ASSESSMENT OF THE CLINICAL AND ECONOMIC EFFECTIVENESS OF THE SURGICAL INTERVENTION FOR HERNIAS USING ROBOTICS: TRENDS AND RESULTS OF TREATMENT

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Abstract
Hernia repair is one of the most commonly undertaken operations in general surgery globally, which causes a huge burden to the health-care system. The emergence of robotic-assisted surgery (RAS) has brought about a revolution in the treatment of ventral and inguinal hernias. Although the application of RAS has increased tremendously in various fields of surgery, there is a lot of controversy regarding the benefits and cost of this approach. This comprehensive narrative review evaluates clinically effective outcomes, cost-effectiveness and quality of life (QoL) from the patients' perspective regarding robotic hernia repair when compared to open hernia repair (OHR) and laparoscopic hernia repair (LHR).This Review is based on the comprehensive analysis of the current literature on robotic surgery of hernias, consisting of randomized controlled trials, meta-analyses, and evaluations in health economics. There are some distinctive characteristics of RAS that include three-dimensional stereo imaging, tremor elimination, and instruments' ability to articulate. All those features make possible performing complicated reconstructions of the abdominal wall and dissecting preperitoneally. Nevertheless, there is enough evidence that RAS might not be less expensive and effective than laparoscopy. For example, rVHR can shorten the length of the hospital stay and decrease the incidence of wound complications in comparison with open repair. But, at the same time, this procedure has higher costs and longer duration in comparison with laparoscopic approach Robotic-assisted hernia repair is safe, efficient, and beneficial from a clinical standpoint in case of complicated conditions. However, its applicability must be justified with reference to both fixed costs and variable costs of procedures. cost amortization tactics and competitive systems have to be developed to make it possible to reduce expenses related to the procedure.

Keywords: Surgical, Robots, Clinical, Economics, hernia.

Introduction
The surgical treatment of abdominal wall and groin hernias is an essential component of surgical procedures performed all around the world. Each year millions of both ventral and inguinal hernia operations are carried out throughout the globe, and such a high number of procedures entail considerable economic losses for the healthcare systems [1]. Owing to its historical significance, open hernia repair can be viewed as the gold standard of hernia treatment that allows reliable results; however, such an approach also implies pain after the surgery, lengthening the duration of stay in the hospital and increasing the percentage of surgical site infection cases. The beginning of laparoscopic hernia repair in the early 1990s allowed doctors to reduce drastically wound morbidity and speed up recovery. Yet despite the obvious advantages of laparoscopic surgery over open surgery, two-dimensional imaging, fixed instruments, and poor ergonomic conditions limit this technique. With the recent growth

in RAS within the past 10 years, there has been a dramatic change in how hernia repairs have been performed. The robotic surgical system was purposely developed to deal with the limitations associated with normal laparoscopy, especially biometrically and optically. The use of HD three-dimensional stereoscopic cameras gives surgeons excellent depth perception and visualization. Additionally, the robotic technology comes with a special computer algorithm that cancels out any resting tremor and wristed instruments that have seven degrees of freedom. These allow for movements that are similar to those made by the human hand, hence making tissue manipulation, adhesiolysis, and suturing very easy. These are extremely helpful in complicated abdominal wall reconstructions such as retro muscular mesh placement and transversus abdominis release (TAR). Though the integration of robotic technology in general surgery operating theatres has been very encouraging, the rate at which this process has been adopted far exceeds the amount of high-quality scientific evidence that proves that this technology is worth universal adoption. The crux of the present-day surgical problem is in trying to strike a balance between the theoretical benefits of robotic technology and the actual clinical success it delivers with all its economic implications [1, 5, 7]. Criticisms focus on the expensive procurement of equipment, pricey semi-reusable supplies, and steep learning curve involved with robotic surgeries. In addition, there is evidence that, while robot-assisted repairs may confer perioperative advantages over OHRs, the superior nature of robot-assisted repairs in comparison with highly optimized LHRs, especially for simple, small defects, is not always evident [5, 7]. In light of the move towards value-based health care models, a detailed analysis of clinical and economic indicators is vital. The goal of this review is to analyze the available scientific literature about robotic-assisted repairs of ventral and inguinal hernias, considering surgical outcomes, true expenses, quality of life, and the potential of the robotic approach in hernia surgery.

2. Clinical Outcomes in Ventral and Incisional Hernia Repair

Surgical management of ventral and incisional hernias constitutes an intricate problem for the general surgeon, being primarily determined by the necessity to achieve the restoration of the biomechanics of the abdominal wall and at the same time decrease postoperative complications. Conventional open hernia repair (OHR) provided a wide range of anatomically precise reconstruction methods, including retromuscular dissection and transversus abdominis release (TAR) in its Rives-Stoppa form. Nevertheless, traditional approaches presupposed rather extensive manipulation with tissues, which resulted in the formation of rather big myocutaneous flaps and thus greatly increased risks of SSIs, SSOs (seromas and hematomas), and the duration of recovery period [4]. The implementation of laparoscopic surgery significantly decreased the number of the mentioned wound-related problems. Nevertheless, the restrictions, imposed by conventional laparoscopy, forced surgeons to perform IPOM procedure, when the prosthesis is laid on the visceral peritoneum and intestine. In addition, the ergonomics of rigid instruments often made impossible to provide primary fascial closure, and thus led to the formation of bridged repairs [8].The invention of the robotic system has marked an incredible change in rVHR, linking the technological difference between the open repair and laparoscopic minimally invasive approach. The ability of the robotic system to provide flexible instruments along with three-dimensional stereoscopic vision helps the surgeon perform all the intricate open procedures such as dissection of retromuscular plane and careful primary fascial closure completely intracorporeally [9]. Extraperitoneal placement of the mesh helps avoid all the physiologic dangers of the IPOM procedure, and hence reduces the risk of developing catastrophic mesh complications in the form of enterocutaneous fistulas and dense visceral adhesions [3, 10].Even with such advantages from an anatomical standpoint, the perioperative efficacy of robotic VHR has been heavily debated regarding time taken to perform surgeries. High-quality evidence has emerged in recently published research namely the multicenter randomized condition-neutral PROVE-IT study which shed light into methodical similarities of rLHR and LHR approaches [5]. The PROVE-IT study revealed that though simple and efficient, rVHR results in many hours of surgical interventions compared to the standard LHR operation [5]. The reasons for this time penalty are complex and numerous. First, there is a need to dock and undock the robotic machine for every use. Moreover, surgeons need some time to learn to use the machine in an adequate way. Finally, rLHR operations require great precision because they typically imply robotic sewing and labored anatomical dissection. Importantly, highly skilled robotic surgeons can really minimize the influence of these obstacles on the time of the operation but the increased number of hours spent still affects the efficiency of surgical interventions [3, 11] (See table no 1).

Table 1: As per the recent systematic reviews and randomized controlled trials done on the comparison of various clinical parameters of hernia repair procedures, including open surgery, laparoscopic technique and robotic surgery.

Outcome Metric	Open Repair	Laparoscopic Repair	Robotic Repair
Operative Time	Moderate	Shortest	Longest [5]
Length of Stay	Longest (avg. >2 days) [4]	Short (~0-1 day) [5]	Shortest (~0-1 day) [4, 5]
Wound Complications	Highest	Low	Lowest
Fascial Closure Rate	High	Low	High

Moreover, the advantage of robotic ventral hernia repair is that it significantly reduces the duration of stay in the hospital as well as rapidly facilitates recovery compared to open surgery and treatment methods. Because traditionally open reconstruction of the abdominal wall is associated with pain experienced by patients, which sometimes makes it necessary to use epidural analgesia and narcotics for a considerable amount of time, requiring patients to stay in hospital longer [12]. Earlier retrospective studies and prospective databases also proved that in case of open surgery, patients typically spend longest time in hospital, which may vary from two to four days, depending on the complexity of the procedure [4]. In comparison, rVHR allow to shorten the time of recovery for patients to a great extent. The process of robotic hernia repair is not resultant in the creation of dead space which occurs in case of open surgery [4, 5]. The postoperative morbidity rates, namely, the frequency of SSI and SSO development, allow making even more accurate comparisons between these three approaches to hernia repair. Wound-related complications are a huge burden both clinically and economically; they cause patient readmission, subsequent operations, and finally, operation failure due to infection of mesh or recurrences. The lowest risk of developing wound complications is found in the rVHR approach [2, 13]. Though standard LHR also has low SSI rate, the use of transfascial sutures and IPOM is associated with high frequency of development of chronic postoperative pain and localized seroma if the sac of the hernia is not dealt with [14]. With its retroperitoneal and retromuscular approach and reliable closure of anterior fascia, rVHR does not require trauma caused by transfascial fixation and reduces postoperative pain syndromes and fluid accumulations [3]. In addition, the use of a robot offers an additional advantage in dealing with complicated or recurring incisional hernias which will inevitably lead to mandatory conversion to an open technique when undergoing a laparoscopic operation. It has been well established that mandatory conversion of surgery from a minimally invasive to open one leads to increased morbidity, longer operating time, and decreased outcome of treatment [15]. Thanks to the ability of the robot to perform operations using the system with seven degrees of freedom and the tremor filtration software, extensive adhesiolysis is possible when the "frozen abdomen" or heavily scarred recurrent defect is present [10]. This helps decrease the rate of open surgery conversion immensely, enabling more complex patients to undergo treatment with less morbidity [3, 5]. The rVHR impacts the surgical quality measurement of the 30-day and 90-day reoperation and readmission rates, which are important beyond the immediate perioperative time frame. Readmissions following hernia surgery are typically caused by extreme pain, intestinal obstruction, and other complications that require either antibiotic infusion or drainage [16]. Due to the high extent of tissue manipulation and consequent systemic inflammatory reaction, open surgery is known to have a great risk of re-admission [4]. At the same time, the rVHR procedure has the potential to minimize the risk of readmission thanks to performing the complete anatomical restoration with maintaining minimally invasive access. The results of contemporary meta-analyses demonstrate that patients who had undergone rVHR have much fewer emergency department visits and readmissions for 90 days postoperatively in comparison to OHR patients [2, 3]. In addition, the special fixation method of mesh in the retromuscular area significantly speeds up the process of tissue growth and integration itself, which allows to minimize the risk of recurrence and necessity for reoperation greatly [11, 17]. To sum it up, despite the use of robotic ventral and incisional hernia surgery requiring more time in terms of its operation than the laparoscopic surgery, this practice has facilitated a new level of anatomical restoration. With the help of this technology, hospitals are capable of performing primary closure of the fascia, easier extraperitoneal mesh placement, which means proceeding with the surgery without too many complications regarding the operations [2, 4, 5].

3. Clinical Outcomes in Inguinal Hernia Repair

Although the benefits of robotic-assisted surgery in complicated ventral abdominal wall reconstruction are being acknowledged more and more, the use of robotic technology in inguinal hernia repair (IHR) has raised a much more controversial discussion. The technique of inguinal hernia repair performed minimally invasively already exists, and involves standard laparoscopic transabdominal preperitoneal (TAPP) or totally extraperitoneal (TEP) procedures. Minimal invasion in IHR gave great results in terms of clinical success, pain after the surgery, and how fast the patients resumed their usual activities. With this in mind, it becomes clear that proving the advantages of the robotic approach (such as robotic TAPP and rhTEP) over traditional approaches (like TAPP and TEP) will be a serious challenge contemplating the success already reached with minimally invasive surgeries [7]. Anatomical complexity of the groin area due to the complex interaction of major vascular and neurological elements requires the utmost surgical accuracy. The preperitoneal space, which consists of the space of Retzius located medially and the space of Bogros located laterally, contains the inferior epigastric arteries, corona mortis, and the important neurovascular bundles that pass through the "triangle of doom" and "triangle of pain." The high definition and stereoscopic image provided by the robotic system allows for a better identification and preservation of these small nerves and blood vessels. In addition, the wristed maneuverability of the robotic surgical tools makes it easier to dissect in the confined preperitoneal space, allowing for the precise reduction of the large chronic and/or inguinoscrotal hernias [18]. An important aspect related to the use of any new technology in surgery is the learning curve associated with the surgeon. The traditional open or laparoscopic technique used for inguinal hernia repair surgery, especially TEP technique, is notorious for being extremely hard to learn, with at least 50 to 100 procedures required before attaining the necessary skills. On the other hand, the ease of using the robot as well as its tremor filtration and ergonomic features have led to a shortened learning curve for this procedure. From what the literature shows, the surgeon's learning curve associated with robotic inguinal hernia repair has been shown to be reduced to between 15 to 23 procedures, after which very consistent surgical outcomes can be obtained [6]. Once this milestone is reached, surgeons display high consistency in perioperative parameters, indicating a fast progression from basic skills to advanced proficiency [6, 19]. Despite the fact that this learning curve is quicker, the time limit for procedures remains a very important measure. In the first year of laparoscopic surgery operations, the time needed for robotic surgery is usually higher than for the classical one due to same process of preparation, usage of tools and adaptation to the system. The time for surgery becomes lower after making operations more than 15-23. But in general, the time for robotic surgery operation still remains longer due to the same important preparation processes [6, 20]. Nevertheless, for the double surgery of complicated hernia, the difference in time for robot and standard surgeries is not very big. Besides operative time, postoperative pain assessment, seroma development, and rates of post-operative urine retention must also be considered in any comparative analysis of the two procedures. Post-operative chronic inguinal pain (CPIP) is the most painful complication after groin hernia surgery, usually due to either traumatic nerve entrapment or severe inflammation during the fixation of the mesh. Traumatic tacking is the standard fixation procedure for the mesh in traditional LHR; improper placement can lead to injury to either the ilioinguinal, iliohypogastric, or genitofemoral nerves. With the help of robotic-assisted technology, surgeons are able to forego the use of traumatic tacks in favor of fine suturing or sealant application. As a result, contemporary systematic studies have found that while the immediate post-operative pain score is similar in rIHR and LHR, there may be a slight advantage in the lower rates of CPIP associated with precise dissection and tailored mesh fixation [7, 21]. Seroma formation and postoperative urinary retention are two commonly reported SSOs that are often seen after inguinal hernia repair. Seromas are formed when there is fluid collection in the area left behind after the hernia sac has been reduced, creating anxiety and discomfort for the patient [7]. Robotic surgery has been linked to seroma rates similar to traditional laparoscopy, with some reports indicating slightly fewer occurrences. The lesser incidence of seroma formation could be due to the robot's capacity to perform more meticulous dissection and help invert larger hernias completely [7]. The same is the case with urinary retention that is often encountered after pelvic dissection, regional anaesthesia, and narcotic use [22]. Studies on robotic inguinal hernia repair indicated that the incidence of urinary retention was the same as that of traditional laparoscopy, although some high-volume centers have indicated that better visualization of the robot operations might contribute to the protection of the nerve plexuses located in deeper spaces and help prevent problems with neurogenic bladder. In conclusion, while laparoscopic surgery continues to be an effective procedure for inguinal hernia repair, robotic surgery has certain ergonomic and technical benefits over traditional methods. By making the learning process easier for the surgeon with just about 15-23 procedures, as well as enabling nerve-sparing dissection, rTAPP and rTEP lead to results that are comparable or even superior to classical laparoscopy with regard to postoperative results such as pain, seroma, and urinary retention [6, 7].

4. The Economic Burden: Direct and Indirect Cost Analysis

As systems of healthcare around the world change to focus on value-based care modalities, the field of surgery is increasingly being called upon to justify the use of new high-cost technology. In the case of abdominal wall reconstruction and groin hernia repair, one must carefully consider all the clinical and ergonomic strengths provided by robotics versus its high costs. According to numerous economic analyses and randomized studies, robotic ventral hernia repair (rVHR) has been established to incur higher costs (direct hospital expenses) than any other alternatives, including open surgery and traditional laparoscopy [1, 3, 5]. In this regard, understanding the economic factors related to robotic surgery and identifying the situations in which expenses are offset by the clinical outcomes of surgery are among the top priorities of healthcare administrators. A comprehensive financial analysis should divide expenditures into fixed, variable (during surgery), and post-operative costs over the follow-up period of three months after surgery. The biggest financial hurdle of setting up the robotic hernia service is the huge fixed cost related to the purchase of the robot itself. The purchase price of a multiple arm robotic surgical system usually exceeds millions of dollars, based on the particular model and advanced technology incorporated. Apart from that, there is no option but to be bound to expensive yearly maintenance and servicing agreements that are critical for software updates, hardware fixes, and technical support. Looking at the accounting side of things, this very significant fixed cost is spread over the lifetime of the robot, which is typically about five to seven years. Hence, the fixed cost per procedure is directly related to the volume of procedures in the institution. In cases where the robotic system is heavily used for various surgical procedures such as urological, gynaecological, colorectal surgery procedures, the fixed cost per hernia repair is substantially reduced. But in low volume community hospitals, the fixed cost per procedure makes the procedure unaffordable. Robotic hernia repair is costlier than conventional laparoscopic surgeries despite the costs being offset by amortization of capital expenditures. The cost of the robotic surgery per case stems from two main sources specialized consumables and operating room-time usage [6]. Robotic surgery utilizes proprietary “reusable” wristed instruments that include fenestrated bipolar forceps, monopolar curved scissors, and large needle holders. The instruments involved in this type of surgery are very sophisticated technologically but only have limited use capability (usually 10 “lives”) before the instruments are rendered unusable and have to be discarded. This forced obsolescence means that the case consumable cost for robotic surgery is much higher than the case cost for reusable instruments used in open surgeries or inexpensive disposable trocars used for regular laparoscopy. Additionally, robotic surgery requires special sterile draping of the mechanical arms and HD cameras, which adds another component to the disposable cost (See table no 2).

Table 2: Breakdown of fixed and variable economic factors impacting the effectiveness of robotic hernia treatment programs.

Cost Category	Key Drivers	Impact on Total Cost
Fixed / Capital	System acquisition, annual service contracts	High initial burden; amortized over high case volumes.
Variable / Intraoperative	Semi-reusable instruments, drapes, OR time	Higher than laparoscopy due to specialized instrumentation and longer OR times [6].
Postoperative offset	Length of stay, readmissions, reoperations	Significantly reduces 90-day episode-of-care costs compared to open repair [4].

Another key factor affecting variable costs is the increased operating time. Operating time is one of the most critical financial resources in the hospital, and costs may range from 60 to 100 dollars, depending on the location and overhead of the institution. Research performed as part of the large-scale multicenter randomized controlled trials showed that robotic-assisted hernia repair is connected with a longer total surgical time compared to conventional laparoscopic surgery [5]. This loss of time consists of the time needed to set up equipment, position instruments, and perform robotic suturing, which is a deliberate process in itself. When robotic materials costs are added to extended operating time costs, the immediate intraoperative costs of robotic-assisted surgery are long considered to be the highest among different types of hernia repair methods [1, 5, 6]. But the economic story takes a sharp turn when the economic story is taken into consideration not just at the stage of the operation itself but at the 90-day care period. The significant operating cost of the robotic approach is economically balanced out during the postoperative period through dramatic decrease in LOS and low morbidity rate [4]. Inpatient hospitalization is one of the major cost drivers in the whole healthcare system. In case of traditional ventral hernia repair, which involves component separation, an inpatient stay after the surgery lasts between two to five days [4]. This extended period includes such costs as nursing, intravenous anaesthesia (such as patient-controlled epidural analgesia), laboratory testing, and general hospital room and board. By utilizing smaller incisions and reducing the amount of dead space produced, rVHR often allows complex reconstruction patients to leave on the same day or only need 23 hours of observation after surgery. There are studies that show that robotic ventral hernia repair has a much shorter hospital stay than traditional open ventral hernia repair by several days [4] (See figure no 1).

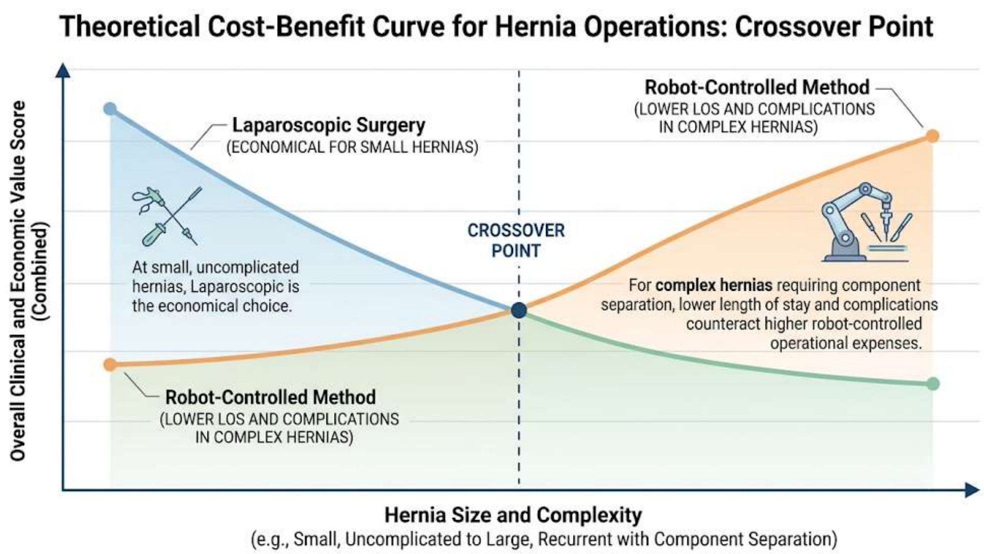

Figure 1: A theoretical cost-benefit curve illustrating the notion of "crossover point" in hernia operations. Laparoscopic surgery continues to be very economical for small, uncomplicated hernias. However, as the size and complexity of the hernia increase (making component separation or retromuscular dissection necessary), the reduced length of stay and lower complications with the robot-controlled method counteract the higher operational expenses.

This short recovery more than compensates for the robotic operation’s high initial costs. In addition, the precise dissection in the preperitoneal space and the closure of the fascia performed by the robot could greatly reduce the chances of experiencing severe wound complications such as deep surgical site infections and enter cutaneous fistulas. The treatment of severe SSI may involve hospital readmissions, surgical clean-ups, prolonged vacuum wound treatment, and extensive administration of IV antibiotics that could cost the healthcare system tens of thousands of dollars each time. Robotic hernia repair ensures extremely low rates of reoperations and readmissions due to which huge expenses are avoided [1, 4]. The combination of high costs during the operation and significant savings after has resulted in health economists pinpointing the so-called "crossover points" that determine the cost-effectiveness of hernia surgery. In the case of small uncomplicated primary ventral and umbilical hernias, standard laparoscopic repair or simple open suture repair is considered economically efficient simply because of the low postoperative morbidity involved. In such simple cases, the use of the robot surgical equipment becomes unreasonable due to its enormous costs. However, with the growth of complexity in the process, the economic aspects change likewise. In recent years, thorough economic analyses have shown that in case of the ventral hernias with a fascia defect larger than approximately 56 square centimeters or needing transverses abdominis release, robotic assistance is seen as a financially viable technique and can become the only cost-saving alternative to the traditional open surgery [1]. This is due to clear benefits that arise from a shorter period of hospitalization, fewer visits to emergency medicine, and decreased number of operations aimed at treating postoperative problems with wounds, thus covering all costs of robotic procedures [1, 5]. Therefore, it can be concluded that the cost-efficiency of robotic hernia surgery does not depend on specific characteristics of the technology, but rather relies on smart selection of its solutions when pleasant economic results will be achieved thanks to the application of their advanced technologies.

5. *Quality of Life and Patient-Reported Outcomes*

Traditionally, the body of literature regarding the outcomes of surgery in patients undergoing hernia repair has been overwhelmingly centered around objective criteria set forth by surgeons, including time of operation, rate of recurrence, and occurrence of surgical site infections. Undoubtedly, all of these metrics are of tremendous importance for gauging the technical and safety aspects of a surgical procedure; however, they often fall short of evaluating the overall impact of the operation on the patient's quality of life. In the modern world of value-based care, the use of Patient-Reported Outcome Measures (PROMs) as the final arbiters of surgical success has become the norm [23]. The perfect execution of an abdominal wall reconstruction, which results in disability or chronic pain, cannot be considered a full success from a clinical perspective. Therefore, the evaluation of the effects of robotic surgery on return-to-work rate, chronic pain disorders, and quality-of-life measures is mandatory [24].An important patient-focused advantage of the robotic hernia repair procedure lies in the ability to quickly recover from the procedure and resume usual physical activities and return to work. The secondary healthcare cost of hernia surgery, including loss of earnings, lower productivity at the workplace, and possible short-term disability compensation, may be comparable to direct healthcare costs [25]. Open ventral hernia repairs require large incisions and substantial injury to the myofascial layer and, therefore, usually require recovery time of six to eight weeks before the patient can engage in heavy physical activity and occupational activities [4]. Robotic-assisted surgical interventions allow performing complex procedures of fascial closure and retromuscular placement of the mesh through small trocar incisions, which reduces trauma to the abdominal wall. Analysis of retrospective data shows that robotic hernia surgery allows recovering the normal functional state of the body quicker than the traditional method and returning to work at an earlier stage [26, 27].Chronic postoperative inguinal pain (CPIP) is one of the most significant drawbacks concerned with a good quality life of patients treated by means of groin hernia repair, since it appears among many patients undergoing surgery [7]. CPIP is known to be a serious pain that continues for over three months after surgery; it is mainly of neuropathic type and is caused by entrapment of nerves, neuromas, or inflamed tissues as a result of the usage of a prosthesis or fixation devices [28]. The superior visualization and movement capabilities of a robotic device gives huge advantage in solving the problem by allowing perfect preperitoneal dissection and thus saving all nerves during surgery [29]. Thus many long-term surveys showed that patients undergoing a robotic repair of inguinal hernia report a good quality of life in terms of pain levels thus competing fairly with classical laparoscopic surgeries in some cases [7, 30].In order to measure the subjective quality of life following abdominal wall reconstruction, scientists use standardized questionnaires; specifically, the Hernia-Related Quality of Life Survey (HerQLes) and the Carolina Comfort Scale (CCS) [31]. The HerQLes survey evaluates physical function, pain, and body image with respect to the abdominal wall. Within the 30-day period following surgery, regardless of the modality used, the patients report a temporary drop in the HerQLes scores due to postsurgical pain and limited mobility [32]. Nevertheless, according to the comparative literature available, the patients who underwent robot-assisted ventral hernia repair tend to have a less pronounced decrease of quality of life and faster upswing of their scores within the first 30 days after surgery than those who had open surgery [33]. This rapid recovery is the result of the minimally invasive technique.As the postoperative timeline lasts for a whole year, the long-term advantages of robotic repair become more visible in terms of psychometric evaluations. By twelve months, the acute inflammation has subsided and the prosthetic mesh has completely assimilated into the abdominal wall. At this important moment, those individuals who had robotic primary fascial closure operation regularly indicate very high HerQLes and CCS scores which signify restored core strength, no or negligible chronic pain and excellent satisfaction with their esthetic results [34, 35]. In fact, despite the fact that the robotic platform requires greater initial resource allocation, its prospective ability to provide better long-term patient-reported outcomes—such as quick recovery, minimal chronic pain, and strong abdominal wall integrity—is a great argument in itself from the viewpoint that matters the most.

6. Future Trends, Training, and Conclusion

The quick integration of robotic-assisted surgery into general surgery has completely disrupted the well-established concepts of surgical education and spending in the healthcare sector. As the number of robotic procedures for ventral and groin hernia clasp has surpassed traditional methods, surgical residency and fellowships now face the problem of learning how to apply robotic technologies while preventing the loss of traditional skills [36]. In the past, the training of a surgeon in abdominal wall reconstruction involved being engaged in a lot of hands-on work with Rives-Stoppa and TAR techniques. Nowadays, the young surgeon is expected to learn complicated anatomical principles, as well as the use of high-tech electromechanical devices [37].To meet this educational requirement, the surgical community has used to its advantage the sophisticated educational modalities inherent in the robotic system. The introduction of the dual-console robotic surgery system has made the intraoperative teaching modality more efficient since attending surgeons can now work along with residents in the same stereoscopic visualization space [38]. This arrangement has helped in an easy transition of the control of instruments during procedures without any significant increase in operation time and risk for patients [39]. In addition to the use of dual-console robotic system in teaching, high-fidelity virtual reality simulation is required for robotic credentialing process. Modern simulation systems simulate the physics of tissue tension, ergonomics of wristed instruments, and procedural steps of hernia repair [40]. Cutting-edge technologies such as machine learning and objective kinematics analysis (C-SATS system) have been incorporated in modern simulation devices to give trainees detailed, un-biased information about their economy of movements, depth perception, and dexterity [41]. The simulation-based approach to credentialing has ensured that the surgeon learning curve is learned safely in a virtual world before moving to the real-world of ORs [42].Changes to the global environment of robotic surgery will also prove impactful. Throughout the last 20 years, soft-tissue robotic solutions have been dominated by one single business (Intuitive Surgical, supplier of the da Vinci solution). Such absence of rivalry determined the preservation of high installation expenditures and costly proprietary consumables [43]. The surgical robotics market, however, is now experiencing diversification of unprecedented scale. The entry of various competing solutions, like Medtronic Hugo™ RAS and CMR Surgical Versius, is expected to change the rest of the field regarding the economics of robotic hernia repair [44]. The novel generation of robotic devices will use modular construction principles and will employ separate, cart-mounted arms capable of dynamic deployment around the operating table and significantly shrinking the huge space occupied by conventional single-pedestal robots [45]. Moreover, the novel platforms will implement open console designs that will improve the surgeon's situational awareness and communication with the surgical team [46]. Finally, the emergence of such rival platforms will lead to the disruption of existing business monopolies, thus decreasing the upfront capital investment cost and compelling the producers to develop more sustainable value-based contracts with respect to their consumables [47]. As both fixed and variable costs inevitably drop in the long run, the cost-effectiveness threshold in the use of robotics in hernia repair will drop and thus make the technology available for a wider array of patients [48, 49, and 50].

Conclusion

The use of robots for hernia repair can be considered an overnight success in abdominal wall and groin repairs. Robotic technology seems to have successfully combined the advantages of open surgery in complex ventral and incisional hernias with the advantages of laparoscopy in surgery with the least surgical trauma. Robotic repairs have made it possible to achieve good outcomes in preperitoneal dissections and direct closing of the fascia, which led to less time spent in hospitals, lower rate of serious infections, and quicker return to normal life for the patient. As for inguinal hernia repair, robotic techniques using rTEP and rTAPP methods are easier to learn and ergonomically more favorable and effective than classical methods of laparoscopic surgery especially in complicated cases and the rates of injuries caused by surgery are similar. Nonetheless, it would be inaccurate to measure the success of these procedures independently. The present economic state of robotic surgery, entailing high levels of upfront expenditure on equipment and high intraoperative variable costs, necessitates the utmost discretion in choosing patients. The robotic technique represents a cost-effective and often cost-saving treatment when it comes to complicated cases of hernia repair, where the reduced risk of complications and extended stay in the hospital compensate for the initial financial input. With advancements being made in the process of credentialing surgeons as well as increased competition among robotic systems that brings the prices down, robotic hernia repair is bound to establish itself as the ultimate standard of care.

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