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REVIEW

Is There a Place for Robotic Inguinal Hernia Repair in the Realm of Laparoscopic and Open Inguinal Hernia Repair? A Narrative Review

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ABSTRACT

Introduction: *Robotic hernia repair is gaining popularity among general surgeons and has potential benefits; however, there are also several issues, of which the one related to increased cost compared to other procedures is the most important one. Integrating a robotic platform in the hernia territory is a difficult task, and this review attempts to analyze the various implications of using robotic assistance in inguinal hernias. From a hernia surgeon's perspective, each new addition to hernia procedures is important; therefore, we encompass the advantages and drawbacks of this technology. The final point is obviously improving hernia surgery and quality of life in our patients.*

Keywords: robotic, hernia repair, rTAPP, TAPP, TEP, open hernia repair, laparoscopic hernia repair, review.

INTRODUCTION

Inguinal hernia repair is one of the most common surgeries performed by general surgeons worldwide. The updated guidelines state that, for patients with primary unilateral inguinal hernia, a minimally invasive technique is recommended, provided that the surgeon has expertise and resources available (1). However, open repair remains the first-choice treatment in some cases. Moreover, when analyzing the long-term recurrence rate, no differences were found between open and laparoscopic techniques. In addition, two more aspects

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favor open repairs: the learning curve and the cost (1). Some authors have stated that the open approach remains the gold standard for hernia repair (2).

In the aforementioned guideline, the robotic approach in inguinal hernia repair was not addressed because of high costs and low penetration in clinical practice and the paucity of high-level studies that could aid in the making of recommendations (1). However, there are promising results with this approach (3). When using the robotic platform, the transabdominal preperitoneal (TAPP) approach is utilized, but there are authors who are also developing and using the totally extraperitoneal (TEP) technique (4).

METHODOLOGY

This narrative review explores the impact of robotic repair in the field of inguinal hernia repair. We performed a literature search of the PubMed database using the terms 'robotic hernia repair', 'robotic inguinal hernia' and 'robotic-assisted hernia repair' to find relevant articles published between 2016 and 2024. Fifty key articles were identified and further subjected to a thorough assessment. Our objective was to offer a nuanced understanding of the current literature and its relevance to the clinical practice of inguinal hernia repair. ❑

COMPARISON WITH OTHER HERNIA PROCEDURES

An updated systematic review and meta-analysis by Solaini *et al* (3) reported similar postoperative outcomes between laparoscopic and robotic repair. Robotic repairs are often used in complicated and bilateral hernias; in the latter, the operative time from robotic surgery was similar to that of the laparoscopic technique. Overall, the operative time and costs were longer and higher, respectively, in the robotic group.

A systematic review and meta-analysis performed by Aiolfi *et al* (5) compared the short-term outcomes of open Lichtenstein, laparoscopic trans-abdominal (TAPP), totally extraperitoneal (TEP) and robotic TAPP (rTAPP) for primary inguinal hernia and concluded that all four techniques were comparable in terms of postoperative hematoma, surgical site infection (SSI), urinary retention and hospitalization.

A multicenter propensity score matching analysis performed in the United States on three groups, including open repair, TAPP laparoscopic repair and robotic repair, demonstrated no difference in SSI, reoperation/readmission and recurrence at 30 days for all groups, and there was no difference in hernia recurrence at one year. Open groin hernia repair had more ASA (American Society of Anesthesiologists) score 4 patients (>50%, P<0.001) and the operating time was higher in the robotic TAPP group. Robotic repair performed better in patients with a BMI >30 kg/m^2 for SSI and seroma than other surgical techniques (6).

A prospective multicenter analysis that evaluated 30-day outcomes across three groups of robotic-assisted, laparoscopic and open inguinal hernia repair demonstrated that there were no differences in conversion and complication rate in the robotic versus laparoscopic groups or robotic *versus* open groups. Inguinal hernia repair can be performed effectively with all three approaches (7). ❑

BENEFITS OF ROBOTIC REPAIR (TABLE 1)

Robotic approach is safe

According to several authors, robotic inguinal hernia repair is a safe and feasible alternative to minimally invasive repair and allows surgeons to perform complex hernia repairs (incarcerated/recurrent) in a day-surgery case and high related quality of life in the long term (8-11).

TABLE 1. Benefits and disadvantages of robotic inguinal hernia repair

Benefits of robotic inguinal hernia repair	Disadvantages of robotic inguinal hernia repair
Robotic approach is safe	Diminished learning potential
Increase in minimally invasive hernia repair numbers	No clinical benefits and ergonomics for the surgeon
Reduced conversion rates	Limitations due to anesthesia
Addressing complex hernia repair	Longer operative time
Reduced postoperative complications	Increased cost
	Spin present in the robot hernia repair studies

For bilateral hernia repair, rTAPP is safe and reported to have lower complication rate than laparoscopic TEP, although the cost for rTAPP is higher (12). Similarly, Ephraim *et al* shows that robotic inguinal hernia repair is safe with comparable outcomes to laparoscopic inguinal hernia repair even in early learning curve (13).

Increase in minimally invasive hernia repair numbers

One benefit of the emergence of robotic options for hernia repair, which was observed by Donkor *et al*, is that it created an increase in minimally invasive hernia repair, a number that remained stagnant over the last decade (14). In addition, robotic TAPP repair can improve conventional TAPP laparoscopic repair by enhancing and clearly defining and deliniating hernia antomy, as showed by Andreou *et al* (15).

In the ROBUST hernia project, Muysoms *et al* described that, by adopting robotic repair in armamentarium hernia repair, there was a decrease in the use of open repair not only for inguinal hernias (from 17% to 6%), but also for ventral hernias (59% to 10%) and incisional hernias (48% to 11%). In addition, robotic platforms have potential for complex inguinal hernias, along with ventral and incisional hernias that require component separation (11). In a similar register, a study using the Vizient database that evaluated trends regarding robotic-assisted surgeries, revealed that significant robotic surgery utilization increased from laparoscopic procedures, and not from open procedure conversion (16).

In another comparative retrospective study, the EASTER study by Muysoms *et al* compared two groups (conventional laparoscopic and robotic repair), which yielded similar results in terms of operative time, complications and readmission rates. There were more outpatients treated in the robotic group, and more SSI were seen in the conventional group. But the cost was significantly higher in the robotic group (17).

Reduced conversion rates

A retrospective Scandinavian study on robotic hernia repair has shown promising results with 1.8% intraoperative complications, but no conversions. Obese and normal-weight patients yielded similar results. With only one recurrence (1/226) being noted in the follow-up period, robotic repair has been proved to be also feasible in the long term (18). Similar results were reported by other authors too (7, 19).

Addressing complex hernia repair

In a large cohort of 1 153 patients (606 laparoscopic and 547 robotic hernia repairs), Kudsi *et al* demonstrated that robotic repair may confer advantages over laparoscopic repair in terms of addressing more complex hernia repairs (19). Furthermore, they emphasized the intraoperative advantages of the robotic approach, with a smaller number of peritoneal breaches and conversions. However, the operative time was in favor of the laparoscopic approach. Moreover, robot-assisted hernia surgery can be advantageous in patients who have undergone transabdominal prostatectomy, whereas the laparoscopic/open approach can be more difficult (20).

A systematic review regarding robotic surgeries in urgent general surgery has shown that hernia surgery in emergency scenario (incarcerated hernias) can be performed robotically without increased risk (21). In the same context, Myla *et al* observe that the high cost of robotic surgery is a potential barrier to the widespread use in acute care surgery (22).

Reduced postoperative complications

A recent multicenter study from Taiwan (23), which comprised 1 080 patients (one group with 279 robotic repairs and another one with 763 laparoscopic repairs), presented some interesting conclusions: robotic repairs were often performed in complicated (incarcerated/recurrent), bilateral hernias and obese patients. There were no significant differences in intraoperative and postoperative complications between the two groups. Reoperation and pain medication use were significantly lower in the robotic group ($p = 0.016$), but the operation time was longer (155.27 min *vs* 95.30 min, $p < 0.001$) in the same group than in the laparoscopic group. The same conclusion was reached by Kudsi *et al*, who emphasized that robotic platforms may have advantages in treating complex cases of inguinal hernias (24).

In a study on 3 547 patients, Pokala *et al* evaluated the outcomes of open, laparoscopic and robotic inguinal hernia repair. The authors found an improvement of outcomes for robotic repairs compared to the other two approaches, regar-

ding postoperative infection rate, readmission rate, opiate use and mortality (25). Although, data about recurrence and postoperative inguinodynia are not listed in this study. Robotic surgery may decrease surgeon stress compared to laparoscopic, but this is probably related to a prior experience in laparoscopic surgery (26). ❑

DISADVANTAGES OF ROBOTIC REPAIR (TABLE 1)

Janjua *et al* claim that robotics has no defined role in inguinal hernia repair and offers minimal advantages over laparoscopic or open repair in inguinal hernia. Robotics can improve ergonomics, visualization, instrument articulation and tremor filtration; however, their main disadvantages include startup cost and system breakdown (27). Also, the rTAPP, the most used approach with robot-assisted hernia surgery, implies entry into the abdominal cavity, which promotes adhesions and injury to intraperitoneal viscera; in contrast, inguinal hernia cure can be performed using a totally extraperitoneal approach avoiding the abdominal entry (28, 29).

Diminished learning potential

One issue with robotic repair is the diminishing learning potential for surgical residents. It is a fact that surgical residents routinely participate in open and laparoscopic groin hernia repairs. However, the increasing popularity of robotic repair could lead to educational losses for residents. In a scoping review of 67 studies, Hansen *et al* reported that 85% of studies described that robotic hernia repair was performed by a surgical specialist. Only 13% of studies reported that a resident underwent robot-assisted repair (30).

Hansen *et al* conducted a study comprising 916 hernia repair surgeons, which found that 98% of robot-assisted hernia repairs were performed by surgical specialists, whereas for the Lichtenstein repair, there were 54% and 89% for laparoscopic repairs. These data show that robot-assisted repair influences training and diminishes the educational potential of hernia repair for residents (31).

It is also noticeable that different robotic platforms demand different educational protocols; virtual reality and simulations can be used to realistically simulate the experience of surgery using robotic instruments (32, 33). Also, it was stated that implementation of a robotic curriculum can enhance minimally invasive surgical training experience for resident education (34).

No clinical benefits and ergonomics for the surgeon

An important randomized clinical trial, The RIVAL trial, concluded that there was no clinical benefit of the robotic approach compared with the laparoscopic approach when performed by experienced surgeons (35). Moreover, there are disadvantages to the robotic approach, including higher costs and increased (almost double) operative time, compared with the laparoscopic approach. Another paramount aspect was that it did not have any ergonomic benefits for surgeons (35).

This is reflected in increased static neck positioning with subjective back stiffness compared with laparoscopy, as shown by Monfared *et al* (36). Still, this idea is inconsistent with other authors stating that robotic surgery is ergonomically superior to open and laparoscopic surgery (37, 38).

Interestingly, follow-up of the RIVAL trial regarding one- and two-year outcomes showed similar long-term outcomes with regard to wound morbidity, pain, quality of life, physical activity and recurrence (39).

Limitations due to anesthesia

Robotic repair requires general anesthesia that can increase the rate of cardiopulmonary complications in certain patients. Thus, this is a further limitation of the robotic approach when compared to the ability to perform open inguinal hernia repair via local anesthesia. Local anesthesia also permits surgery in older patients with a higher burden of comorbid conditions (40, 41).

Local anesthesia in open repair has been proven to reduce costs and represents the least expensive option. In addition, the operative and hospitalization times are reduced compared with other options (28, 42, 43).

Operative time

Anoldo *et al* found a longer operative time and higher costs in robotic repair with the advantages of a shorter hospital stay and faster recovery in the robotic group (44). A systematic review and meta-analysis support the fact that robotic inguinal hernia repair is associated with significantly

longer operative time compared to laparoscopy and open repairs (45).

In a multivariate analysis comparing the early and late experience of surgeons undergoing robotic inguinal hernia repairs, it was found that the mean operative time and mean direct operative cost decreased with increasing surgeon experience, as expected (46).

In regards to bilateral inguinal hernia repair, a multicenter retrospective study analysed two groups of robotic-TAPP and laparoscopic-TAPP, that showed no clinical recurrences in the two groups, but found statistical difference in the operative time – longer for the rTAPP (79 ± 21 *versus* 98 ± 29 min; $p < 0.001$) and length of hospital stay – longer for the rTAPP (1.05 ± 0.22 *vs* 1.50 ± 0.74 days; $p < 0.001$) (47). Pirolla *et al* reported similar results, highlighting the need for randomized studies (48). Prabhu *et al* found in the RIVAL Trial that rTAPP had a median time of 75.5 minutes (35).

In the standard algorithm of robot-assisted TAPP, the first step is docking the robot, and the second to last steps are undocking the robot (49). These steps increase the operative time in robotic platforms; however, they are also dependent on the experience of the surgical center with robots. In more experienced centers, the docking time is lower, which translates to a shorter operative time, and therefore comparable to the operative time in laparoscopic surgery (15, 45, 50).

The majority of the studies refer to robotic TAPP, but it was proven that rTEP is a feasible procedure (4). A comparative study conducted to compare r-TEP to laparoscopic TEP revealed an overall higher operative time for rTEP (60.47 minutes *versus* 38.45 minutes, $p<0.001$). Interestingly, when console time of rTEP was compared to that of the overall laparoscopic TEP, there was no significant difference ($p=0.053$). The authors also emphasized the idea that rTEP can be a better alternative to rTAPP (4). In contrast, Limper *et al* preferred to use laparoscopic TEP as the standard procedure for unilateral inguinal hernia repair due to the reduced operative time (approximately three times lower than the robot platform) and use robots in complex incisional hernias (49).

Cost of the robotic repair

Abdelmoaty *et al* did a comprehensive cost analysis on 2 405 cases (734 robotic and 1 671 laparoscopic) in the Western United States, which emphasized that robotic inguinal hernia repair had higher cost and longer operative time compared to the laparoscopic repair. One detail of the study was that fixed cost contributed to the cost difference between the two approaches; the cost difference is based on medical device cost and longer operative time (51).

Concerns regarding the excess cost of robotic hernia repair were analyzed in a comparative study on robotic versus laparoscopic inguinal hernia repair which was conducted by Waite *et al* (52). Their results showed increased operative time for the robotic patients, but less time in recovery and less postoperative time when compared to laparoscopic patients. The average direct cost and contribution margin were reported to be nearly equivalent.

Ayuso *et al* found comparable outcomes between laparoscopic and robotic inguinal hernia repairs, both of them being associated with low morbidities. The difference was in the longer operative time and higher cost for the robotic group (53).

In terms of costs, many authors claim higher procedural and total hospitalization costs for the robotic approach than for laparoscopic repair (40, 44, 54, 55).

Hinojosa-Ramirez *et al* suggest that robotic hernia repair do not justify the additional costs, but it can represent a simpler way to initiate the robotic learning curve (40). Choi *et al* advocates the same idea (56).

Spin present in the robot hernia repair studies

Finally, a systematic review found that robot-assisted hernia repair studies had spin, particularly those funded by, or receiving grants from, a robot company. There are authors advocating that the literature related to robot platforms should be treated with cautious (57). ❑

CONCLUSIONS

Whether robotic inguinal hernia repair should be offered to all patients is a matter of debate, and although actual guidelines do not integrate robotic platforms for hernia cure, there are numerous studies proving its value. One benefit is improving the knowledge of anatomy in the hernia field and increasing the number of total laparoendoscopic repairs for inguinal hernias. The main drawback is the higher cost of the

procedure and increased overall operative time, but with a reduced length of stay and lower rate of complications and conversion from laparoendoscopic procedures. Complicated and bilateral hernias can be treated better with robotic platforms but at the expense of affecting the learning process of trainees. However, the robotic platform represents a new addition to the hernia surgeon's armamentarium for delivering the best for the patient. ❑

Availability of data and materials: All information in this review was documented by relevant references.

Authors' contributions: C-O. U. designed the review; C-O. U., F.S., O.G. and N.I performed the literature search, selection of articles and wrote the paper. All authors read and approved the final manuscript.

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