

Authors

Sara Morais Pires

Lisbon School of Nursing, Lisbon
Nursing Research, Innovation and
Development Centre

Ana Rita Maurício

Lisbon School of Nursing, Lisbon
Nursing Research, Innovation and
Development Centre

Lúcia Jerónimo

Lisbon School of Nursing, Lisbon
Nursing Research, Innovation and
Development Centre

Bruno Teixeira

Ordem Terceira Hospital

Ana Ramos

Lisbon School of Nursing, Lisbon
Nursing Research, Innovation and
Development Centre

Idalina Gomes

Lisbon School of Nursing, Lisbon
Nursing Research, Innovation and
Development Centre

Eunice Sá

Lisbon School of Nursing, Lisbon
Nursing Research, Innovation and
Development Centre

Corresponding author

Sara Morais Pires

Lisbon School of Nursing, Lisbon
Nursing Research, Innovation and
Development Centre
sarapires@esel.pt

Nursing interventions to promote safety in robotic surgery: A systematic literature review

Abstract

Introduction: The use of robotic surgery has revolutionised surgical procedures, offering benefits such as less blood loss, faster recovery and fewer post-operative complications. However, the increase in surgical time and technical challenges impose the need for systematic perioperative nursing interventions to guarantee patient safety and the efficiency of the process.

Aim: To systematise the nursing interventions in the pre-, intra- and post-operative phases of robotic surgery that generate safety in the perioperative period.

Method: Systematic literature review using the Joanna Briggs Collaboration methodology and the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) extension. The MEDLINE, CINAHL, LILACS, SCOPUS and Cochrane Library databases were searched and 16 primary and secondary studies published between January 2014 and May 2024 were included. The data were extracted and analysed independently by two reviewers.

Results: Nursing interventions in the pre-operative phase were characterised by rigorous technical preparation, effective communication and the use of checklists. In the intra-operative phase, team communication and coordination, proper patient positioning and the use of support surfaces were crucial. In the post-operative phase, continuous monitoring, pain management, self-care training and emotional and educational support were identified as fundamental.

Conclusion: Nursing interventions play a crucial role in the safety and effectiveness of perioperative care in robotic surgery. Continuous training, technological adaptation and the use of systematic approaches are essential to maximise the benefits of this technology, as well as promoting patient safety and wellbeing.

Keywords: robotic surgery, nursing care, perioperative nursing, safety, systematic review.

Introduction

Continuing technological advances and the laparoscopic revolution of the 1980s promote the use of less invasive traditional approaches and new techniques, such as modern robot-assisted surgery^{1,2}. The first DaVinci robot was introduced in London in 2001³ and now, just 24 years later, robots are increasingly being used in various specialties. The use of robots is central to the new technological surgical environment, driving new horizons for humanity and constant evolution beneficial to health care.

The operating theatre is a complex environment, and the increasing

integration of new technologies is a challenge for perioperative nursing. This requires the development of new skills and procedures to ensure a safe environment for patients undergoing robotic surgery. Existing studies have highlighted the importance of this area, pointing to the need for continuous training of the professionals involved^{4,5}.

Robotic surgery, being a differentiated and innovative procedure, requires trained professionals both in the technical, scientific aspects and in the practice of the procedures performed⁶. It represents technological evolution in the medical field and has allowed for greater precision and efficiency in surgical procedures^{6,7}.

Robotic surgery offers numerous advantages and contributes to increased surgical safety and efficiency by enabling more controlled and stable movements, thereby minimising human error. It enables highly technical procedures that would be challenging or impossible with conventional surgical methods. There is evidence that robotic platforms provide superior visualisation through stereoscopic imaging, allowing for greater precision in tissue dissection and suturing. Additionally, robotic systems eliminate hand tremors and allow for scaled movements, enabling surgeons to perform delicate procedures with enhanced accuracy. Robotic surgery also accelerates post-operative recovery by decreasing surgical trauma and bleeding⁷. These technological advancements expand the scope of minimally invasive surgery, reducing patient trauma, minimising complications and shortening hospital stays, thereby revolutionising surgical practice across multiple specialties¹².

Concerns about robotic surgery predominantly focus on the increase in surgical time, although the gains in recovery times and the benefits of robotic techniques in more complex surgeries may counterbalance this disadvantage⁸.

Specific nursing interventions have been developed to maximise the safety, efficiency and quality of care provided to patients undergoing robotic surgery^{5,9,10}. In turn, some authors argue that perioperative nurses need to undergo continuous training to keep up with technological developments¹¹. The impact of this innovative technology has the potential to bring about transformative clinical improvements¹², and perioperative nurses are one of the main players in coordinating all robotic surgery¹³.

It is essential to prepare, train and update health professionals, especially perioperative nurses, to provide the specific support that a robotics programme requires¹⁴. Perioperative nurses carry out interventions such as safely positioning the client, checking and confirming the sterilisation of re-usable equipment and the surgical field, handling the robot and solving any problems that may arise during surgery^{4,5},

as well as improving the quality of care, reducing costs and promoting efficiency in management¹⁴.

Research shows that perioperative nurses act from the beginning to the end of the procedure. They not only prepare the robot for the surgical procedure but also prepare the patient and assist the surgeon who will operate the robot⁴⁻⁶; therefore, there is a clear need for education and training for nurses who work with robotic surgery, in order to promote safe and effective care¹⁵.

The aim of this review is to identify which nursing interventions practiced during the perioperative period promote safe care, effectively contributing to the quality of nursing care in this context.

Methods

This systematic literature review was conducted using the method proposed by the Joanna Briggs Collaboration^{16,17} and written in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for scoping reviews (PRISMA-ScR)¹⁸.

The methods proposed by the Joanna Briggs Collaboration have been widely used and recognised in multiple areas of knowledge and by experienced reviewers, representing a primary approach to support decision-making based on the best available evidence¹⁹.

The PRISMA-ScR was developed in 2018 and provides a reporting checklist for this specific type of review and is consistent with that proposed by the Joanna Briggs Collaboration²⁰. Overall, the steps that should be followed are: formulating the review question, defining inclusion and exclusion criteria, locating studies through searching, selecting studies for inclusion, and extracting, analysing and synthesising the data from relevant studies²⁰. The protocol for this systematic review was previously published on the PROSPERO platform, with registration identification CRD42024548448.

Review question

The guiding question of this review was: What are the nursing interventions that promote safety in robotic surgery?

Inclusion and exclusion criteria

Primary and secondary studies and studies conducted in Portuguese, English and Spanish were included. A time limit of ten years was set, from January 2014 to May 2024, in order to integrate the most recent evidence. Studies that did not address robotic surgery or that consisted of editorials, letters to the editor, books, book chapters, guidelines, expert opinion articles, conference proceedings and abstracts were excluded.

Search strategy

This review used a three-stage search strategy. An initial search limited to MEDLINE (PubMed) and CINAHL (EBSCO) was carried out to identify articles about the topic. The text words contained in the titles and abstracts of the relevant articles, and the indexed terms used to describe the articles, were used to develop a preliminary search strategy.

Subsequently, a definitive strategy was formally proposed for each of the databases included, and the strategy was adjusted based on the lexicons and specificities of each one (see Table 1). A combination of controlled and non-controlled descriptors was used to maximise the search and take into account the available evidence. The controlled descriptors were selected from the Medical Subject Headings (MeSH), Health Sciences Descriptors (DeCs) and CINAHL headings. The databases included were MEDLINE (via PubMed) and CINAHL (via EBSCO), LILACS, Scopus and the Cochrane Library.

Finally, in a third phase, the reference lists of the articles included in the review were analysed to include potentially relevant studies.

A pilot process of initial analysis was conducted independently by both reviewers, based on 25 titles and abstracts. The results of the analysis were compared and discussed, while allowing for changes to the eligibility criteria to ensure that both reviewers agreed. In accordance with Peters et al.²⁰, this pilot process continued until at least 75 per cent agreement was reached between the reviewers.

Table 1: Search strategy applied to each database

Database	Research strategy
LILACS	(robotic surgery*) OR (robotic surgical) OR (robotic-assisted) OR (robotic*) OR (RAS) OR (robotic surgical) AND (nurse*) OR (nursing) AND (perioperative) OR (operating room)
MEDLINE	“robotic surgical procedures”[MeSH Terms] OR “robotics”[MeSH Terms] OR “robotic surgery”[Title/Abstract] OR “surgical robot”[Title/Abstract] OR “robotic surgeries”[Title/Abstract] OR “robotics surgical”[Title/Abstract] OR “robotic-assisted”[Title/Abstract] OR “robotically assisted”[Title/Abstract] OR “robotic”[Title/Abstract] OR “robotics”[Title/Abstract] OR “robot-assisted”[Title/Abstract] OR “RAS”[Title/Abstract] AND “nurses”[MeSH Terms] OR “nursing”[MeSH Terms] OR “nurse”[Title/Abstract] OR “nursing”[Title/Abstract] AND “perioperative period”[MeSH Terms] OR “perioperative care”[MeSH Terms] OR “perioperative nursing”[MeSH Terms] OR “surgical procedures, operative”[MeSH Terms] OR “operating rooms”[MeSH Terms] OR “surgery”[MeSH Subheading] OR “perioperative”[Title/Abstract] OR “surgery”[Title/Abstract] OR “surgeries”[Title/Abstract] OR “operating room”[Title/Abstract] OR “operating theatre”[Title/Abstract]
CINAHL	(MH “Robotic Surgical Procedures”) OR “robotic surgical” OR (MH “Robotics”) OR “robotics” OR “robotic surgery” OR “surgical robot” OR “robotic surgeries” OR “robotics surgical” OR “robotic-assisted” OR “robotically assisted” OR “robotic” OR “robot-assisted” OR “RAS”) AND (MH “Nurses”) OR “nurses” OR “nursing” OR “nurse”) AND (MH “Perioperative Care”) OR (MH “Perioperative Nurses”) OR (MH “Perioperative Nursing”) OR “PERIOPERATIVE” OR “SURGERY” OR (MH “Surgery, Operative”) OR “SURGERY, OPERATIVE” OR “OPERATING ROOM” OR (MH “Operating Rooms”)
Scopus	(TITLE-ABS-KEY (“robotic surgery”) OR TITLE-ABS-KEY (“Surgical robot”) OR TITLE-ABS-KEY (“robotic surgeries”) OR TITLE-ABS-KEY (“robotics surgical”) OR TITLE-ABS-KEY (“robotic-assisted”) OR TITLE-ABS-KEY (“robotically assisted”) OR TITLE-ABS-KEY (robotic*) OR TITLE-ABS-KEY (ras) AND TITLE-ABS-KEY (nursing) OR TITLE-ABS-KEY (nurse*) AND TITLE-ABS-KEY (perioperative) OR TITLE-ABS-KEY (“operating room”) OR TITLE-ABS-KEY (“surgical procedures”) OR TITLE-ABS-KEY (“surgical procedures, operative”) OR TITLE-ABS-KEY (surgir*))
Cochrane Library	(robotic surgery*) OR (robotic surgical) OR (robotic-assisted) OR (robotic*) OR (RAS) OR (robotic surgical) AND (nurse*) OR (nursing) AND (perioperative) OR (operating room)

The full texts of the included articles that potentially met the inclusion criteria were assessed based on the PICO (population, Intervention, control, outcome) framework²⁰ with:

- **population** being perioperative nurses providing care in robotic surgery
- **intervention** being the nursing interventions
- **control** being usual care
- **outcome** being promotion of safety in robotic surgery.

The study selection and review process were operationalised using

Rayyan® (Qatar Computing Research Institute, Doha, Qatar) and duplicates were removed.

Study selection

Initially, 967 studies were identified in the selected databases. After removing duplicates, the full text was analysed by two independent reviewers in order to ensure the quality of this stage. The assessment of whether or not to include the study in the current review was based on reading the title and abstract. Disagreements between the two reviewers were resolved with the participation of a

third reviewer. The full texts of selected articles were assessed to ensure that the inclusion criteria were met. Among the reasons for excluding the studies were: population not defined, study typology, outcome not determined and language not considered. A PRISMA-ScR flowchart is presented in Figure 1.

Data extraction and synthesis

Data from the 16 studies included in the review was extracted by two independent reviewers using a data extraction tool developed by the reviewers.

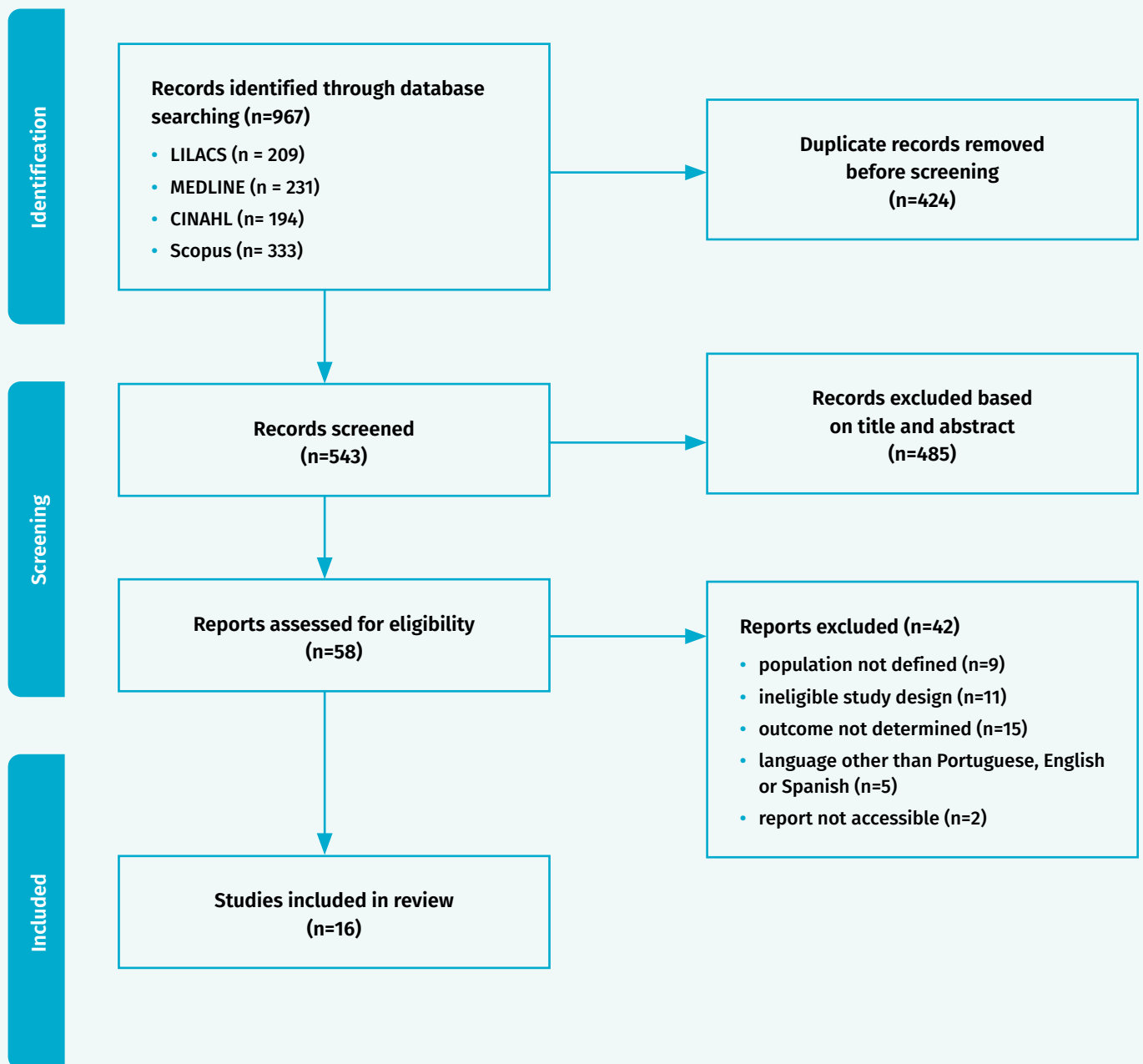


Figure 1: PRISMA flow diagram of article selection process

Methodological quality assessment

The methodological quality of the included studies was assessed using the Critical Appraisal Checklist for Systematic Reviews and Research Syntheses, developed by the Joanna Briggs Institute (JBI)²¹. This tool was applied by two independent reviewers to ensure that the studies met strict criteria for validity and methodological reliability. Only studies that met more than 80 per cent of the criteria with 'yes' answers were included, ensuring high methodological quality and minimising potential bias.

This evaluation method allowed a careful analysis of the quality of the studies and contributed to the formulation of evidence-based recommendations, with an emphasis on the importance of promoting future studies with greater methodological rigour to strengthen the evidence base in the area of nursing interventions in robotic surgeries.

Results

At the end of the search of the electronic databases, 967 articles were identified, of which 424 were automatically removed by Rayyan® for being duplicates. Subsequently, two reviewers independently read the title and abstract of 543 reports. Of these, 58 were selected to be read in full and any disagreement between the reviewers was discussed, or a third reviewer was asked to evaluate them, until a consensus was reached. At the end of the selection process, 16 studies were selected to make up the systematic review.

The reviewed articles were subjected to a descriptive analysis, as summarised in Table 2. The nursing interventions that promote the safety of people undergoing robotic surgery were identified and organised into the three phases that make up the perioperative period.

Discussion

After analysing the evidence, nursing interventions emerged that demonstrate the complexity and technical-scientific rigour that characterises robotic surgery. These interventions each belong to a distinct phase of the perioperative period – pre-operative, intra-operative or post-operative.

Pre-operative interventions

Evidence shows that nurses put patient safety first, even when they face challenges or experience work-related overload, and look for opportunities to learn about robotic surgery²⁶. Studies highlight the importance of standardised training and the development of systematic assessments to prepare nursing staff²²⁻²³. Simulation training of the nursing team, using realistic scenarios, allows critical thinking to be developed which enables assessment of the singularities and specificities of the surgical procedure and the patient in order to choose the best course of action³².

Research also points to the importance of continuous training and rigorous technical preparation on the part of nurses²⁵. In addition, effective communication and familiarity with robotic equipment are crucial to surgical safety²²⁻²³.

With regard to preparing the equipment before surgery, nurses check that the instruments are working properly, check the electrical and carbon dioxide connections and position the robot appropriately; this preparation helps to prevent complications during the intra-operative period^{23,26}. The evidence also suggests that checking the robot the day before surgery and on the day itself, before and after surgery, is crucial to ensure that the equipment is working properly and to prevent emergencies related to system failure²⁶.

As far as nursing care is concerned, a detailed pre-operative assessment of the patient as well as discussion of possible side effects and clarification of doubts with the patient are important to reduce patient anxiety and improve patient cooperation during the procedure^{24,34}. Research also refers to the use of safe surgery checklists to ensure that all procedures are followed in a uniform and systematic way²⁷.

Intra-operative interventions

Different types of robotic surgeries present unique challenges that influence the roles and responsibilities of perioperative nurses. This review identified several key robotic procedures, including urological (prostatectomy, nephrectomy)^{23,24}, gynaecological

(hysterectomy, myomectomy)²⁵, thoracic (lung resections, mediastinal mass excision)²⁸, colorectal (colectomy, rectal resection)³¹ and general abdominal surgeries (hernia repair, cholecystectomy)^{27,32}. Nurses must be proficient in troubleshooting robotic systems, ensuring sterility, preventing positioning-related injuries and anticipating intra-operative challenges unique to each specialty^{23-25,32}.

In the context of robotic surgery, communication plays a critical role in ensuring the success and efficiency of surgical procedures²². Communication is particularly critical in robotic surgery compared to traditional surgical methods because robotic surgery involves advanced technology with complex instruments, and effective communication is necessary to ensure that all team members understand how to operate the equipment, troubleshoot issues and respond to unexpected events³⁰.

During the intra-operative phase, effective communication and continuous technical support are essential. Research emphasises the importance of effective communication, both verbal and non-verbal, in order to coordinate complex actions and guarantee patient safety²². The presence of inexperienced nurses can negatively affect team functioning and increase the incidence of adverse events²⁹; therefore, adopting systematic approaches to integrating new team members is essential. Research also suggests that adapting communications and managing the robotic system can optimise workflow and minimise errors^{23,31}.

Robotic surgery brings new responsibilities to perioperative nurses, such as preparing the necessary materials, connecting and checking all connections to the chargers and ensuring that the robot is positioned correctly²³. Connecting, calibrating and handling the robot correctly have also been identified as important, as well as being prepared for emergency undocking procedures²⁸. These responsibilities require nurses to acquire technological competence²³. Nurses have reported both positive feelings, such as enthusiasm and fascination for the technology, and negative feelings, such as stress and anxiety mainly due to the lack of experience and the high responsibilities

Table 2: Summary of nursing interventions to promote safety in robotic surgery identified from the included studies (n = 16)

Perioperative phase	Nursing intervention	Evidence	Reference
Pre-operative phase	Staff training and education	Standardised training and detailed assessments to prepare the team.	Tiferes et al. (2018) ²² Celik et al. (2023) ²³
	Effective communication	Importance of effective communication and familiarity with the robot.	Tiferes et al. (2018) ²² Schuessler et al. (2019) ²⁴
	Patient education	Pre-operative education to reduce anxiety and improve co-operation.	Schuessler et al. (2019) ²⁴
	Rigorous technical preparation	Ongoing training and detailed technical preparation of the patient and the system.	Porto and Catal (2021) ²⁵
	Checking equipment	Checking the robot the day before and on the day of surgery to ensure proper functioning.	Kang et al. (2016) ²⁶
	Safe surgery checklists	Checklists to ensure that all procedures are followed uniformly.	Vitoriano et al. (2023) ²⁷
	Adapting to technology	Adaptation to robotic surgery technology and clear definition of tasks and responsibilities.	Celik et al. (2023) ²³
Intra-operative phase	Effective communication	Importance of verbal and non-verbal communication in coordinating complex actions.	Tiferes et al. (2018) ²²
	Patient positioning	Connecting, calibrating and handling the robot correctly, being prepared for emergency undocking.	Møller et al. (2023) ²⁸
	Integrating new members	Systematic approaches to integrating new team members and minimising adverse events.	Schiff et al. (2016) ²⁹
	Adaptation of communications and robotic system management	Optimisation of workflow and minimisation of errors.	Celik et al. (2024) ³⁰ Gillespie et al. (2020) ³¹
	Support and protection surfaces	Use of viscoelastic polymer gel and pyramidal foam support surfaces to protect pressure points.	Ângelo et al. (2020) ³² Ângelo et al. (2017) ³³
	Peripheral injury prevention	Assessing risk factors, using padded support surfaces to prevent injuries during positioning.	Bjoro et al. (2023) ³⁶ Bjoro et al. (2020) ³⁷
	Visual assessment and body alignment	Visual assessment of skin and bony prominences, body alignment during surgery.	Ângelo et al. (2020) ³²
	Realistic simulation	Simulation training for the interdisciplinary team in surgical positioning.	Ângelo et al. (2020) ³³
Post-operative phase	Continuous monitoring	Monitoring of vital parameters and regular pain assessment.	Tiferes et al. (2018) ²²
	Pain management	Specific pain management interventions, such as the appropriate administration of analgesia and non-pharmacological techniques.	Silva et al. (2021) ³⁴
	Self-care training	Addressing deficits in self-care and sexual domains, pelvic floor exercises to improve quality of life.	Silva et al. (2021) ³⁴
	Continuing education and patient support	Providing support to and receiving feedback from patients to ensure effective adaptation and recovery.	Porto and Catal (2021) ²⁵
	Improved working conditions	Clear definition of nurses' responsibilities and improving working conditions to increase job satisfaction.	Uslu et al. (2019) ³⁵

associated with the use of expensive and complex equipment³⁰.

The most common injuries are related to patient positioning and research highlights the importance of positioning patients appropriately for the type of surgery and protecting pressure points³⁶ and that operating room nurses take responsibility for positioning in order to prevent injury³⁶. Factors that increase the risk of peripheral injuries in patients include being in the same position for a prolonged period, high body mass index, comorbidities and remaining anaesthetised for a long time as well as being placed in certain positions³⁷.

Patient positioning in robotic surgery presents unique challenges due to the fixed nature of robotic arms. Once engaged, repositioning the patient is difficult, increasing the risk of pressure injuries and nerve damage. Prolonged procedures further exacerbate these risks, making pre-operative planning and intra-operative vigilance essential. Nurses use strategies such as using viscoelastic supports, continuous monitoring and ergonomic adjustments to help mitigate these issues^{24,28,32}. Viscoelastic polymer gel supports and pyramidal foam support surfaces are used for fixing the chest and protecting pressure points during surgical positioning^{32,33}. In addition to using suitable devices for this surgical modality, nurses inspect the skin and bony prominences, respect anatomical body alignment and document any changes in skin integrity in the information system³³.

Perioperative nurses play a fundamental role in robotic surgery by ensuring the seamless operation of complex surgical systems. Studies emphasise their role in maintaining patient safety, optimising workflow and contributing to successful surgical outcomes^{24,28,29}. Their responsibilities include equipment preparation, instrument management, troubleshooting robotic malfunctions and maintaining sterility, all of which directly impact the efficiency and safety of procedures^{22,23,25}. The complexity of robotic procedures demands continuous education and advanced technical skills, reinforcing the indispensable role of perioperative nurses in supporting these cutting-edge surgeries^{27,32}.

Perioperative nurses also ensure compliance with surgical protocols, facilitate team coordination and help prevent complications through vigilant monitoring and rapid response to intra-operative challenges. They relay critical information between the console surgeon and bedside assistants, ensuring that instructions are executed accurately and efficiently. This level of coordination is essential in robotic procedures where the primary surgeon is physically removed from the patient, making perioperative nurses indispensable in maintaining workflow and preventing errors^{29,31}.

Post-operative interventions

In the post-operative phase, nursing interventions aim to identify and manage complications, promote comfort and facilitate rehabilitation. The main post-operative interventions that emerge from the available evidence are monitoring and managing pain, promoting self-care and providing strategies to enhance sexual health, continuing education and patient support.

Continuous monitoring of pain and effective pain management are crucial for patient recovery after robotic surgery. Nurses monitor vital parameters and carry out regular pain assessment which are essential for quickly identifying and treating any complications²². In addition, nurses provide specific pain control interventions, such as the appropriate administration of analgesia and the use of non-pharmacological techniques, which are fundamental to improving patient comfort³⁴.

Post-operative rehabilitation also involves enabling patients to resume their daily activities and take care of themselves. Education about self-care practices and ongoing assistance are essential for a successful recovery³¹. Furthermore, addressing deficits in self-care and providing training in strategies to enhance sexual function, for example pelvic floor exercises, are recommended to improve the patient's quality of life³⁴. The reference to 'sexual health' specifically pertains to genito-urinary robotic procedures, such as prostate and gynecological surgeries, where post-operative sexual function can be affected. Nurses address sexual health through patient education, rehabilitation strategies and counselling which is crucial

for improving quality of life following these surgeries³⁴.

Ongoing support for and feedback from patients is necessary to ensure effective adaptation and recovery; ongoing education about post-operative care and rehabilitation should be an integral part of the discharge process²⁵. A lack of clarity about nurses' roles and poor working conditions can lead to professional dissatisfaction and conflicts in the workplace, which can negatively affect post-operative care³⁵.

Limitations

The methodological limitations of this study highlight the importance of carefully considering the heterogeneity of the included studies, the potential for selection and publication bias and the need for larger and more diverse samples. Also, time and language limitations could be a limitation of this systematic review. To strengthen future research, it is crucial to address these methodological aspects by applying rigorous bias control practices and ensuring adequate follow-up to capture the long-term effects of interventions.

Conclusion

The studies included in this review show the complexity and importance of nursing interventions in the different phases of robotic surgery. From pre-operative care through the intra-operative phase to the post-operative period, nurses play a vital role in ensuring the safety and effectiveness of procedures. Effective communication, adequate training and clear roles are essential to the success of nursing interventions. Implementing systematic approaches and improving working conditions are necessary to increase the quality of care as well as nurses' job satisfaction.

Implications

This study has important implications for both nursing practice and research. For nursing practice, it suggests improvements in nurses' preparation, communication, pain management and continuing education, as well as the implementation of checklists to ensure the safety and effectiveness of procedures. For research, it emphasises the need for longitudinal studies, the

exploration of confounding factors, the diversification of study contexts and the promotion of interdisciplinarity, providing a solid basis for future research and more effective clinical practices in the area of robotic surgery.

Conflict of interest and funding statement

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