

INCORPORATION OF ROBOTIC SURGERY INTO GENERAL SURGERY PRACTICE: BENEFITS, CHALLENGES, AND FUTURE PERSPECTIVES

MARCELLA VALENTE MARTINS¹, MARCELA DOURADO BORGES¹, MATHEUS DE SOUZA LOPES¹, NATÁLIA PERES NOLETO¹, PHABIA ASSUNÇÃO PEREIRA¹, LEONARDO EMÍLIO DA SILVA²

1. Undergraduate student in medicine at the Federal University of Goiás (UFG-GO), Goiânia, Goiás, Brazil.
2. Professor at the Federal University of Goiás (UFG-GO), Goiânia, Goiás, Brazil.

ABSTRACT

Robotic surgery has emerged as a revolutionary technology in contemporary surgical practice, initiating a new era for surgeons across various specialties. This article presents an integrative literature review that aims to analyze the benefits, challenges, and perspectives of robotic assistance specifically in general surgery. The objective was to gather and synthesize recent scientific evidence regarding the impact of this technique on surgical practice, highlighting both its advantages and the limitations encountered. The methodology was based on the criteria proposed by Whittimore and Knafl, with a search performed in the PubMed database using predefined inclusion and exclusion criteria. Ten articles published between 2019 and 2024 were selected. The findings indicate that robotic procedures offer numerous benefits for both patients and healthcare professionals. However, relevant limitations persist, particularly related to the high operational costs and the need for specialized technical skills to handle the equipment. Nevertheless, the future of robotic surgery appears promising, given the emergence of new technologies and the enhancement of training centers, which contribute to the strengthening and expansion of this field, including its application in general surgery.

Keywords: Robotic surgery, Minimally invasive surgery, Health technology assessment, General surgery, Cost-benefit analysis.

INTRODUCTION AND RATIONALE

The growth of robotic surgery, evident in the last two decades, signals an irreversible change in the paradigms of contemporary medicine, with the use of advanced technologies becoming increasingly intrinsic to surgical practices.¹ In this context, the use of this technology, which was initially restricted to specific areas, is now widespread across several specialties, including general surgery.²

The expansion of robotic technology, evident in university and reference hospitals, has enabled the enhancement of surgeons' skills, especially in procedures performed in restricted anatomical spaces. This approach allows for safer, more effective, and less invasive interventions.¹ Thus, the use of robots not only favors the surgeon's performance but also positively impacts the patient experience,

reducing recovery time and postoperative pain, in addition to providing better aesthetic outcomes.

However, the incorporation of this technology still faces barriers related to high cost, the need for highly specialized technical support, and the lack of structured training programs, which restricts its use to high-complexity medical centers with greater financial and human resources.³

On the other hand, despite these limitations, it is undeniable that surgical education in medical schools has been reconfigured. Gradually, more modern technologies have been safely and promisingly implemented, promoting effective learning and the development of a qualified workforce to operate robotic equipment with safety and precision.⁴

Furthermore, the outlook for this field is promising, with rapid technological evolution through the use of augmented reality, new platforms, and, more recently, artificial intelligence.⁵ Thus, it is important to note that the emergence of new devices, cheaper, more precise, and more versatile, contributes to the dissemination and integration of these resources into medical practice, making this tool inseparable from contemporary surgical practice.

In this context, the aim of this integrative review is to gather and analyze recent scientific evidence on the incorporation of robotic surgery into general surgery, in order to provide a comprehensive and updated overview.

OBJECTIVES

This study aims to evaluate, through an integrative literature review, the incorporation of robotic surgery into general surgery practice, with emphasis on the identification of its main clinical, operational, and educational benefits, as well as the technical, structural, and economic challenges that still limit its widespread adoption. In addition, it seeks to analyze future perspectives for the use of this technology, considering the advancement of robotic platforms, the evolution of surgical training programs, and the impact of this modality on the quality of care and the training of new professionals.

METHODOLOGY

The methodology used to achieve the objective of this study, entitled “The Incorporation of Robotic Surgery into General Surgery Practice: Benefits, Challenges, and Future Perspectives”, was the integrative literature review. According to Whittemore and Knafel⁶ (The integrative review: updated methodology), the integrative review constitutes an approach that enables the synthesis of theoretical and empirical evidence on a specific topic, allowing for a broad and critical understanding of the phenomenon investigated. Thus, following this perspective, this study sought to integrate and analyze the available evidence in order to broaden the understanding of the benefits, challenges, and future perspectives of robotic surgery in general surgery practice.

To conduct this review, the methodological procedures described by Broome⁷ were adopted, which involve the following steps: (a) identification of the problem and definition of the guiding question; (b) systematic search of studies in scientific databases; (c) application of inclusion and exclusion criteria; and (d) analysis and synthesis of the data obtained. The guiding question established was: “What are the benefits, challenges, and future perspectives of the incorporation of robotic surgery into general surgery practice?”

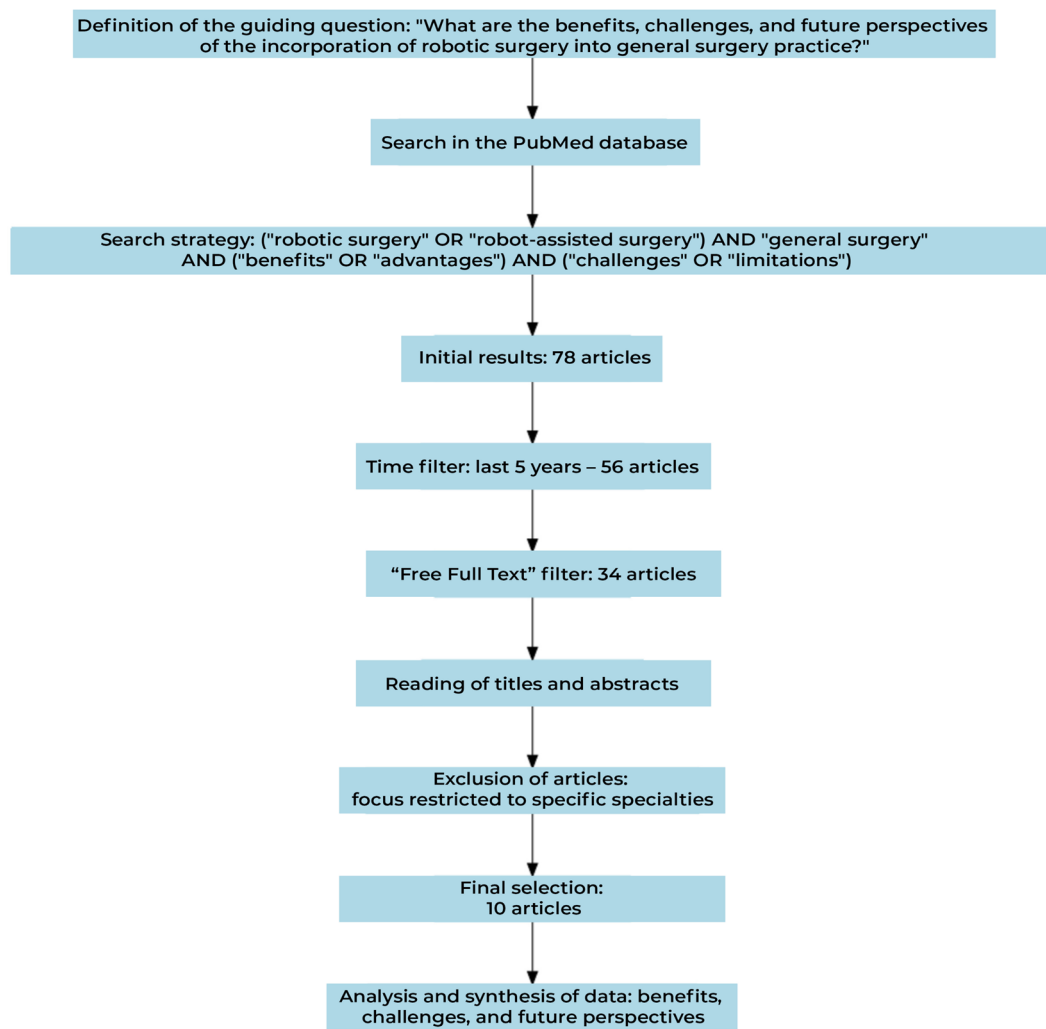
The search was carried out in the PubMed database using the following advanced search strategy: (“robotic surgery” OR “robot-assisted surgery”) AND “general surgery” AND (“benefits” OR “advantages”) AND (“challenges” OR “limitations”). Initially, 78 articles were found. Then, a time filter for the last five

years was applied, resulting in 56 articles. Subsequently, the “free full text” filter was used, yielding 34 full-text publications available.

After reading the titles and abstracts, inclusion and exclusion criteria were applied: articles published in English, available in full text, addressing robotic surgery broadly, with emphasis on its benefits, challenges, and future perspectives, within or in interface with general surgery, were included. Articles with a restricted focus on unrelated specialties were excluded. In the end, 10 articles were selected to compose this review.

The included studies addressed general aspects of robotic surgery and also discussed applications in related surgical specialties, such as gynecology and gastrointestinal procedures, providing a comprehensive view of the incorporation of this technology and its impact on contemporary surgical practice.

Table 1: Methodology for Article Selection



Source: Author’s elaboration, 2025

RESULTS AND DISCUSSION

The incorporation of robotic surgery into general surgery practice has promoted a profound transformation in contemporary operative paradigms. Over the past two decades, robotic platforms have evolved significantly and have increasingly been integrated into operating rooms, with particular emphasis on university hospitals and leading private institutions. What was once a technology restricted to niches such as urology and gynecology has expanded to encompass a much broader scope of procedures, including colorectal, esophagogastric, hepatobiliary, and even emergency interventions, consolidating robotic surgery as a versatile and promising tool.

From a technical standpoint, the main advantage of robotic surgery lies in its ability to enhance the surgeon's skills. Studies such as that of Gangemi et al.⁵ demonstrate that the platform provides an enlarged three-dimensional high-definition view, combined with articulated instruments with seven degrees of freedom, allowing movements more precise and delicate than those obtained by conventional laparoscopy. In practice, this superiority translates into less tissue trauma, reduced intraoperative bleeding, lower risk of conversion to open surgery, and shorter hospital stay. These benefits are particularly evident in procedures performed in confined anatomical spaces, such as the deep pelvis, where millimetric precision in dissection has a direct impact on oncological and functional outcomes.

Cheng et al.⁸, in reviewing the evolution of single-incision robotic-assisted surgery (SIRAS), highlight the technological effort to make procedures increasingly less invasive while maintaining safety and efficacy. The Da Vinci SP™ platform, for example, allows the entire procedure to be performed through a single port, using articulated instruments and a flexible endoscopic camera. The authors emphasize that this approach not only improves postoperative aesthetics but also reduces pain and recovery time. Figure 1, adapted from this study, illustrates the timeline marking the development of this technology, from the first cadaveric tests to its consolidated clinical application.

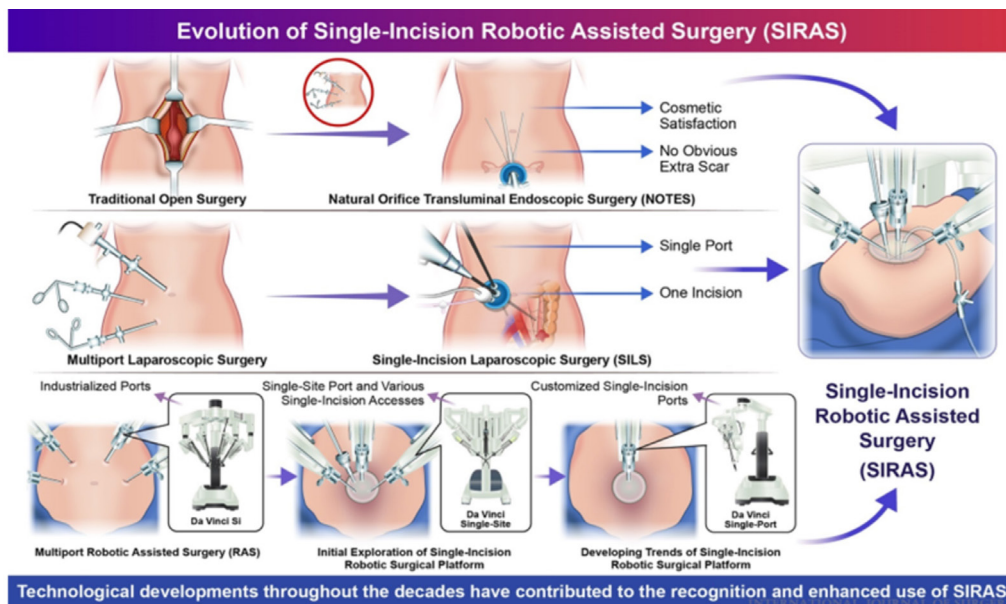


Figure 1. Timeline of the evolution of single-incision robotic surgery in general surgery (Adapted from Cheng et al., 2023, p. 4223).

In addition to technical benefits, robotics also contributes to surgeon ergonomics. As highlighted by Gangemi et al.⁵, positioning at the robotic console, combined with the absence of direct contact with the patient and the elimination of physiological tremor, provides a more comfortable and less exhausting operative experience. This is particularly important in long or repetitive surgeries, in which physical fatigue can compromise the surgeon's performance and the safety of the procedure. This paradigm shift also positively influences the occupational health of professionals, reducing the incidence of musculoskeletal injuries associated with traditional surgical practice.

Despite these advances, the large-scale adoption of robotic surgery still faces significant barriers. The most frequently cited in the literature concerns cost. According to Peng et al.⁹, the investment required to acquire a robotic platform ranges from 1.5 to 2.5 million US dollars, in addition to recurring costs for maintenance, sterilization, instrument replacement, and training. Yadav et al.¹⁰ specifically analyzed the economic impacts of robotic surgery in gynecology and observed that, although there are clear clinical advantages, hospital costs remain up to 30% higher compared to laparoscopy. This scenario limits the adoption of the technology to institutions with robust budgets, concentrating its use in large hospitals and deepening inequalities in access.

The financial impact is not limited to hospital infrastructure. As emphasized by Orvieto et al.¹¹, the adoption of robotics requires significant logistical changes, including new operative workflows, hiring of trained professionals, and adaptation of operating rooms. These adaptations not only increase indirect costs but also demand institutional maturation time for efficient program implementation. In addition, there are challenges related to the maintenance of the technology, which requires highly specialized technical support that is not always available in remote regions or peripheral centers.

Another central obstacle is the learning curve, pointed out as a limiting factor by several authors (Alverdy, Gangemi^{12,5}). Although the robotic console interface is intuitive, its mastery requires intensive practical training, generally in high-fidelity simulators, cadavers, or laboratory animals. The safe transition from simulated practice to the real clinical setting is gradual and must be accompanied by rigorous supervision, which demands time, investment, and standardized protocols. The absence of structured training programs in many countries compromises the training of new surgeons and may generate a false sense of security, increasing the risk of adverse events.

Population-based data on clinical outcomes also generate debate. Muaddi et al.¹³, in a study with more than 100,000 robotic procedures performed in Canada, observed that although the rate of adverse events was lower than in open surgery, it was not statistically superior to laparoscopy in many interventions. This suggests that, for certain types of procedures, such as hysterectomies, cholecystectomies, and partial nephrectomies, the main benefit lies in the minimally invasive route itself and not necessarily in the platform used. Such findings reinforce the importance of well-established criteria for indication, avoiding trivialization of the technique and adoption driven by commercial pressures or unfounded expectations.

Despite these limitations, the prospects for robotic surgery are highly promising. The trend toward miniaturization of platforms, the development of independent robotic arms, the incorporation of artificial intelligence algorithms, and integration with real-time imaging point to a new generation of robots that are more accessible, precise, and versatile. Marchegiani et al.¹⁴ describe the current clinical landscape of these platforms, while Peng et al.⁹ highlight that new players in the market are breaking the previous monopoly, reducing costs through competition, and accelerating the pace of innovation. These new platforms, still in the stage of clinical trials, promise to expand accessibility and adapt to

different hospital realities, including small- and medium-sized hospitals.

In the field of medical training, a true reconfiguration of surgical education is observed. The combination of robotic simulators with augmented reality, libraries of operative videos, and collaborative learning platforms creates a favorable environment for active and safe learning. Gangemi et al.⁵ emphasize that this immersive approach contributes to the training of a new generation of highly qualified surgeons, familiar with the latest technologies and prepared to integrate robotics into their daily practice.

In clinical terms, the trend is toward the expansion of robotics into more complex surgeries, such as major hepatic resections, pelvic exenterations, esophageal reconstructions, and emergency surgeries in patients with multiple comorbidities. Okamoto et al.¹⁵ point out that, in Japan, there is increasing use of robotics in advanced reconstructive surgeries and in procedures with very narrow anatomical margins, where the precision of the robotic system becomes a critical differential for therapeutic success.

In view of this scenario, it is evident that robotic surgery, although still permeated by challenges, is on its way to becoming an inseparable part of modern surgical practice. Its incorporation, when carried out in a judicious, ethical, and evidence-based manner, has the potential to raise the standard of surgical care, benefit patients and professionals, and redefine the boundaries of general surgery for the coming decades.

CONCLUSION

Based on the results presented, it is concluded that robotic surgery is a promising tool in different areas of intervention, due to its ability to provide the surgeon with more precise movements, thereby causing less tissue trauma. However, as it is still a relatively recent resource, there are challenges to be overcome in its use, such as the high cost of the technology, the materials used, and, consequently, the procedure itself.

In this sense, further studies are needed to compare the cost-effectiveness of robot-assisted surgeries, laparoscopic surgeries, and open surgeries, fully assessing the panorama of costs, intraoperative and postoperative complications, readmissions, length of hospital stay and recovery, mortality, among other relevant factors. In this way, it will be possible to establish more specific eligibility criteria for robotic surgeries, while, for now, the surgical approach is defined by technical feasibility and the surgeon's assessment.

In addition, there is a need to review training in robotic surgery and regulatory policies for the use of robotic platforms, since there is no general consensus for assessing the surgeon's competence in this modality, which has its own specificities regarding handling and technique.

Thus, the benefits of robotic surgery in daily hospital practice are noteworthy, but in order for the technology to be used in the best possible way, further studies and discussions on the subject are still required.

REFERENCES

1. Picozzi P, Nocco U, Puelo G, Labate C, Cimolin V. Telemedicine and robotic surgery: a narrative review to analyze advantages, limitations and future developments. *Electronics*. 2024;13(1):124.
2. D'Etterre C, Mariani A, Stilli A, Baena FRY, Valdastrì P, Deguet A, Kazanzides P, Taylor RH, Fisher GS, DiMaio SP, Menciassi A, Stoyanov D. Accelerating surgical robotics research: a review of 10 years with the da Vinci research kit. *IEEE Robot Autom Mag*. 2021;28(4):56-78.

3. Childers CP, Maggard-Gibbons M. Estimation of the acquisition and operating costs for robotic surgery. *JAMA*. 2018;320(8):835-6.
4. Haltaufderheide J, Pfisterer-Heise S, Pieper D, Ranisch R. The ethical landscape of robot-assisted surgery: a systematic review. *J Robot Surg*. 2025;19(1):102.
5. Gangemi A, Chang B, Bernante P, Poggioli G. Robotic surgery: rediscovering human anatomy. *Int J Environ Res Public Health*. 2021;18(23):12744.
6. Whittemore R, Knafk K. The integrative review: updated methodology. *J Adv Nurs*. 2005;52(5):546-53.
7. Broome ME. Integrative literature reviews for the development of concepts. In: Rodgers BL, Knafk KA, editors. *Concept development in nursing: foundations, techniques and applications*. Philadelphia: W.B. Saunders Company; 2000:231-50.
8. Cheng X, Huang C, Jia W, Guo Z, Shi Y, Song Z, Feng H, Huang H, Xu S, Li H, Wang S, Zhang Y, Zhang T, Liu K, Ji X, Zhao R. Clinical status and future prospects of single-incision robotic-assisted surgery: a review. *Int J Surg*. 2023 Dec 1;109(12):4221-4237.
9. Peng Y, Liu Y, Lai S, Li Y, Lin Z, Hao L, Dong J, Li X, Huang K. Global trends and prospects in health economics of robotic surgery: a bibliometric analysis. *Int J Surg*. 2023 Dec 1;109(12):3896-3904.
10. Yadav P, Chaudhari K, Dave A, Sindhu A. Exploring the evolution of robotic surgery in obstetrics and gynecology: past, present, and future perspectives. *Cureus*. 2024;16(3):e57155.
11. Orvieto MA, Marchetti P, Castillo OA, Coelho RF, Chauhan S, Rocco B, Ardila B, Mathe M, Patel VR. Robotic technologies in surgical oncology training and practice. *Surg Oncol*. 2011 Sep;20(3):203-9.
12. Alverdy JC. The Benefits of Robotic Surgery: Are They Technical or Molecular? *J Gastrointest Surg*. 2021 Feb;25(2):578-580.
13. Muaddi H, Stukel TA, de Mestral C, Nathens A, Pautler SE, Shayegan B, Hanna WC, Schlachta C, Breau RH, Hopkins L, Jackson T, Karanicolas PJ. Adverse events following robotic surgery: population-based analysis. *Br J Surg*. 2022 Jul 15;109(8):763-771.
14. Marchegiani F, Siragusa L, Zadoroznyj A, Laterza V, Mangana O, Schena CA, Ammendola M, Memeo R, Bianchi PP, Spinoglio G, Gavriilidis P, de'Angelis N. New Robotic Platforms in General Surgery: What's the Current Clinical Scenario? *Medicina (Kaunas)*. 2023 Jul 7;59(7):1264.
15. Okamoto K, Miyata T, Nagayama T, Sannomiya Y, Hashimoto A, Nishiki H, Kaida D, Fujita H, Kinami S, Takamura H. Current Status and Future Applications of Robotic Surgery in Upper Gastrointestinal Surgery: A Narrative Review. *Cancers (Basel)*. 2025 Jun 10;17(12):1933.

MAILING ADDRESS

MARCELLA VALENTE MARTINS

Av. Marconi, Qd 7, Lt 12, nº 39, Apto 1, Jardim Planalto, Goiânia - GO, Brazil.

E-mail: marcellavalente@discente.ufg.br

EDITORIAL AND REVIEW

Chief editors:

Waldemar Naves do Amaral - <http://lattes.cnpq.br/4092560599116579> - <https://orcid.org/0000-0002-0824-1138>

Nílzio Antônio da Silva - <http://lattes.cnpq.br/1780564621664455> - <https://orcid.org/0000-0002-6133-0498>

Authors:

MARCELLA VALENTE MARTINS - <http://lattes.cnpq.br/9834150244194958> - <https://orcid.org/0009-0001-7531-1140>

MARCELA DOURADO BORGES - <http://lattes.cnpq.br/2778815089454853> - <https://orcid.org/0009-0004-1601-3698>

MATHEUS DE SOUZA LOPES - <http://lattes.cnpq.br/6604798216026762> - <https://orcid.org/0009-0001-2155-4104>

NATÁLIA PERES NOLETO - <http://lattes.cnpq.br/1237365080387526> - <https://orcid.org/0009-0004-6358-7790>

PHABIA ASSUNÇÃO PEREIRA - <http://lattes.cnpq.br/6452290799223389> - <https://orcid.org/0009-0003-9666-2331>

LEONARDO EMÍLIO DA SILVA - <http://lattes.cnpq.br/0016679496054418> - <https://orcid.org/0000-0002-1612-0344>

Library Review - Izabella Goulart

Spell Check: Dario Alvares

Translation: Soledad Montalbetti

Received: 04/08/25. Accepted: 28/09/25. Published in: 17/09/25.