience, insight and knowledge of the perioperative nurse, rather than based on a structured assessment tool[13]. As a result of these internal findings and continuing reports of perioperative pressure injuries, an alternative solution was sought to find a structured risk assessment tool which was specific for patients in the operating theatre.

Proposed solution

In 2019, two perioperative nurses from the RAH, Lauren Goudas and Steven Bruni, were awarded the 2017–2018 South Australian Premier's Nursing and Midwifery scholarship that facilitated a study tour of pressure injury prevention practices in America. Based on observation of several pressure injury prevention practices and assessment tools at various American hospitals, it was suggested that one of the observed American assessment tools be trialled in the RAH operating theatres. Specifically designed for operating theatres and considering specific risk factors for perioperative pressure injury development, the Scott Triggers® tool was chosen for use as an additional tool to the Braden Scale[9,11]. Consent to trial the Scott Triggers® tool was obtained from the creator Susan Scott and staff began preparations to commence the trial, including advertising, education and baseline data collection.

This project trialled the Scott Triggers® tool in a small sample of perioperative patients, aiming to identify those who were at high risk of developing a pressure injury in the operating theatre. Instead of using only the Braden Scale, nurses also assessed patients using the Scott Triggers® tool to identify their specific intra-operative pressure injury risk. The additional tool included four perioperative-specific factors: age, body mass index (BMI), length of surgery and American Society of Anaesthesia (ASA) score[7].

The surgical team were made aware of patients who were identified as high risk so they would receive additional evidence-based care in the form of a 'pressure injury prevention bundle', in line with recommendations from the Joanna

Briggs Institute (JBI)[14]. The pressure injury prevention bundle included several preventative measures, such as application of silicone foam dressings to vulnerable areas e.g. sacrum and heels[14]. Nurses were also prompted to consider sourcing an air mattress for post-operative care, to perform thorough pre-operative and post-operative skin assessments and to include the patient's pressure injury risk during the clinical handover. It was proposed that by using the Scott Triggers® tool, all high-risk patients would be identified pre-operatively and thus receive evidence-based care in line with their level of risk.

Project plan

The project was supported by medical and nursing management, allowing the Scott Triggers® tool to be trialled within a defined context across the RAH operating theatres. The trial was conducted over an eight-week period from 5 July to 30 August 2021, in four theatres and within two specialties – plastics and vascular. Each of the four scrub/scout clinic team leaders received face-to-face education before the trial began and were provided trial resources for reference within the operating theatre. In-service education sessions were conducted before and during the trial, aiming to educate all other clinical staff who may be involved.

All plastics and vascular patients who were undergoing surgery with a general anaesthetic and supinely positioned were included in the trial, with the remainder of patients excluded. Those who met this inclusion criteria were assessed pre-operatively by a theatre nurse using the Scott Triggers® tool and if identified as high risk received interventions from the pressure injury prevention bundle. Data from the trial was collated by the circulating nurse, who was responsible for recording each patient's details, the pressure injury prevention interventions used and any relevant feedback.

Project successes

The trial highlighted vast variations between the ability of the Braden Scale and the Scott Triggers® tool to pre-operatively identify patients with a high risk of developing a pressure injury. Over the eight-week period, the Scott Triggers® tool identified 37 patients as high risk. Of these 37 patients, the Braden Scale identified 25 as no risk, three as low risk, one as high risk and eight as unknown.

The Scott Triggers® tool demonstrated greater sensitivity in its ability to more accurately identify high-risk patients during the intra-operative period based on its specific design around intra-operative risk factors. The data demonstrated that the Braden Scale, although suitable for other environments, such as the pre- and post-operative surgical wards, lacked the ability to factor the unique risks of the operating theatre and subsequently only identified one patient as high risk.

All patients who were identified as being high risk using the Scott Triggers® tool, did not develop any pressure injuries during their perioperative care.

Nurses who participated in the trial gave positive feedback in post-implementation surveys, reporting that the Scott Triggers® tool was easy to use and the pressure injury prevention bundle was mostly simple to implement. They also expressed increased knowledge and awareness of the management of pressure injuries leading to an increase in incident reporting and documentation. Positive feedback was also noted from patients, with one patient expressing their feelings of reassurance in staff who were implementing preventative strategies, particularly as they had previously suffered a HAPI.

Opportunities for improvement

Despite a hundred per cent compliance rate using the Scott Triggers® tool, staff reported some challenges when implementing the pressure injury prevention bundle, with 28 per cent of high-risk patients not receiving all of the associated interventions. Reasons for this included difficulty applying dressings on the anaesthetised patient, the patient condition taking clinical priority and impacts relating to the surgical procedure.

To improve ongoing compliance, it was suggested that dressings could be applied, either in the holding bay or the operating theatre, before induction of anaesthesia. This would avoid having to roll anaesthetised patients, thus preventing possible airway disturbance and reducing the manual handling risk for staff. Applying dressings to awake patients may also be a valuable strategy to align with the National Safety and Quality Health Service (NSQHS) standard, Partnering with consumers, demonstrating evidence of consumer engagement in care.

The trial relied on the cooperation of the multidisciplinary team and many lessons were learned regarding the importance of teamwork in change management. The trial highlighted that a strong collaboration with the supply department was essential to ensure that stock availability matched the increase in usage. This was made apparent when staff expressed some frustration when attempting to apply dressings – stock was unavailable, not easily accessible or an unsuitable alternate brand.

The Scott Triggers® tool uses specific information provided by medical staff (e.g. ASA score, height/weight, length of surgery), and the trial highlighted a need for further education and increased awareness among surgeons and anaesthetists to integrate the tool into practice. Some staff found that obtaining this information took additional time and resulted in minor delays, a finding consistent with a similar implementation project using the Scott Triggers® tool conducted by Perrenoud et al. Although Perrenoud et al.[15] reported that the process of collecting necessary information was time consuming and a potential deterrent to use, they reinforced the value of a structured risk assessment tool compared to nursing clinical judgement.

Recommendations

The trial piloted an evidence-based change to pressure injury prevention practice in intra-operative patient assessment and care. Results indicated the suitability of the chosen assessment tool and preventative measures. The Scott Triggers® tool was found to be a valuable additional assessment for intra-operative identification of patients at high risk of developing a pressure injury. This tool was used in addition to the existing Braden Scale, which was found to be unsuitable for use as the only tool for identifying high-risk patients in operating theatres. These findings were parallel to other similar studies and, as a result, it is recommended that intra-operative practice based solely on the Braden Scale needs to be reconsidered. The use of an additional assessment tool that is appropriate for the theatre environment, such as the Scott Triggers® tool, should be considered for pressure injury risk assessment for all patients undergoing surgery.

Declaration of conflicting interests

The authors have declared no competing interests with respect to the research, authorship and publication of this article.

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Effectiveness of fascia iliaca compartment block in adult fractured neck of femur patients: An integrative review

Abstract

Introduction: According to the Australian and New Zealand Hip Fracture Registry approximately 19 000 patients in Australia and 4000 patients in New Zealand will fall and fracture their hip every year. This poses a huge burden on health care facilities (both fiscally and functionally) and has an even more dramatic effect on the older patients who fall and their families. The purpose of this review is to give perioperative nurses a deeper understanding of regional blocks that may be considered – in particular, the fascia iliaca compartment block. Traditional pain management strategies, such as opioids, have limitations which leads to the use of several different types of regional blocks (some single injection, some continuous infusion) being administered as an alternative approach in providing pain relief prior to surgery.

Methods: A thorough search was conducted using CINAHL, MEDLINE and PubMed databases to find relevant papers published in English from 2016 to the present. Primary research studies – namely cohort studies, retrospective and prospective studies, and randomised controlled trials – were integrated to provide a synthesised overview of this topic. A recent systematic review that focussed on delirium was also reviewed to add to this discussion.

Discussion: While this review primarily investigated fascia iliaca compartment blocks, numerous research studies have been cited in this review to demonstrate an overview of the several different types of regional blocks available for fractured neck of femur patients. These include femoral nerve blocks, femoral obturator nerve blocks and pericapsular nerve group blocks as well as fascia iliaca compartment blocks. Some of these are administered by a single injection while others are provided via continuous infusion.

Conclusion: In patients with neck of femur fractures, fascia iliaca compartment blocks have consistently demonstrated success in reducing pain, decreasing the use of opioids, improving patient satisfaction and hastening healing. Although fascia iliaca compartment blocks appear to lower the likelihood of post-operative delirium, more research is needed to definitively determine the long-term cognitive effects. This review places a strong emphasis on the importance of pain treatment being tailored for each individual health care facility and patient.

Keywords: neck of femur, fascia iliaca compartment block, femoral obturator nerve block, continuous infusion fascia iliaca block, pain, pre-operative

Introduction

As we age, the risk of both falls and fractures increases. According to the Australian and New Zealand Hip Fracture Registry[1] approximately 19 000 patients in Australia and 4000 patients in New Zealand fall and fracture their hip every year. As the world population is aging, neck of femur (NOF) fractures will become more prevalent, necessitating comprehensive and adaptable interventions[2]. Sadly, for this elderly cohort, NOF fractures are associated with debilitating pain, functional limitations, adverse outcomes, including substantial morbidity that significantly impacts quality of life, and mortality[3]. Timely and effective pain management is crucial to alleviate suffering and facilitate optimal surgical outcomes and early mobilisation[4]. One approach that has gained attention in recent years is the fascia iliaca compartment block (FICB), an effective pre-operative analgesia for NOF fracture patients[5].

This integrative review looked at Australian and international literature, delving into the collective experience with FICB in adult NOF fracture patients to examine its effectiveness as a pre-operative analgesic technique. This integrative review aims to provide pre-operative, intra-operative and post-operative nurses with a deeper understanding of this regional anaesthetic technique.

Review methods

This review of literature has followed the Whittemore and Knafl[6] methodology for writing an integrative review, looking at different research methodologies and combining these in a way that allowed greater understanding and analyses of the phenomenon to be reviewed.

Literature search

To identify quality research for inclusion in this literature review, a comprehensive search was conducted across three reputable databases: CINAHL, MEDLINE and PubMed. The search strategy incorporated various combinations of keywords and phrases, including the Boolean operators AND/ OR, (Fascia Iliaca Block) AND (Neck of Femur) OR (hip fracture) AND (elderly) along with corresponding MeSH terms as appropriate in PubMed. The search was limited to studies focusing on the adult population and published in English from 2016 to the present to ensure the most current and relevant evidence. Following the initial search, a rigorous screening encompassed duplicate checks, title assessments and abstract reviews. Articles that were deemed potentially relevant based on these criteria were then subjected to a comprehensive evaluation using tools from the EQUATOR network.

Inclusion and exclusion criteria

A total of 15 papers, representing a range of evidence levels, met the inclusion criteria. The studies used a range of research approaches including, randomised controlled trials, retrospective and prospective investigations, cohort studies and a systematic review. Limiters on database searches were applied, including publication years 2016 to 2024, English language, peer reviewed and full text.

While papers published within the last five years were used in this review, a ten-year limiter was used to allow any salient or germinal research to be identified and older papers to be cited forward. Further inclusion criteria included primary research papers using quantitative, qualitative or mixed-methods methodology, and systematic reviews. Exclusion criteria included, papers of poor research quality, non-primary research, quality improvement studies, conference papers, reviews, opinion pieces and guidelines.

Data evaluation

Employing the EQUATOR critical appraisal tools, it was determined whether the identified papers were of good quality[7].

Discussion

Regional analgesic techniques like the FICB have become a compelling alternative for pain management in NOF fractures[8]. The research landscape supports the efficacy and multifaceted benefits of FICB[9]. FICBs have been administered in various clinical settings, including the emergency department, pre-hospital care and operating rooms[10].

Regional nerve blocks are administered by injecting local anaesthesia solution into specific anatomical landmarks by using guidance from either a nerve stimulator or ultrasound machine[11]. In Australia, NOF fracture patients may be offered either an FICB, a femoral nerve block (FNB) [11] or the more recently described pericapsular nerve group (PENG) block[12].

Thematic analysis of the studies included in this review revealed three themes – administration sites and techniques, pain management and cognitive function and delirium. This discussion will be presented under these themes and include implications of the research for perioperative nurses.

Administration sites and techniques

Administration sites

Three of the studies included in this review compared FICB to other pain management. Aprato et al. conducted a blind randomised control trial (n=120) comparing FICB with intra-articular hip injection (IAHI) for pain management in elderly patients (>65 years) with an intracapsular hip fracture. The results of this prospective study were intriguing. Aprato et al.[13] reported that IAHI provided better pre-operative pain management and significantly reduced pain in the Post Anaesthesia Care Unit (P<0.05); however, FICB offered superior analgesia on the first and second post-operative days for most patients (72.9%). These findings indicate that the block technique may influence pain relief and should be tailored to the patient's condition and the type of hip fracture.

Assessing the safety and potential side effects of FICB is critical in determining its overall utility. A prospective, double-blind, controlled study (n=154) by Zhou et al.[14] compared the analgesia of femoral obturator nerve block (FONB) and FICB in elderly patients (>65 years) with hip fractures and reported that the FONB group required significantly fewer post-operative analgesic drugs and experienced less nausea and vertigo than the FICB group (*P*=0.031 and *P*=0.034, respectively). In addition, post-operative function was significantly improved in the FONB group of patients ($p< 0.029$)[14]. These findings suggest that while FICB may be effective, alternative techniques like FONB may provide better pain management with fewer side effects in some patients reminding us of the need to assess every patient's individual circumstances and provide pain relief accordingly.

An Australian pilot study by Fahey et al. compared FICB (n=19), PENG (n=19) and FNB (n=14) administered as a single injection (often referred to as a 'one-shot' block) to patients with an NOF fracture. Fahey et al.[12] reported that there was no difference in maximum pain score reduction between the three groups. What was interesting was that inexperienced providers were able to successfully perform the PENG block[12]. As this was a small pilot study, it was recommended a larger randomised control trail be conducted to investigate this finding further[12].

Administration techniques

FICBs can be administered as a single injection ('one-shot') or continuously via a catheter. In their prospective, observational cohort study (n=107), Stephan et al.[15] compared one-shot FICB with continuous catheter FICB (CFICB) and found no significant differences in pain management, post-operative analgesia requirements or functional outcomes (*P*=0.067). In a single shot injection, it is envisaged that the patient will receive surgical intervention before the block wears off (approximately six hours) or a second one shot injection will be required.[15] These findings implied that single-shot FICB and CFICB may provide some options for variability in use, depending on the expected time to surgery.

A retrospective matched case-control study (n=40) by Rasappan et al. investigated the CFICB in geriatric hip fracture patients. According to Rasappan et al.[16], the CFICB group experienced much lower post-operative pain levels and consumed considerably fewer total opioids during the first three days after surgery than the control group (P<0.0001). However, the CFICB group had slower rehabilitation in the short term but no significant difference in function and mobility at one-year after surgery. These findings suggest that CFICB provides safe and effective post-operative pain relief without adversely affecting long-term outcomes.[16]

Pain management

Castillón et al.[17] conducted a prospective cohort study focusing on the effects of FICB on pain management and reported a statistically significant reduction in patients' visual analogue scale (VAS) pain scores after FICB administration (95%CI: 2.45–3.53%, *P*<.001).

In the following year, Ma et al.[18] carried out a prospective randomised controlled trial (n=88) examining the effects of CFICB on pain management in patients with hip fractures and reported that patients who received CFICB had considerably lower VAS pain scores than those who did not (*P*=0.023). This suggests that this method effectively lessened pain intensity. Additionally, participants in the CFICB group reported higher levels of satisfaction with their analgesic regimen (*P*<0.001) revealing not only enhanced pain management but also enhanced patient satisfaction with their pain reduction.[18]

Ma et al.'s findings are supported by a double-blinded, randomised clinical trial (n=90) carried out by Hao et al.[19] who also reported less pain after CFICB. Pre-operative pain was reduced in the experimental group (*P*<0.05)[19], suggesting that CFICB was successful in treating pain before surgery. Further findings revealed that there was no difference in side effects of analgesia; however, the length of stay was shorter in the CFICB group.[19]

In a retrospective observational trial (n=192) on patients with different forms of fragility hip fractures, Li et al.[20] also reported the pain-relieving capabilities of FNB finding statistically significant pain score reductions (P=0.006) and a notable decrease in the need for opioid analgesia after FNB. This reduction in opioid consumption is particularly relevant in the ongoing opioid crisis, highlighting the potential role for nerve blocks in mitigating this issue[20].

In a systematic review of literature conducted by Wan et al.[21], collective findings revealed that FICB could offer post-operative pain relief that was on par with or better than that offered by traditional analgesics, therefore reducing the need for additional analgesics and decreasing consumption of morphine and the incidence of nausea. Additionally, the review emphasised how FICB aided in earlier mobilisation and helped to prevent common complications such as post-operative delirium.[21] These results emphasise the advantages of incorporating FICB into pain management regimes.

The effectiveness of FICB in decreasing opioid consumption was further corroborated by two other studies. Schulte et al.[22] conducted a prospective randomised controlled trial (n=97) and demonstrated significantly fewer morphine milligram equivalents were consumed (13 vs. 17, P=0.04) and a significantly higher proportion of patients were discharged home (50.9% vs 32.5%, P=0.05) in the FICB group than the non-FICB group[22].

In a randomised prospective study, Thompson et al.[23] also found a statistically significant reduction in morphine usage (P<0.05) among patients (n=47) who received pre-operative FICB. Furthermore, this study also noted an improvement in patient-reported satisfaction as evidenced by the reduced demand for morphine and greater patient satisfaction levels (31%, P<0.01)[23]. Both authors recommend integrating FICB into institutional geriatric hip fracture pain protocols as an adjunctive pain control strategy[22,23].

More recently, a retrospective cohort analysis of patients with hip fractures (n=110) conducted by Houserman et al. in 2022, compared length of hospital stay, post-operative pain scores, time from admission to surgery, narcotics use and readmission within 30 days of surgery in patients who received CFICB and patients who did not. Houserman et al.[24] found that patients in the CFICB group had significantly shorter length of hospital stay than patients in the non-CFICB group (respectively, 3.9 and 4.8 days, P<0.001), and lower pain scores on the second and third day after surgery (P=0.019) suggesting that CFICB could accelerate healing and aid in pain management following surgery. However, Houserman et al.[24] also found that more patients in the CFICB group were readmitted within 30 days after surgery than in the non-CFICB group (P=0.047).

Similarly, Hao et al. explored the effects of FICB on post-operative pain and hip function in patients with hip fractures. Their prospective observational randomised trial (n=120) also revealed that the FICB group had significantly lower pain scores (P<0.05) at rest and with movement and more rapid recovery of hip function after surgery[25]. The incidence of post-operative complications and adverse events did not differ significantly between the FICB and control groups (P=0.13).[25]

Cognitive function and delirium

In a double-blind randomised controlled trial (n=127) Wennberg et al.[26] investigated the impact of FICB on cognitive function in elderly patients with a single hip fracture and found that cognitive function deteriorated in fewer patients in the FICB group than in the non-FICB group. However, this result was not statistically significant.

Wennberg et al. also grouped participants into four groups according to level of cognitive impairment and compared the dose of prehospital pain medicine administered. While there was no significant difference between groups with mild, moderate and no cognitive impairment, it was found that the mean dose of prehospital pain medicine given to patients with severe cognitive impairment was significantly lower than the mean dose given to patients with higher levels of cognitive function (4.02mg and 6.43 mg respectively)[26]. This highlighted the importance of behavioural pain assessment with patients with severe cognitive impairment as they are likely to have communication difficulties[26].

Hao et al.[19] carried out a double-blind randomised clinical trial (n=90) to investigate the impact of CFICB on post-operative delirium and found a lower occurrence of post-operative delirium in the CFICB group than the non-CFICB group (13.9% vs 35.7%, P=0.018). These findings suggested that pre-emptive analgesia via CFICB positively impacted post-operative delirium by providing more effective pain relief and mitigating the risk of delirium.[19]

A very recent systematic review, conducted by Lay et al. in 2024 in Australia, looked at delirium in 21 research studies (n=5096) of patients

following fractured NOF. While the results indicated some positive effects of FICB, the sample sizes were small and there is an urgent need for larger research trials to closely investigate possible preventative connections between regional blocks and delirium[27].

Implications for perioperative nurses

This review has contributed to the expanding body of knowledge for perioperative nurses, revealing that FICB, FOB, PENG blocks are effective pain management options for NOF patients.

FICB could be viewed as a useful pre-operative analgesic for patients with NOF fractures, either as a single shot or continuous infusion. Studies indicate that FICB administration has the potential to lower the use of opioids, reduce the incidence of post-operative delirium and improve patient outcomes. These outcomes have a huge impact on the perioperative nurse's ability to provide safe care for patients in both the PACU and ward areas.

The learning in this review aids in informing perioperative nurses of some of the options open to their patients and gives valuable insights into possible pain management outcomes both before arrival and after leaving the operating suite. In particular, the association between cognitive impairment and analgesia, and pain assessment methods should be investigated in more detail to enable individualised pain management plans.

Conclusion

This integrative review of literature examining FICB in hip fracture patients has revealed that pre-operatively, FICB reduces pain, lowers opioid use and enhances patient satisfaction. The reviewed studies consistently reported superior pain relief in patients who received FICB compared to those who received conventional analgesia. FICB was also associated with reduced opioid consumption, which is crucial considering the potential adverse effects of opioids in the elderly population. Additionally, FICB was found to shorten hospital stays and improve patient satisfaction due to better pain control and earlier mobilisation.

However, the studies also indicated that alternative techniques such as FNB, FONB and PENG blocks may also benefit some patients. CFICB also effectively controlled pain but may cause short-term rehabilitation delays. Research also emphasises the importance of personalised pain assessment and management, particularly for patients with cognitive impairment. FICB may help reduce the risk of post-operative delirium, but further research is needed regarding its long-term cognitive effects.

Current Australian and international research encourages clinicians to consider incorporating FICB into multimodal pain management strategies tailored to individual patient needs and preferences, and emphasises the need for further high-quality research to validate and refine the role of FICB and other regional blocks in the comprehensive care of NOF fracture patients.

Declaration of conflicting interests

The authors have declared no competing interests with respect to the research, authorship and publication of this article.

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