

EVALUATION OF THE EFFECTIVENESS OF ROBOTIC SURGERY IN THORACIC SURGERY: A SYSTEMATIC REVIEW

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Abstract: Thoracic surgery has undergone significant transformations with the introduction of robotic surgery, which stands out for its precision, reduced complications and faster recovery times. This study performed a systematic review of the literature to evaluate the effectiveness of robotic surgery in thoracic procedures. Studies that evaluated the effectiveness of robotic surgery compared to traditional and VATS techniques were included, analyzing clinical outcomes, economic and training aspects. The results showed that robotic surgery offers several clinical advantages, including a lower rate of conversion to open surgery, less intraoperative blood loss, and a significant reduction in hospitalization time. Additionally, patients reported less postoperative pain and a faster recovery. The rate of complications associated with robotic surgery was generally lower or equivalent to that of traditional techniques, with fewer infections, bleeding and respiratory complications. Mortality and morbidity associated with robotic surgery were comparable to or lower than those with conventional techniques. Despite clinical benefits, widespread adoption of robotic surgery faces challenges related to high initial costs and the need for specialized training. However, economic analyzes suggest that these costs may be offset by reduced hospitalization time and postoperative complications. Successful implementation of robotic surgery requires structured training programs that include simulation and supervised practice, as well as continuous adaptation to new technologies and staff experience. In conclusion, robotic surgery in thoracic procedures offers significant clinical and operational benefits. However, its widespread implementation will depend on overcoming economic and training challenges. With appropriate training programs and resource optimization, robotic surgery has the potential to become a standard practice in

thoracic surgery, providing better outcomes for patients and greater efficiency for healthcare institutions.

Keywords: thoracic robotic surgery, Clinical effectiveness, Postoperative recovery.

INTRODUCTION

Thoracic surgery, traditionally performed using open or minimally invasive techniques, has undergone significant transformations with the introduction of robotic surgery. Since the late 1990s, robotic surgery has gained prominence for its precision, reduced complications and faster recovery times for patients. The pioneering and widely used da Vinci robotic system offers expanded three-dimensional vision, greater dexterity and surgical control, overcoming some limitations of traditional approaches [1,2,3]. The application of robotics in thoracic procedures, such as pulmonary, mediastinal and esophageal resections, has shown promising clinical and operational results. Studies indicate a lower conversion rate to open surgery, less intraoperative blood loss and reduced hospitalization time, compared to conventional techniques [4,5,6]. Furthermore, the transition from multiportal to uniportal approaches has demonstrated significant advantages in terms of visualization and accuracy, driving the evolution towards uniportal robotic thoracic surgery [7,8,9]. However, the associated high costs and the need for specialized training pose significant challenges to the widespread adoption of this technology [10,11,12]. Effective training programs and optimization of financial resources are crucial to overcome these barriers and ensure the successful implementation of robotic surgery in different clinical contexts [13,14,15]. Furthermore, the evolution of surgical techniques and the development of new technologies, such as artificial intelligence, have the potential to

further improve the results of robotic thoracic surgery. The use of these innovations can lead to safer and more efficient procedures, expanding the indications for robotic surgery [16,17,18].

OBJECTIVE

This article aims to perform a systematic review of the existing literature to evaluate the effectiveness of robotic surgery in thoracic surgery. We will analyze the main clinical outcomes, such as the rate of complications, postoperative recovery, associated mortality and morbidity, as well as economic and training aspects.

This review aims to provide a comprehensive and critical overview of the benefits and limitations of robotic surgery, contributing to clinical decision making and the implementation of new technologies in the field of thoracic surgery.

METHODOLOGY

To conduct this systematic review on the effectiveness of robotic surgery in thoracic surgery, a comprehensive literature search was conducted using the PubMed, Scopus, and Web of Science databases. Search terms included “robotic thoracic surgery”, “efficacy”, “outcomes”, “training”, “costs”, and combinations thereof. The search was limited to articles published in English between 2000 and 2024. The inclusion criteria were: studies evaluating the effectiveness of robotic surgery in thoracic procedures; comparative studies between robotic surgery and other surgical approaches (open and VATS); studies that report clinical outcomes such as complication rates, postoperative recovery, mortality and morbidity; articles that discuss economic and training aspects associated with robotic surgery; and review studies, clinical trials, cohort studies and case reports. Studies unrelated to thoracic surgery, articles that

do not present specific data on clinical or economic outcomes, duplicate studies and opinion articles without empirical data were excluded. Data collection was carried out by two independent reviewers who evaluated the titles and abstracts of the articles identified in the initial search. The selected articles were reviewed in full to confirm eligibility. Extracted data included information on study design, population, interventions, clinical and economic outcomes, as well as training aspects. The data collected was organized and analyzed in a descriptive way, highlighting the main trends and results reported. Statistical methods were used, when applicable, to compare outcomes between robotic surgery and other surgical techniques. The quality of included studies was assessed using the Newcastle-Ottawa scale for cohort studies and the Cochrane risk of bias tool for randomized controlled trials. Evaluation criteria included participant selection, group comparability, and adequacy of outcome measurement methods. The results were summarized according to the main clinical and economic outcomes, facilitating the understanding of the available evidence on the effectiveness of robotic surgery in thoracic surgery. This rigorous methodology aims to ensure the validity and reliability of the findings, providing a solid basis for discussing the benefits and limitations of robotic surgery compared to other surgical approaches.

RESULTS

The systematic review revealed that robotic surgery in thoracic procedures, such as pulmonary and mediastinal resections, presented several clinical advantages compared to traditional techniques and VATS (Video-Assisted Thoracic Surgery). Studies have indicated a lower conversion rate to open surgery, less intraoperative blood loss and a significant reduction in hospitalization time [1,4,5]. Furthermore, patients undergoing

robotic surgery have reported less postoperative pain and a faster recovery [6,22]. The rate of complications associated with robotic surgery was generally lower than or equivalent to that of traditional techniques. Complications such as infections, bleeding and respiratory complications were less frequent in patients undergoing robotic procedures [2,7,26]. These results suggest that the improved precision and control of robotic technology may contribute to better surgical outcomes. Postoperative recovery was significantly faster in patients who underwent robotic surgery. Studies have reported that these patients resumed their daily activities sooner than those who underwent open surgery or VATS [3,9,12]. Less postoperative pain and reduced need for intensive care contributed to a more efficient recovery. The included studies indicated that mortality associated with robotic surgery in thoracic surgery is comparable to or lower than that of conventional techniques [8,17,19]. Morbidity, including long-term complications, was also lower, reflecting the benefits of a minimally invasive technique [10,20]. Although the initial costs of robotic surgery are high due to the sophisticated equipment and specialized training required, economic analyzes have shown that these costs can be offset by reduced hospital stays and postoperative complications [13,15,22]. Resource optimization and greater operative efficiency can also contribute to the long-term economic viability of robotic surgery. The successful implementation of robotic surgery in healthcare institutions is significantly dependent on effective training programs. Studies have highlighted the importance of structured training curricula, which include simulation and supervised practice, to ensure that surgeons develop the necessary skills [14,21,27]. Furthermore, the team's experience and adaptation to new technologies are crucial to the success of the program [11,18,24].

DISCUSSION

The findings of this systematic review indicate that robotic surgery in thoracic procedures offers significant advantages compared to traditional and VATS techniques. The lower conversion rate to open surgery, lower intraoperative blood loss and reduced hospitalization time observed corroborate the existing literature [1, 4, 5]. Furthermore, the reduced postoperative pain and faster recovery reported by patients are consistent with the benefits of a minimally invasive approach [6, 22]. Additional studies highlight that the improved precision and control provided by robotic technology contribute to better surgical outcomes, reducing complications such as infections, bleeding and respiratory complications [2, 7, 26]. The implementation of robotic surgeries, however, faces significant challenges, mainly related to high initial costs and the need for specialized training [10, 11, 12]. Economic analyzes suggest that although the initial costs of robotic surgery are high, they can be offset by reduced hospitalization time and postoperative complications, making it a viable long-term option [13, 15, 22]. The studies indicate that efficient management and optimization of resources in day surgery units can further improve economic viability [23]. Effective training is crucial to the successful implementation of robotic surgery. Structured training curricula, including simulation and supervised practice, are essential to ensure that surgeons develop the necessary skills [14, 21, 27]. Furthermore, the team's experience and continuous adaptation to new technologies are fundamental to the success of the program [11, 18, 24]. Technological innovations, such as artificial intelligence, have the potential to further improve the results of robotic thoracic surgery, expanding its indications and increasing the safety and efficiency of the procedures [28].

CONCLUSIONS

The systematic review carried out highlights the significant benefits of robotic surgery in thoracic procedures, demonstrating clear advantages in terms of lower complication rate, faster postoperative recovery and lower mortality and morbidity compared to traditional and video-assisted surgical techniques. The improved precision and control provided by robotic technology contribute to these positive results, making robotic surgery a viable and effective alternative in thoracic surgery. Despite clinical benefits, widespread adoption of robotic surgery faces significant challenges related to high initial costs and the need for specialized training. However, economic analyzes suggest that reducing hospitalization time and postoperative complications can offset initial costs, especially with the optimization of resources and greater long-term operative efficiency. Successful implementation of robotic surgery requires robust, well-structured training programs that include simulation and supervised practice, ensuring that surgeons develop the skills needed to utilize this technology effectively. Furthermore, continuous adaptation to new technologies and staff experience are crucial to the success of robotic surgery programs. In conclusion, robotic surgery in thoracic procedures offers significant clinical and operational benefits, but widespread implementation will depend on overcoming economic and training challenges. With appropriate training programs and resource optimization, robotic surgery has the potential to become a standard practice in thoracic surgery, providing better outcomes for patients and greater efficiency for healthcare institutions

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