

Robotic-assisted inguinal hernia repair: A historical review

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ABSTRACT

Inguinal hernia repair is one of the most common procedures performed in general surgery. Approximately 20 million hernia surgeries are performed every year worldwide. Conventionally, hernial repair is carried out with the open Lichtenstein technique; however, laparoscopic and robotic inguinal hernia repairs have been developed as a minimally invasive alternative to the classic Lichtenstein repair. The prosthetic mesh can be placed by totally extraperitoneal and transabdominal pre-peritoneal approaches. Choosing the best technique for repairing an inguinal hernia is a challenge because the available data are contradictory. However, a growing number of studies have claimed that robotic-assisted hernia repair is not only feasible and safe, but it is associated with outcomes that are comparable to those obtained with laparoscopy and open surgery, including shorter hospital stay, and fewer complications. The aim of the review article is to provide an overview of the current practice of inguinal hernia repair, with a focus on the advances in robotic-assisted inguinal hernia repair, as well as the advantages and disadvantages of this surgical procedure compared to the laparoscopic technique in view of the current reports in the literature.

Key words: Inguinal hernia, Laparoscopic inguinal hernia repair, Robotic-assisted inguinal hernia repair, Lichtenstein technique, Mesh, Transabdominal Pre-peritoneal approach, Totally extraperitoneal approach

Surgery has seen a paradigm shift from open to minimally invasive approaches and has been revolutionized by minimally invasive surgery in the past two decades. The benefits of minimally invasive surgery, such as shorter hospital stays, earlier return of normal bowel functions, minimal post-operative pain, and improved cosmesis, are now recognized in almost all surgical specialties.

Inguinal hernia repair is one of the most common operations in general surgery. Approximately 20 million hernia surgeries are performed every year worldwide [1]. Various repair techniques are currently used for inguinal hernia; however, the Lichtenstein tension-free hernioplasty is the most popular technique [2].

Laparoscopy has progressively gained popularity over the past few decades. However, laparoscopic hernia repair has its own inherent difficulties. These include two-dimensional (2-D) imaging (although 3-D platforms are becoming increasingly available), straight instruments, an unstable assistant-dependent camera, poor ergonomics, and an augmented tremor effect. The robotics approach has recently revolutionized the adoption of minimally invasive hernia repairs by overcoming the limitations of the laparoscopic approach. In the United States, there has been a substantial increase

in robotic-assisted inguinal hernia repairs. From 2015 to 2018, robotic hernia repairs have grown explosively from <2% to 20% of all hernia repairs performed in the United States [3]. The majority of published data on the safety and outcomes of this technique comes from the United States and Europe. In Qatar, since robotic surgery was introduced in 2016, over 160 patients with inguinal or ventral hernias have received this advanced treatment [4].

Choosing the best technique for repairing an inguinal hernia is challenging because the available data is controversial. To date, numerous observational studies [5-8] and one randomized trial have failed to demonstrate that short-term and functional outcomes after robotic surgery are superior to those of laparoscopic surgery for patients with inguinal hernia. The aim of the review is to provide an overview about the current practice for inguinal hernia repair with the focus on robotic approach.

HISTORY OF INGUINAL HERNIA SURGERY

Inguinal hernia repair has evolved from the old herniorrhaphy techniques to tension-free repair using mesh and, ultimately, laparoscopic and robotic approaches. Marcy in 1871 emphasized the necessity of closure of the internal ring and high ligation of the hernia sac. In 1884, Bassini described the extraperitoneal

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approach of hernia repair and the reconstruction of the floor of the inguinal canal. Frauchard discussed and demonstrated the mesh repair in 1956. The use of Prolene mesh, based on the tension-free concept, was a breakthrough in the repair of inguinal hernias. It is now used in most hernia repairs in adult patients since popularized by Lichtenstein in 1986 and improved by other surgeons [9]. The problems associated with hernia surgery are post-operative pain, prolonged hospital stay, and recurrence. In the beginning, repeated recurrence was the expected course after surgery, however, the Lichtenstein tension-free repair contributed to decrease the recurrence and complication rate [10].

Among the many techniques introduced to decrease recurrence and complications associated with hernia repair, laparoscopic techniques have become widely available all over the world. Minimally invasive inguinal hernia repair was first described by Ger [11] in 1991 using a laparoscopic technique. The introduction of minimally invasive laparoscopic techniques initially showed higher recurrence rates, but recent studies show results similar to open repair techniques. Subsequently, many advances have been made that have led to widespread acceptance of laparoscopic hernia repair, which has become the recommended procedure for inguinal hernia repair based on superior results in three main parameters: Recurrence rate, long-term pain, and health economics [12]. Despite the clearly documented advantages and published guidelines, the laparoscopic inguinal hernia repair has not been popularized among the surgeons and the growth curve remained flat for years [13]. The reason of why surgeons have failed to widely adopt laparoscopic inguinal hernia repair as their procedure of choice could probably be related to the requirement of advanced laparoscopic skills and long learning curve which differs from other minimally invasive procedures such as cholecystectomies [14]. Similarly, learning the anatomy of the posterior approach and the details required to safely complete repair without damaging vital structures. The evolution of minimally invasive operations made room for the growth of robotic surgery, which was first described by urological surgeons who performed such a procedure successfully during a robotic prostatectomy [15], but Dominguez *et al.* were the first who described it in the general surgery literature in 2015 [16]. Since then, general surgery has experienced the fastest growth of all surgical specialties, and hernia repairs are among the most frequently performed general surgeries procedures.

ROBOTIC-ASSISTED HERNIA REPAIR VERSUS LAPAROSCOPIC REPAIR

From the technical point of view, laparoscopy has its own limitations which include two-dimensional (2-D) imaging (although 3-D platforms are becoming increasingly available), straight instruments, an unstable assistant-dependent camera, poor ergonomics, and an augmented tremor effect. Robotic surgery is in essence laparoscopy with sophisticated instruments to overcome the limitations of laparoscopic surgery by providing stable 3-D views from a surgeon-controlled camera, angulated instruments with seven degrees of freedom, markedly improved

ergonomics, and tremor filtering. This has led to the increasing adoption of robotic surgery across many surgical specialties over the past 10 years [17-20].

Nowadays, robot-assisted surgery is becoming more adopted than its laparoscopic counterpart. In the United States, the number of robotic hernia surgeries has increased significantly. From 2015 to 2018, robotic hernia repair surged from <2% to 20% of all hernia surgeries performed in the United States [3]. Concomitantly, there have been many centers outside the United States, such as the Al Wakra Center in Qatar, which have been adopted this technique. However, the advantages of this surgery over laparoscopic approaches in patients with inguinal hernia are unclear as the available data are conflicting.

In March 2020, Prabhu and colleagues in their randomized pilot study concluded that no clinical benefit to the robotic approach to straightforward inguinal hernia repair compared with the laparoscopic approach, the results of this first randomized trial are disappointing. They reported that no ergonomic benefits were observed when using the Rapid Upper Limb Assessment tool [21]. In contrast, Forrester and colleagues reported that short-term quality of life after robotic approach was improved compared to open and laparoscopic repair [22].

One of the biggest concerns regarding robotic repair of inguinal hernia is the cost. Prabhu and colleagues concluded that the robotic approach incurred higher costs and longer operative time compared with the laparoscopic approach. In addition, Kohraki and colleagues revealed that the outcomes of laparoscopic approach were significantly superior to the robotic approach and at lower hospital costs [23]. They reported that the average direct cost per case in the laparoscopic repair group was \$3216, compared with \$3479 in the robotic group. Muysouni and colleagues reported that robot-assisted laparoscopic inguinal hernia repair was significantly more expensive than conventional laparoscopy [24]. Contributing factors to the high cost include purchasing the robot by the healthcare institution, maintenance costs, disposable materials, and longer operative times [25]. In contrast, Awad and colleagues concluded that increasing surgeon experience with robotic inguinal hernia repair is associated with a predictable reduction in operative time, complication rates, and direct operative cost per case [26]. In addition, Waite and colleagues [20] pointed out the decrease in duration of post-operative care (22 min less) in the robotic group due to less pain [26], which was not reproduced in the randomized trial by Prabhu [21].

ROBOTIC SURGICAL SYSTEMS AND FUTURE DIRECTIONS

Technology has rapidly advanced in the field of surgery especially in the past 10 years, which is thought to progress even more in the near future. Robots have increasingly gained popularity and would be the future of surgery according to some authors [27]. Considering the rapidly growing industry and the huge progress made in the field of artificial intelligence, it is difficult to keep oneself updated with the recent advances. At the time of writing this report, there are two newly launched clinical robotic systems

that include Cambridge medical robotics and Medtronic's HUGO system. The systems include individual robotic working arms footprint with central console with offering same degrees of ergonomics freedom to the operating surgeon [28]. It is estimated that over a period from 2017 to 2025, the number of Robotic systems will increase from 713 to over 2100. The global surgical robots market size was \$5.16 billion in 2021 but is expected to reach \$20.98 billion by 2030. North America currently has the largest market share by region, with a valuation of around USD 3.27 billion [29].

CONCLUSION

The comparative studies between robot technique and laparoscopic surgery in the literature did not show any superiority in the use of the robot. With increasing practice and experience around the world, robotic surgery is gaining wider acceptability. However, adopting any new technique demands very careful integration, which must be underpinned by structured training to the professionals by the professional. The issue of higher cost with robotic surgery is being addressed due to increasing number of new providers of clinical robots, which would bring the price down and would make the availability of the newer technologies to wider community of surgeons.

AUTHORS' CONTRIBUTION

Al-Dhaheri M aided in conceptualization, literature review, manuscript preparation, critical review, and revisions of the manuscript. Mubarak R, Wali AA, and Al-Yahri O aided in the literature review, manuscript writing, critical review, and revisions of the manuscript. All the authors reviewed and approved the final version of the manuscript.

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