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CHALLENGES IN ROBOTIC SURGERY FOR THE TREATMENT OF LUNG PATHOLOGIES: AN INTEGRATIVE REVIEW

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Abstract: Objective: This study aims to analyze the advances and challenges of robotic surgery in the treatment of pulmonary pathologies, through an integrative review of the literature. Method: 107 studies related to the topic were identified and reviewed, of which 5 were selected for detailed analysis. An integrative approach was used to summarize the main findings and trends in the application of robotic surgery in pulmonary pathologies. Results: The review revealed an increasing adoption of robotic surgery for the treatment of lung cancer, highlighting significant advances in sublobar resections, lymphadenectomy quality, and complex resections. Furthermore, the contribution of innovative technologies, such as three-dimensional reconstructions and artificial intelligence, to improving surgical results was highlighted. Final Considerations: The results indicate that robotic surgery for pulmonary pathologies presents promising perioperative and oncological results, however, there are still challenges to be overcome, such as the need for more prospective clinical trials to validate the exact benefits.
Keywords: Robotic surgery, lung pathologies, lung cancer.

INTRODUCTION

Thoracic surgery has witnessed a significant revolution in recent decades, driven by the advancement of minimally invasive technologies. Among these innovations, the application of robotic surgery in lung segmentectomy emerges as a promising approach, with the potential to transform the scenario of thoracic oncology and other complex lung conditions (Cerfolio et al., 2016).

Pioneering studies, such as the one conducted by Pardolesi et al. (2012), and other subsequent investigations, have explored the technical aspects and initial results of this innovative technique. By adopting the DaVinci system,

these studies highlight the feasibility and safety of robotic surgery in performing anatomical lung segmentectomies, providing a promising perspective for its clinical application.

The increasing availability of evidence, such as the results reported by Velez-Cubian et al. (2015), reinforces confidence in the efficacy and safety of video-assisted robotic surgery in the management of lung diseases. With minimal conversion rates, reduced morbidity, and oncological outcomes comparable to conventional techniques, robotic lung segmentectomy emerges as an attractive alternative, especially in selected patients with primary or metastatic lung lesions.

This condition is reinforced by the observations of Cerfolio et al. (2016), who provide data on the technical details and clinical outcomes of a significant series of planned lung segmentectomies, demonstrating the safety and effectiveness of the robotic approach in accurately removing affected lung segments. In this context, considering the unique scenario of thoracic surgery in Brazil, as outlined by Vannucci and de Castro (2022), the adoption of robotic surgery in Brazilian clinical practice may represent an opportunity to expand access to advanced lung resection techniques, potentially improving clinical results in different socioeconomic contexts.

Therefore, this review aims to contextualize the application of robotic surgery in lung segmentectomy, highlighting technical advances, clinical results and implications for contemporary surgical practice, both nationally and internationally.

METHODOLOGY

This integrative review was conducted with the aim of synthesizing and analyzing the most relevant studies related to robotic surgery in the treatment of lung cancer. Initially, an extensive search was carried out in academic databases, including PubMed, using search terms related to robotic surgery and lung cancer. The inclusion criteria adopted were studies published between 2019 and 2023, available in English or Portuguese, that addressed technical aspects, perioperative results or oncological outcomes of robotic surgery in the treatment of lung cancer.

After the initial search, 107 potentially relevant studies were identified. Then, the titles and abstracts of these studies were reviewed, and those that clearly did not meet the inclusion criteria were excluded. The remaining studies were then subjected to a full full-text review, where they were assessed for their contribution to the objectives of this review.

Through a detailed analysis, five studies were selected as the most relevant for the present integrative review. These studies were chosen based on their relevance to key points of interest, including surgical techniques, perioperative outcomes, oncologic outcomes, and technological advances in robotic surgery for lung cancer.

The synthesis of the results of these selected studies allowed a comprehensive understanding of the current state of robotic surgery in the treatment of lung cancer, highlighting both the benefits and challenges of this therapeutic approach (Table 1.0).

Study	Publication	Methodology	Main results
Terra et al. (2019)	Rev Col Bras Cir. 2019;46(4).	Data collection from a prospective robotic surgery database of patients undergoing robotic segmentectomy between January 2017 and December 2018. Performing robotic segmentectomy with the da Vinci system, three-port technique plus a 3cm utility incision.	A total of 49 patients underwent robotic segmentectomy, average age 68 years, most with non-small cell lung cancer (NSCLC). Median total operating time of 160 minutes. Postoperative complications in 18.3% of patients, with 14.2% having prolonged hospitalization (>7 days).
Yang et al. (2023)	J Robot Surg. 2023;17(4):1477-1484.	Investigation of the learning curve of 4-arm robotic portal segmentectomy (RPS-4) in patients with small lung lesions. Prospective data collection on 100 consecutive patients between June 2018 and April 2021.	Identification of three phases in the RPS-4 learning curve: learning phase (1-37 cases), plateau phase (38-78 cases) and mastery phase (> 78 cases). 64 cases needed to ensure acceptable surgical results. Reduced total operational time, console time, blood loss, and chest tube duration with experience.
Xie et al. (2019)	Thorac Cancer. 2019;10(9):1812-1818.	Retrospective comparison between 88 patients undergoing typical segmentectomy and 128 patients undergoing atypical segmentectomy by robotic surgery or VATS.	RATS showed resection of more lymph nodes and shorter operating time than typical segmentectomy. There were no significant differences in postoperative complications between groups.
Rocha Júnior e Terra (2022)	J Thorac Dis. 2022;14(12):5039-5055.	Narrative review of the literature on the role of robotic surgery in the primary treatment of lung cancer.	Highlighting the application of robotic surgery in sublobar resections, improvement in the quality of lymphadenectomy and results equivalent to VATS in terms of oncological results.
Aboukheir et al. (2023)	Cancers (Basel). 2023;15(22):5379.	Retrospective analysis of 166 patients undergoing robotic-assisted segmentectomy at a single institution. Assessment of the association between preoperative SUV value and clinical and oncological results.	Statistically significant association between preoperative SUV and tumor histology, tumor grade, lymphovascular invasion, visceral-pleural invasion, recurrence and site of recurrence. Significant differences in survival curves between SUV groups.

Table 1.0: Studies used in the integrative review on robotic surgery for the treatment of pulmonary pathologies.

Source: Michelon S. et al. (2024)

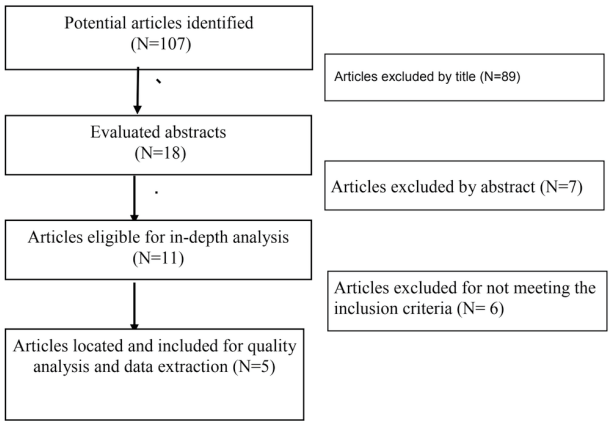

Figure 1.0: Flowchart of the distribution of articles found and selected.

Source: Michelon S. et al. (2024)

RESULTS

The five studies reviewed highlight several advantages of RAS, including sublobar resections with preservation of lung tissue, better quality of lymphadenectomy, and shorter operative time compared to other approaches.

DISCUSSION

The study by Terra et al. (2019) provides information on the application of robotic lung segmentectomy in clinical practice. The results presented corroborate previous findings, demonstrating that the robotic technique is safe and feasible, resulting in a short period of hospitalization and low morbidity. The absence of conversions to laparoscopic or open surgery, together with the low rate of intraoperative complications,

highlights the effectiveness of the robotic approach in performing anatomical lung segmentectomy. The detailed description of the surgical technique and preferred port positioning offers valuable insights for surgeons interested in adopting this approach. However, it is important to highlight that postoperative complications still occurred in a significant proportion of patients, mainly related to persistent air fistula and abdominal complications.

The study conducted by Yang et al. (2023) offers a crucial perspective on the learning curve of robotic lung segmentectomy, specifically using the four-arm system (RPS-4), in patients with small lung lesions. This research fills a significant gap in the literature, as studies on the learning curve of robotic segmentectomy are scarce. The results highlight that the RPS-4 learning curve can be divided into three distinct phases: learning, plateau and mastery, with a total of 37 cases needed to go through the initial learning phase and 78 cases to achieve mastery of the technique. This characterization of the learning curve provides valuable guidance for surgeons who are initiating or planning to adopt robotic lung segmentectomy into their clinical practice.

Xie et al. (2019) offers a comparative analysis between typical and atypical segmentectomies, performed through minimally invasive surgeries, both by robotic (RATS) and video (VATS) approaches. The results highlight significant differences in several parameters between the two types of segmentectomy and between the surgical approaches. Firstly, it was observed that resection of a greater number of lymph nodes was achieved using RATS compared to VATS, indicating a potential advantage of the robotic approach in terms of lymph node dissection. Furthermore, the operating time for atypical segmentectomy was significantly longer than for typical segmentectomy, regardless of the surgical technique used, suggesting that atypical segmentectomy may be more complex and time-consuming.

The retrospective study conducted by the authors investigated the perioperative and long-term outcomes of patients undergoing robotic-assisted segmentectomy (RAS) for the treatment of non-small cell lung cancer (NSCLC) at an NCI-designated cancer center. The results demonstrated that RAS for NSCLC provides reasonable perioperative results, with more common postoperative complications such as atrial fibrillation, persistent air leak, and pneumonia. Pathological analysis revealed statistically significant associations between preoperative standard uptake value (SUV) and several parameters, including tumor histology, tumor grade, lymphovascular invasion, and visceral-pleural invasion, highlighting the prognostic potential of SUV for characterizing the tumor and outcome prediction.

The review carried out by Rocha Júnior and Terra (2022) offers a comprehensive overview of the current role of RATS in the primary treatment of lung cancer. The objective of the study was to investigate the main advances and challenges in the application of RATS, focusing on sublobar resections, quality of lymphadenectomy, complex resections, postoperative results and innovative technologies. The authors highlight that the spread of sublobar resections has been driven by the flourishing of the robotic platform, leveraging technological benefits to promote improved quality of lymphadenectomy and a shorter learning curve compared to video-assisted thoracic surgery.

FINAL CONSIDERATIONS

Considering the results presented in the studies discussed, it is possible to observe a clear trend towards the increasing acceptance and adoption of robotic surgery in the treatment of lung cancer. Robotic-assisted segmentectomy is becoming a viable and safe option for patients with early-stage lung cancer, offering satisfactory perioperative results and oncological outcomes comparable to conventional methods. However, it is essential to recognize that further prospective studies and randomized clinical trials are needed to provide more robust evidence on the specific benefits of the robotic technique compared to other approaches, as well as to fully explore the potential of new technologies such as augmented reality and artificial intelligence in robotic lung surgery.

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