IJPSR (2025), Volume 16, Issue 6 **(Review Article)**

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 08 January 2025; received in revised form, 12 February 2025; accepted, 23 February 2025; published 01 June 2025

MODERN SOLUTIONS FOR HERNIA REPAIR: A REVIEW OF MESH INNOVATIONS AND EMERGING SURGICAL TRENDS

S. Rajesh [1], R. Akash [1], S. Deepa [* 2] and K. Sathesh Kumar [3]

Department of Pharmacy [1], Department of Pharmaceutical Chemistry [2], Department of Pharmaceutics [3], Sri Ramachandra Faculty of Pharmacy, Sri Ramachandra Institute of Higher Education and Research (DU), Porur, Chennai - 600116, Tamil Nadu, India.

Keywords:

Hernia, Hernia repair, Robotic surgery, Biologic meshes, Hybrid meshes, 3D-printed meshes

Correspondence to Author:
S. Deepa

Assistant Professor,
Department of Pharmaceutical Chemistry,
Sri Ramachandra Faculty of Pharmacy, Sri Ramachandra Institute of Higher Education and Research (DU), Porur, Chennai - 600116, Tamil Nadu, India.

E-mail: deepa.s@sriramachandra.edu.in

ABSTRACT: Hernia repair is one of the most common surgeries, with recent advancements in mesh technology and surgical techniques significantly improving outcomes. Mesh implants are the standard for reinforcing abdominal walls, reducing recurrence rates compared to traditional sutures. However, complications like chronic pain, infection, and adhesions have driven innovations in mesh development. Modern synthetic meshes are designed to enhance biocompatibility, featuring lightweight, macro-porous structures to promote tissue integration while minimizing complications. Biologic meshes, derived from human or animal tissue, support tissue regeneration and gradually degrade, reducing long-term foreign body reactions. Hybrid meshes combine the durability of synthetics with the regenerative qualities of biologics, offering superior performance in complex repairs. Tailored approaches, including 3D-printed and custom-made meshes, are gaining popularity for their ability to match individual anatomy, minimizing complications such as displacement. Future developments focus on anti-adhesion coatings and bioactive meshes capable of releasing antimicrobial agents to address postoperative issues like adhesions and infections. Despite these advancements, challenges remain in selecting the optimal mesh type and technique for each patient. Financial constraints limit access to advanced meshes in resource-poor settings, underscoring the need for cost-effective solutions. Ongoing research aims to improve safety, effectiveness, and personalization in hernia repair, emphasizing patient-specific care while addressing socioeconomic barriers. These developments highlight the need for continued innovation to optimize outcomes and ensure broader access to advanced technologies in hernia repair.

INTRODUCTION: Hernias are the most common medical defects it simply means a displacement of an organ or tissue through a weak spot in the muscle or connective tissue covering it. These anomalies usually appear as swellings around the abdomen and can cause different sorts of symptoms, including aching and pain unless diagnosed and treated.

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.16(6).1494-18

This article can be accessed online on www.ijpsr.com

DOI link: https://doi.org/10.13040/IJPSR.0975-8232.16(6).1494-18

Understanding what the various types of hernias are and their prevalence is highly important for proper diagnosis, treatment, and prevention [1]. The most common types are inguinal and femoral, umbilical, incisional, and hiatal hernias. Risk factors that could contribute to this condition include heavy lifting, obesity, and chronic coughing.

Femoral hernias are less common, but more likely to be found in women, especially over the age of 50 years, due to anatomical differences and increased intra-abdominal pressure from factors such as pregnancy or obesity [2]. An umbilical hernia is most often seen in infants where part of the abdominal

wall has failed to close after birth, but can be seen in adults too, especially over- weight or have had many children. Incisional hernias result from breaks in tissue integrity at surgical sites, and is extremely common in patients who have had surgery on the abdomen or whose conditions interfere with normal healing [3]. In addition, hiatal hernias result from the stomach protruding into the thorax through an opening in the diaphragm; usually, it causes symptoms of GERD rather than appearing as bulges. In underdeveloped countries, the chronic lack of timely surgery is problematic, where the chances of unfavourable outcomes improve with such conditions including obstruction and strangulation [4]. Knowledge of hernia types and their occurrence is crucial to enable healthcare professionals to educate patients appropriately and provide prevention strategies and appropriate surgical techniques.

Inguinal and Femoral Hernias:

Prevalence and Risk Factors: Inguinal hernias are the most common type of hernia and this is very common in males because of the innate anatomical weakness that has been made vulnerable at the inguinal canal. Most cases with this type of hernia are due to weakness in muscles combined with exertion, and risk factors include heavy lifting, obesity, chronic coughing, and straining while passing stools. Inguinal hernias can actually occur at any age, though most commonly seen in middle-aged and older patients. Symptoms include early signs such as a bulge in the groin area, discomfort, and often pain when bending or coughing or lifting heavy objects [5].

Femoral hernias are less common, but they tend to occur more frequently among females especially those above the age of 50 years. They occur right below the inguinal ligament in the upper thigh; they occur often with increased intraabdominal pressure secondary to pregnancy, delivery, or obesity. Femoral hernias are more prone to complications such as strangulation, a condition where blood supply to the herniated tissue is cut off, causing tissue necrosis. These warrant immediate diagnosis and surgical intervention [6]. Inguinal or femoral hernias need careful assessment for risk factors to determine the best mode of repair, whether by open surgery or by the more minimally invasive laparoscopic techniques.

Umbilical and Incisional Hernias:

Special Considerations: While relatively common in the pediatric population, umbilical hernias for unrelated reasons are also seen in adults. In infants, it tends to occur because the abdominal wall fails to close up after birth, which results in a small opening near the umbilicus. Most children's umbilical hernias spontaneously resolve by their second birthday. In adults, causes of umbilical hernias often are explained by increased intrabdominal pressure due to a condition like obesity, multiple pregnancies or conditions that cause chronic coughing or fluid accumulation in the abdominal cavity [7]. Unlike what occurs in other groups, most umbilical hernias in adults do not spontaneously resolve and operative intervention may be necessary to avoid the risk of incarceration of the herniated tissue, being trapped by the hernia.

Incisional hernias arise post-abdominal surgery. Incisional hernias occur near or after the site of a surgical incision because of lost or poorly healed tissue integrity. Risk factors for incisional hernia formation include complications from postoperative infections, poor wound healing process, obesity, and advanced age, among others which increase intra-abdominal pressure. Incisional hernias range from defects and small protrusions to large protrusions and sometimes cause discomfort and other sequelae [8]. Incisional hernias most often recur and, therefore, require a surgical intervention. Advanced techniques in surgery, such as component separation and mesh reinforcement, are often used to provide more power to the abdominal wall against recurrence.

Hiatal Hernias: Symptoms and Diagnostic Challenges: The other forms of hernias protrude from external spaces, hiatal hernias protrude from an internal space. There is part of the stomach that protrudes past the diaphragm into the thoracic cavity. These hernias can be broadly classified into two: sliding and paraesophageal hernias. Sliding hiatal hernias, in which the stomach and the inferior oesophagus move up above the diaphragm, are more prominent [9]. Paraesophageal hernias are less common but carry much greater risk, as an organ of the stomach is herniated adjacent to the oesophagus, which may potentially lead to major complications like strangulation.

Key manifestations associated with hiatal hernias often overlap with those of GERD, including heartburn, regurgitation, dysphagia, and thoracic discomfort [10]. One needs to be aware that a few patients might be asymptomatic, which complicates the diagnosis. Most symptomatic hiatal hernias are identified on imaging studies which include upper GI series, barium swallow studies, and endoscopic evaluation. Since these hernias may cause chronic GERD with subsequent damage to the oesophagus, the treatment for hiatal hernias would depend on the severity and may include lifestyle modifications, pharmacotherapy, or surgical intervention [11]. The surgical interventions include laparoscopic Nissen fundoplication-an important procedure where anatomical and physiological restoration of gastroesophageal junction is ensured with functional recovery, thus relieving symptoms of reflux and preventing such complications in the future.

Factors Influencing Hernia Development: Interaction of various genetic, lifestyle, and environmental determinants triggers the occurrence of hernias. Genetic factors play a considerable role in this disease because studies indicate that patients with a genetic predisposition to hernias enhance the probability of its occurrence [12]. Formation of hernias is also enhanced by conditions that compromise the integrity of connective tissues such as Marfan syndrome and Ehlers-Danlos syndrome. Lifestyles including obesity, smoking, and a poorly constructed diet may lead to weaker abdominal muscles and increased intra-abdominal pressure that increase risks of hernias. Obesity is particularly pertinent in that excess body weight creates permanent stress on the abdominal wall [13]. Chronic conditions, as those defined by chronic obstructive pulmonary disease (COPD), that compels chronic coughing, and constipation, causing a person to strain at the process of defecation are also important risk factors. This lack of collagen synthesis will progressively weaken the strength of the tissue. This makes the tissue more susceptible to the development of hernias. Occupational factors contribute to the causation of hernias particularly jobs requiring heavy lifting and straining[14]. Preventive measures through weight management, smoking cessation, and ergonomic measures at the workplace should help decrease the occurrence of hernias in populations particularly exposed.

Epidemiology and Global Impact: It is a significant medical issue because over 20 million surgical repairs are made annually. Inguinal hernias, in particular, account for about 800,000 surgical interventions yearly in the United States, which puts the condition in a relatively common position. Incidence of the disease shows regional distribution and is found to be significantly higher in low- and middle-income countries wherein access to timely surgery is not always available[15]. Delay in diagnosis and treatment, along with prevailing clinical features, has resulted in increased morbidity and mortality from bowel strangulation and obstruction in these regions. From the global epidemiology of hernias, it is noticed that considerable inequalities exist concerning healthcare access, which consequently affects outcomes for patients [16]. In such scenarios where facilities are poor, hernias often present at a more advanced stage than what is common in the industrialized countries meaning repairs are much harder and likely to have complications soon after the surgical intervention. This scenario has called for it to be essential that, as a measure to reduce the disease burden caused by hernias, there's a need for emphasis on improvement in surgical training and infrastructure in these regions [17]. Global initiatives toward hernia management involve efforts such as Hernia Surge Guidelines, with the aim of standardizing the treatments for hernias to improve patient outcomes. An epidemiological understanding of hernia by the practitioners and policy formulators across the world is required to appropriately utilize resources and formulate targeted prevention and treatment strategies to reduce global incidence of hernias [18].

Advances in Mesh Technology for Hernia Repair: Advances in mesh technology have revolutionized hernia repair techniques. Implantation of mesh has become the standard of care for permanent reinforcement of weakened abdominal walls and has significantly lower recurrence rates than those achieved by traditional suture repairs. Novel, superior mesh materials continue to be developed to further enhance biocompatibility, reduce complications, and better the patient results [19]. This section would discuss the latest developments in mesh technology, particularly the advanced materials and designs geared toward a better outcome in hernia surgery.

Therefore, modern hernia meshes are designed for achieving the ultimate strength-flexibility balance through intricate compositions of body tissues. The first-generation synthetic meshes, primarily made up of polypropylene, have proved effective for the prevention of hernia recurrence. However, they have also been associated with a variety of complications, such as infection, adhesion formation, and chronic pain [20]. Newer generations have produced meshes that are lighter and more flexible but also easier for the surgeon to handle, which may also help reduce postoperative morbidity. For example, a light mesh that boasts pores larger in size allows for better tissue in growth and, at the same time, controls the inflammatory response. It has recently been possible to develop biologic and hybrid meshes to complement other available options to the surgeon [21]. Biologic meshes-from either human or animal-will be supplied with the very important and priceless advantage of slow absorption by the body. Any biologic mesh, in whatever quantity, does far more benefits than the synthetic one might just be insufficient in a contaminated environment. Hybrid meshes combine synthesis with biologic features in the best way possible to provide the best balance of resiliency with biological compatibility [22]. This, in turn, enhances the possibility of providing patients with tailored treatment for a hernia; thus, such solutions can be applied based on the individual patient's needs and the complexities involved with the patient's hernia.

Evolution of Synthetic Meshes: Synthetic mesh development began in the 1950s when materials such as polypropylene, having enough strength, became useful for reinforcing defects in the abdominal wall. Problems associated with early rigid meshes included chronic pain, infection, and mesh shrinkage [23]. Successive generations of meshes showed design improvements that addressed such complications with lightweight, macroporous mesh. These changes result in greater flexibility and tissue integration, which helps reduce the inflammatory response of the body. The materials Prolene and Marlex emerged as favorites because of their good strength and economical efficiency [24]. Over time, manufacturers are able to constantly create synthetic meshes by designing materials with high strength and better biocompatibility. For example, recent polypropylene meshes have been designed with low weight and larger pore sizes to permit better tissue integration but reduce the chances of fibrosis and adhesions. In addition, absorbable coated composite meshes have recently been designed to reduce the incidence of intestinal adhesions in intraperitoneal applications and subsequently lower the incidence of the complications [25]. However, despite these innovations, synthetic meshes are by no means free of risk altogether especially in the contaminated surgery scenario where infection rates tend to be higher. Consequently, new researches have focused on confirming that the artificial mesh implants are safe and effective.

Biologic Meshes:

Innovations and Applications: Biologic meshes are a significant innovation in the treatment of hernia, mainly in the cases when use them is contraindicated to synthetic materials. Meshes are derived from either human or animal tissue which has been so treated as to remove cellular elements, leaving a collagen matrix amenable to tissue regeneration [26]. The basic appeal of biologic meshes is that they can integrate with the patient's native tissues with a view to later being absorbed by the organism. These properties make them particularly suitable for use in a dirty/infected surgical environment, such as failed hernia repairs or following an emergency surgery where the patient's risk of infection is increased [27]. Biologic meshes, including Strattice and SurgiMend, are mainly used for complex abdominal wall reconstruction and for immunocompromised patients. Such meshes promote the growth of natural tissue and are less likely to have adverse reactions that most synthetic meshes exhibit. However, biologic meshes are more expensive, and those that reach nearer to similar strength as their synthetic equivalents have relatively limited applications [28]. In this effort to create stronger biologic meshes, new processing techniques that may help reduce their production costs are also coming under investigation in research. As technology continues to advance, biologic meshes would emerge as a more reasonable alternative for an enlarged list of techniques in hernia repair.

Hybrid Meshes:

The Best of Both Worlds: Hybrid meshes combine the benefits of both synthetics and

biologics and are therefore the most flexible approach of hernia repair. Typically, this includes a synthetic based core and biological or absorbable coating designed to promote tissue integration while minimising risks of adhesions and infections. Hybrid meshes are highly useful for circumstances in which surgeons want to get the benefits of synthetic material strength without bringing the implications of a foreign body in contaminated fields [29]. The soluble coatings that are applied to hybrid meshes prevent contact with the intestines and reduce the risks of adhesion and erosion. Products such as Ovitex and Phasix have become very popular as they offer strength along with biocompatibility. These meshes break down over time, thus creating a natural scaffold that stimulates tissue regeneration. Hybrid meshes are now gaining popularity in laparoscopic and robotic-assisted hernia repairs with a focus on precision and recovery times. Hybrid meshes have held promising futures but pose many challenges [30]. Surgeons must select those patients most likely to benefit from this technology because absorption can be poor with these absorbable materials, especially in high tension repairs. Further developments will aim to hone the balance of absorption rates versus mechanical strength so that hybrid meshes can be used even in more complex hernias.

Anti-Adhesion Coatings and Advanced Mesh Designs: Among the new technologies for hernia repair is antiadhesion coatings for mesh implants. Adhesions, which constitute scar tissue that forms between the mesh and other organs, have created several problems concerning traditional mesh repairs, especially intraperitoneal placements. To overcome the problem, meshes have been engineered to be impregnated with compounds such as omega-3 fatty acids, collagen or hydrogel barriers that create a barrier coating hence eliminating adhesion formation [31]. The newest mesh designs integrate coatings that serve as not only an inhibitory layer of preventing the development of adhesions but may even promote healing and integration with host tissue. For example, Sepramesh and Parietex have absorbable coatings that slowly dissolve over a period of time, leaving a mesh behind to support tissue development, thus avoiding the negatives inherent in the long-term presence of foreign material. Such developments are highly beneficial in minimal invasive surgical procedures wherein the occurrence of complications has to be minimized[32]. These future developments of anti-adhesion mesh will entail studies on bioactive coatings which would be able to provide therapeutic anti-inflammatory and/or antimicrobial agent delivery. Such achievement should translate to fewer occurrences of complications post-operation, shorter stays in the hospitals, and more overall well-being of patients undergoing herniorraphy.

3D and Customizable Mesh Implants: The development due to 3D printing technology yields the production of a patient-specific mesh implant, which satisfies the increasing needs for individualized meshes in hernia repair. Unlike flat meshes, well-designed meshes in 3D correctly adapt to the anatomy of the patient and thus boast excellent support to avoid complications such as migration or bulge of the mesh. However, mesh variations are used for complex hernias such as large ventral hernias wherein the orthodox mesh would offer negligible coverage [33]. Generally, 3D mesh implants may be beneficial in robotic-assisted surgery wherein precision is more crucial. Since the pre-shaped meshes should coincide with the contours of the defect, their placement would be more efficient, thus reducing the time of operation and eventually improving the outcome of the patient. These are typically a soft, biocompatible material which encourages rapid tissue integration, hence minimizing postoperative pain and shortening recovery. Scientists have been investigating ways in which bioresorbable polymers can be employed in 3D printing to create meshes that degrade over time once they have given enough structural support without any foreign object permanently being within the body[34]. That certainly makes some very promising claims for reduced long-term complication rate as well as higher success with hernia repair surgeries. The methods are likely to evolve as efficacy increases and customization becomes more tailored to the individual patient in hernia repair procedures with advances in 3D printing technology.

Laparoscopic Hernia Repair Techniques: The technique of laparoscopic hernia repair marks an important improvement in present surgical practices. It is considered a minimally invasive

option for open hernia repair. This technique involves incisions in the abdominal wall that are very small; a laparoscope, a long thin tube with a camera, and instruments for laparoscopic hernia repair can be used to treat the hernia. There are many benefits gained with laparoscopic surgery, including less postoperative pain, smaller incisions, shorter recovery times, and a lesser chance of developing surgical site infections [35]. An important development in laparoscopic hernia repair is the internal positioning of mesh implants. These implants are used to internally cross the hernia defect to enhance internal strength of the abdominal wall while at the same time reducing the likelihood of hernia recurrence. This is an excellent area for the application of the laparoscopic technique, especially with bilateral and recurrent hernias. However, open surgical techniques have challenges in such conditions. Laparoscopic techniques offer more vision of the abdominal cavity during the procedure and, therefore, more care in the dissection and accurate placement of the mesh to achieve better results in patients. It requires specific skills and instrumentation that renders it less accessible in some contexts. Surgeries require profound training on the part of the surgeons to carry out the procedure effectively since this method involves passing through intricate anatomical structures with minimal tactile sensations [36]. Nevertheless, on-going developments include technologies that aid in robotics, where these complexities are being addressed to achieve enhanced precision and control. With ongoing research, ways of enhancing laparoscopic techniques instead receive attention towards improved patient outcomes as it offers the preferred hernia repair approach in many instances. Introducing laparoscopic techniques in hernia surgeries represents an important step toward greater safety and more effective treatment plans, in line with the prevalent trends in minimally invasive surgical approaches.

Types of Laparoscopic Techniques: Typically, laparoscopic hernia repair employs two main approaches: Transabdominal Preperitoneal (TAPP) and Totally Extraperitoneal (TEP). Regarding the TAPP approach, access to the abdominal cavity is required to cover the defect created by the hernia with a mesh. It allows for an extensive view of the internal organs and is recommended in the repair of complex and recurrent hernias. On the contrary, TEP is one of the minimally invasive procedures that do not require entering the peritoneal cavity and therefore reduce the risk of causing injury to some organs [37]. It is very popular in the correction of inguinal hernia because postoperative pain and recovery times reduce post their surgery. Moreover, recurrences remain within the same range for both approaches when carried out by appropriately experienced surgeons. The choice between these two is generally determined by the surgeon's experience and type of hernia. Though TAPP allows a good view during dissection, TEP minimizes complications made by intra-abdominal adhesions [38]. Both have been quite effective in recent studies, though the success heavily depends on the surgeon's skill for patient outcomes.

Benefits of Laparoscopic vs. Open Surgery: The laparoscopic technique has manifold advantages over open hernia repair, making it a popular choice among many patients. One of them is the highly reduced postoperative pain, which enables the patient to return to their normal life much earlier than in the case of open surgery. Small incisions for laparoscopic repair create only very slight scarring and a lower risk of wound infections, the common complications associated with open surgery [39]. Recovery patients, after laparoscopic surgery, have shorter hospitalizations and quicker return to work, with obvious overall health care cost savings and less interference with life. In addition to improved visualization with laparoscopy, mesh placement is more precise and decreases the risk of recurrence and chronic pain associated with open repairs [40]. However, for the laparoscopic procedure, general anesthesia is needed; hence, it may not be feasible for patients with certain comorbid conditions.

Challenges and Limitations of Laparoscopic Repair: Despite its several merits, laparoscopic hernia repair has its drawbacks. The significant problem is the steep learning curve, as surgeons have to achieve an expertise in laparoscopic techniques to avoid complications, including organ injury or improper placement of the mesh. This requirement limits access to laparoscopic repair to hospitals staffed by experienced surgeons and equipped with special devices. In addition, the process might also have a higher capital cost of initiation for the fact that it requires more

complicated laparoscopic equipment and even longer surgery, especially in novice surgeons. The other disadvantageous aspect of the procedure is its risk of intraoperative complications, such as bowel or vascular injuries, which may lead to longer recovery periods and morbidity. Laparoscopic repair may not be as successful in patients with large or complex hernias or those in which open surgery would most likely yield better results [41]. Best patient selection is important, and sometimes the best approach in surgery depends on the information gathered from imaging studies before surgery.

Role of Robotics in Enhancing Laparoscopic Repair: The arrival of robotic systems has transformed the surgical landscape of laparoscopic hernia repair. Robotic-assisted surgery provides unmatched dexterity, accuracy, and control in performing complex hernia repairs with better outcomes than the traditional method. High-definition 3D visualization and articulating instruments of a da Vinci Surgical System provide better manipulation of tissues and better placement of meshes in the hands of the surgeon. It is used more importantly in large or recurrent hernias, where conventional techniques using laparoscopy become very difficult [42]. Better control results in better dissection and suturing with a lesser rate of complications like nerve injury or mesh migration. However, the cost of robotic surgery is significantly higher than that of conventional laparoscopy and access to robotics systems often is limited to specialized centres. Despite all of these limitations, the future of hernia repair is bound to see a surge in the uptake of robotic systems with advancing technology, expanding training programs, and continued research to assess results over many years as well as potential cost-effectiveness in comparison to open techniques [43].

Future Directions in Laparoscopic Hernia Surgery: Prospects, in comparison with this development of laparoscopic hernia repair, are more promising. It aims at surgical results and concern for patient safety. Among the innovations includes the use of AR and AI assisting surgeons during laparoscopic procedures. They can always give immediate guidelines for improvement in surgical precision and the reduced scope of errors. Another area of high research interest is in the use of intelligent meshes incorporating sensors that can detect the healing process and complications that include infections. Such advanced meshes can forward data to healthcare providers, which can therefore provide timely interventions in case complications are emerging [44]. Another innovation that promises to improve the outcome for the patient is the development of bio-absorbable meshes that would degrade at a controlled rate alongside tissue healing. Personalized surgery is soon to become a reality with patient-specific 3D printing of mesh tailored to the anatomy of each patient. Customization will improve fit and reduce complications, laying a new basis for more effective repairs in hernia repairs. With each forward leap in technology that makes this surgery safer, more efficient, and better suited to the needs of the patient, there will be the potential to revolutionize laparoscopic hernia repair [45].

Robotic-Assisted Hernia Repair: Robotic-assisted hernia repair is an emerging technology in the world of minimally invasive surgeries, providing better accuracy and management as compared with traditional laparoscopic methods. Because of the technology of da Vinci Surgical System, it has enabled surgeons to achieve complex hernia repairs with added dexterity and vision. Robotic-assisted surgery combines the benefits of laparoscopy, such as smaller incisions and reduced recovery times, the added advantages of improved ergonomics and 3D high-definition visualization [46].

One of the most important benefits of robotic-assisted hernia repair lies in its potential to facilitate delicate such as suturing and mesh placement, which may be difficult to achieve with conventional laparoscopic procedures. The robotic arms offer a level of mobility that may be superior to the motion created by human hands, especially in relation to procedures in crowded areas, such as with large or complex hernias. Indeed, robotic technology lends itself all too readily to ventral, incisional, and recurrent hernias, because these would entail exquisite dissection and reinforcement to facilitate lower recurrence rates. But robot-assisted hernia surgery also has its own set of disadvantages [47]. The high cost of robotic systems and the need for specialty training limit access to this technology. In addition, longer operative times have been described in some cases that may

outweigh the decreased postoperative pain and more rapid recovery that are generally associated with robotic surgical approaches. However, the emerging evidence now has confirmed that robotic-assisted hernia repair happens with much fewer complications as well as higher patient satisfaction rates, hence becoming a far more fashionable option worldwide in surgical hospitals. Better technology along with the availability of robotic system will increase the usage of robotic assistance for hernia repair [48]. Patients will thus be offered safer and more effective surgical options.

Benefits of Robotic-Assisted Repair: High precision performance would be the first advantage of robotic-assisted hernia repair over the traditional approaches like laparoscopy. Because the robotic instruments permit 360-degree rotation, much more precise dissection and suturing, as well as mesh placement, could be achieved during the surgery, and thus the risks of complication such as nerve damage and improper positioning of mesh would be lessened. Another related benefit is the 3D high-definition visualization offered by the robotic system. This enhanced visualization enables the surgeon to have a significantly better view of anatomy with complex or recurrent hernias [49]. Improved ergonomics that are obvious with robotic surgery also contribute to reduced surgeon fatigue, hence enabling longer and more precise procedures without compromising quality. Most robotic techniques for surgery also help reduce postoperative pain and scarring and decrease recovery times in comparison to open traditional surgery. This makes it a valuable option for those wishing to have treatments that are minimally invasive while still allowing quicker returns to normal functioning [50]. Thus, robotic surgery for hernia repair increasingly forms the preferred procedure where precision and patient outcome are high on priority.

Limitations and Challenges: Despite all the benefits drawn from robotic-assisted hernia repair, an enormous list of hindrances and challenges still calls for consideration. Among the major drawbacks is the substantially increased cost involved in carrying out robotic surgery. The costs in acquiring, maintaining, and running the systems are quite high, making them inaccessible to small-sized healthcare facilities or to uninsured patients. Another major challenge is the immense learning curve needed to use robotic-assisted techniques appropriately [51].

Master of Robotic Systems: Surgeons need to undergo special training to master robotic systems. This might restrict the further wide implementation of technology. Robotic-assisted surgical procedures take extra preparation time, and may be more time-consuming to complete. They could become more expensive as well, challenging the day-to-day management of hospitals. Moreover, while robotic-assisted surgery diminishes some of the risks of traditional methods, it is not risk-free. Still, trocar site hernias, mesh migration, and damage to surrounding organs may still be encountered if the operation is not done with utmost care[52]. So, proper patient selection and surgical expertise are two essential components in delivering satisfactory results.

Comparison of Robotic vs. Laparoscopic Techniques: Robotic-assisted versus laparoscopic hernia repairs, there are many similarities between the two procedures. However, each has its advantages and disadvantages but in different ways. This gives greater dexterity as well as 3-D visualization that the surgeon may have the opportunity to perform more complex operations. Particularly in complex procedures, like large ventral hernias or those with dense adhesions, this is helpful. On the contrary, laparoscopic repair tends to be less costly and requires less operative time; therefore, it is more practical for wide access of patients and clinical environments [53]. However, it does not provide superior manoeuvrability of robotic systems that in selected cases would unfavourably impact. Both the techniques are similar in recurrence rates, but the robotic assisted surgery is supposed to produce less postoperative pain and has a greater satisfaction to the patient due to its minimally invasive nature [54]. This will depend upon different variables including individual surgeon preference, patient-related factors, and complexity of hernia involved.

Cost-Effectiveness and Accessibility: It is frequently controversial whether the robotic-assisted hernia repair is economical. While the robotic surgical techniques might show high accuracy and good outcomes in patients, high

capital investment will be unbearable for the majority of health care organizations. The costs of purchasing and maintaining the robotic equipment combined with this lengthy procedure may make the hernia repair procedures expensive overall. On the other hand, proponents of robotic surgical approaches claim that benefits in the long run, such as a lower complication rate, reduced recurrence rate, and better rapid recovery for the patient, will probably offset the initial cost[55]. This would especially be the case in complex hernia cases where precision found with robots produces better clinical results and fewer revisions. As robotics technology continues to advance and become generally accepted, the associated technologies should become less expensive, thereby making such state-of-the-art technologies more widely available. Training programs and network systems are also being developed to extend the availability of robotic-assisted surgery, so that more surgeons can acquire competencies in these advanced systems [56]. Therefore, patients in a more varied range of settings will benefit from the superior capabilities of the robotic systems.

Future Innovations in Robotic Hernia Repair: Robotic assistance for hernia repair appears to have a very bright outlook with many very interesting advancements that will emerge in the near future. Indeed, much of the ongoing research is focused on advanced developments of more compact, less expensive, and user-friendly robotic systems. Most of these advances aim at broadening the accessibility of robotic surgery to numerous healthcare delivery institutions in underserved areas. Artificial intelligence also plays a more central role in robotic surgery. Much better images, predictive analytics, decision support, and real time assistance of surgeons can contribute to the improvement in accuracy of hernia repairs by artificial intelligence algorithms [57]. AR technology gives an excellent visualization of the internal structures and leads to accurate dissection with ideal placement of the mesh. Intelligent sensor-enabled meshes are also a new innovation, where it would be possible to monitor healing and signs of complications during the initial stages. The "smart meshes" will revolutionize postoperative management by providing for immediate returns of data about recuperation of the patient, which could lead to more timely interventions when needed. Prospective landscapes for robotic hernia repair will brighten in efficacy as such technologies continue to advance-owed to a more patient-centered and individualized approach to care [58].

Biodegradable Meshes in Hernia Repair: Biodegradable meshes are gradually becoming mainstream in hernia repair because they can potentially replace the traditional permanent synthetic meshes. These meshes provide temporary support to the abdominal wall in the healing phase, and since this degradation occurs within the body, permanent implants may be avoided. Most importantly, biodegradable meshes might avoid late complications, such as chronic pain and infections and adhesions secondary to mesh, sometimes associated with permanent meshes [59]. Biodegradable meshes consist of materials chosen with the intent to degrade at a controlled rate, allowing time for the regeneration and strengthening of the hernia defect. PLA, PGA, and PCL are amongst the very commonly used polymers in such mesh applications. On degrading the mesh, it gets assimilated by the organism and is removed in a non-toxic metabolic form thus causing minimum possibility of an inflammatory response for an extended period. Biodegradable meshes offer significant benefits to the patient who is at risk of complications related to permanent implants, such as an infected patient or a patient requiring temporary hernia repair. In addition to that, their use is also considered in pediatric hernia repair where permanent implants are not commonly used because of growth throughout the lifetime of the patient [60]. As studies into biodegradable materials are conducted, such meshes may emerge as a routine option for patients who want to render hernia repair safer and more biocompatible. Nonetheless, longitudinal studies are still necessary for the full consideration of their efficacy and safety in comparison with conventional meshes.

Types of Biodegradable Mesh Materials: Biodegradable meshes are prepared from a variety of biocompatible polymers that degrade slowly *in-vivo*. Among the commonly used resorbable include PLA, PGA, and PCL. Meshes prepared from PLA have excellent tensile strength but degrade into naturally metabolized products of the human body, namely lactic acid. PGA mesh degrades quickly and is better suited to the support

requirements of patients who would require a short-term support; the degradation of PCL meshes is slower but provides prolonged reinforcement [61]. The most recent developments are combining synthetic and biological components together to enhance degradation rates while increasing mechanical strength. These composites are designed to foster tissue ingrowth with minimal inflammatory responses. Natural polymers such as collagen and silk are also taken into consideration to be used for biodegradable meshes due to their higher biocompatibility and probable capacity to promote tissue regeneration [62]. Such materials are now entering into the introduction of next-generation biodegradable meshes that could yield better results for hernia patients.

Advantages of Biodegradable Meshes: The most crucial advantage of biodegradable meshes is that they tend to minimize complications that permanent synthetic implants may introduce in the long term. Because these meshes gradually degrade within the body, they significantly minimize the risk of chronic inflammation, infections, and adhesions-all very common issues associated with conventional meshes. Therefore, they are an extremely suitable choice for patients with a tendency for infections or those who have experienced complications after previous hernia repairs. Another highly important advantage pertains to the reduced foreign body reaction [63]. Biodegradable meshes are fashioned in order to give tissue support over the critical healing period and then degrade in order to allow natural tissue to be preserved. This process contributes to the alleviation of pain and discomfort for a long time. It also minimizes the need for multiple surgeries to remove the mesh thus lowering healthcare costs and ameliorating the quality of life of the patients. Biodegradable meshes are superior in pediatric hernia repairs because the growing child's tissue reduces the desirability of permanent implants [64]. The inherent degradability of these meshes allows for natural growth and adaptation of the child's tissues, thus minimizing complications.

Limitations and Challenges: Although the meshes are biodegradable, a few disadvantages exist. It is a major disadvantage for ensuring degradation should happen at an ideal rate thereby continuing to provide adequate support over the natural healing time of the tissue. Possible recurrence of hernia could happen with debris that degrades too quickly because of inadequate support. On the other hand, slow degradation may lead to prolongation of the inflammatory response beyond that seen with permanently a fixated meshes. Its biggest disadvantage, however is that it is relatively more costly than the more widely used synthetic meshes [65]. Economic factors may limit it from being applied widely, particularly in health care facilities with limited budgets. This is supplemented by a lack of sufficient long-term clinical follow-up data on the results of the biodegradable meshes thereby making some surgeons resistant to embracing the new technology. The difference in degradation rates of the materials also makes it challenging for surgeons to select specific meshes that will be suitable for the condition of the patient and the type of hernia [66]. This may have implications of creating an increased amount of training and expertise in the use of biodegradable meshes.

Clinical Applications and Patient Selection: Patients predisposed to complications associated with permanent implants would benefit greatly from biodegradable meshes. These include patients who have had recurrent infections or previous complications owing to the use of the mesh and even those with contaminated hernia repairs that may require surgical revision. To such individual patients, biodegradable meshes pose a safer alternative based on elimination of risks associated with chronic inflammation and subsequent infection [67].

Biodegradable meshes are increasingly preferred in pediatric surgery for hernia repair procedures. Thus, permanent synthetic meshes are limited only to pediatric patients due to the dangers of late retention of the foreign body and also the rapid growth of children. On the other hand, biodegradable meshes provide time-dependent natural absorption of the implant by the body, thereby responding to the changing needs of children. In addition, there is also research involved for transitory assistance in situations like emergency surgeries or in patients at risk where revisions may be required [68]. The ability to provide transitory reinforcement without requiring a permanent implant makes these meshes versatile for use in a variety of clinical settings.

Future Research and Innovations: Current prospects into biodegradable meshes seem promising, with continuous work aimed at enhancing and expanding the scope of the applications for such structures. Another aspect in advancement is biodegradable mesh with intelligent coatings containing bioactive films designed specifically for tissue repair in order to avoid the occurrence of post-operative infections. Among such properties, the coatings can release antimicrobial agents or growth factors that enhance tissue repair while reducing the potential chances of developing complications after surgery [69]. Furthermore, nanotechnology is also used in the production of meshes that have excellent mechanical properties and degradation rate. The nanofiber-based biodegradable mesh has multifaceted strengths and flexibility; therefore, it can be applied for almost all kinds of hernias. Researchers have also developed the application of 3D printing technology to produce patient-specific biodegradable meshes that would more or less resemble the anatomy of the patient, and thus, yielding a highly customized approach to repair this condition. Further studies are needed to judge the long-term results of biodegradable meshes in comparison with synthetic standard meshes [70]. Therefore, with the advent of technology, biodegradable meshes are going to become a conventional choice in hernia repair, providing patients with a safer more biocompatible alternative.

Biological Meshes in Hernia Repair: Biologic meshes have emerged as a potential alternative to synthetic meshes for hernia repair in patients for whom the stakes are higher due to increased risks of infections or complications in this context. Originating from natural tissues, such as human dermis, porcine skin, and bovine pericardium, decellularized with removal of cellular constituents but leaving the ECM, these meshes form an emerging alternative. The result would therefore be a scaffold to allow tissue regeneration and integration, and could thus minimize chronic inflammation and foreign body reaction, which are typical responses with synthetic materials [71]. Another very important advantage in biological meshes relates to better integration with patient's tissues and encouragement of natural healing mechanisms that otherwise biocompatibility would offer. They are designed to be slowly resorbed by the body, which might decrease the incidence of complications related to long-term periods such as mesh erosion and chronic pain. They are particularly useful in contaminated surgical fields where the risks of infections are higher, as they also have a lower rate of infection than synthetic meshes. However, biological meshes have their own special problems. Being biologically sourced, their costs are significantly higher than the artificial ones, hence also being a limitation to their wide usage. The quality and functionality of the biological meshes vary with the source and manufacturing methods applied to them. Despite all these limitations, nowadays, biological meshes are preferred in complex hernia repairs, particularly where artificial meshes are not used [72]. As research advances, new generations of biological meshes under development are expected to better possess superior qualities for patients, thereby providing safer and more efficacious alternatives for hernia repair.

Types of Biological Meshes: Biological meshes can be further subclassified based on the source. This includes human, porcine or pig and bovine which is cow. Derivatives of human-derived meshes include AlloDerm, which is made by processing procured human dermal tissue where cellular components have been removed leaving a matrix rich in collagen. These meshes are known to have excellent biocompatibility with good host tissue integration [73].

The most commonly used biological meshes used in hernia repair are sourced from the porcine or pigs, specifically Strattice. They are made from pig skin or small intestine submucosa to act as a firm but also pliable scaffold for tissue ingrowth. Examples include bovine meshes, for example SurgiMend, which has an impressive strength and resistance to degradation from bovine pericardium. Biological meshes are generally used for applications aimed at supporting tissue healing in high-risk patients, particularly those that will undergo a procedure in an infected or contaminated field [74]. Depending on the patient condition, size of the hernia, and surgeon preference, one type of mesh is preferred over the others, as each offers some unique advantages in certain clinical situations.

Benefits of Using Biological Meshes: Biological meshes in hernia repair bring many advantages, mainly for those patients who are disposed to the complications of a synthetic implant. The vulnerability to infections is much reduced, making them especially perfect for deployment in contaminated surgical environments or among patients with weakened immunological defenses. Nonetheless, the propensity of synthetic meshes towards bacterial colonization is much lower than that of biological meshes and could help reduce the chances of infection post the operation. The second advantage is that biological meshes are more biocompatible [75]. They integrate better with the patient tissue and may be conducive to natural tissue growth, thereby reducing inflammation. It, therefore, reduces chronic pain and mesh complications. The overall outcomes in the patient also improve. Since the body absorbs biological meshes slowly, long-term complications such as erosion and fistula formation are reduced. Biological meshes are pliable and strong, thus can be used for reconstruction of large or complex hernias that require more support. It is a resistant alternative that closely mimics the shape of the anatomical structure of the patient, which may be particularly advantageous in cases of recurrent hernias, in which traditional synthetic meshes have failed [76].

Limitations and Drawbacks: Despite these advantages, there are several disadvantages associated with biological meshes. The first is the high cost, which is in most cases much higher compared to synthetic meshes. Such a factor may be a limiter in their application especially when healthcare systems are short of funds. Additionally, there exists variability in terms of quality among various biological meshes and it leads to unpredictable results, and thus crucial that the surgeon decides on which product would suit the case best [77]. The other issue is the degradation of the mesh before the adjacent tissue can be adequately bonded; then, the hernia may reoccur. On the contrary to this, synthetic meshes provide permanent reinforcement. Biological meshes get gradually absorbed by the body. In this context, if the degradation process is too rapid, then it will compromise the long-term success of the repair. Moreover, although this is the least probable event, some patients could be allergic or sensitive to biologic materials. The immune response risk depends on the mesh source and the individual health profile of the patient [78]. Thus, optimal outcomes will be achieved by careful selection of appropriate patients and thorough preoperative assessment when using biological meshes.

Clinical Applications and Best Practices: Biological meshes offer several advantages over traditional mesh for complex hernia repairs, particularly in contaminated surgical site or in a patient with previous infection sites. They are also used for the placement in immunocompromised patients because synthetic meshes may increase the risk of complications in the infected tissue. Biological meshes are commonly used by surgeons for large ventral hernias, incisional hernias, and recurrent hernias not managed effectively by previous surgical intervention [79]. Best practices in biological meshes include suitable mesh type selection to take into account the patient factors and complexity of the hernia. More importantly, the surgical techniques must be meticulous enough to minimize complications as much as possible. And most importantly, it is the preoperative planning and postoperative care that determines what outcome would be optimum, especially when using expensive biological material. These biological meshes allow for an absorbable choice in cases of pediatric hernia repair that is adaptive to patient growth, allowing healing while effectively eliminating any long duration of foreign substance existence [80].

Future Directions and Innovations: New development of biological meshes for hernia repair will be directed towards its functionality improvement and applications extension. Investigators are busy ascertaining whether treatment by other means of regenerative medicine, including stem cells or growth factors in biological meshes, could better augment tissue recovery within a shorter period. This method can enhance mesh assimilation with the patient's biological tissues, reducing the possible complications and recurrence. Another area of innovation is hybrid meshes which combine biological and synthetic materials to leverage the benefits that are contributed by each class of material [81]. Such meshes are designed to offer biocompatibility that is provided by a biological mesh while conferring

to the user the prolonged durability seen with synthetic meshes, making them suitable for a broader range of surgeries to repair hernias. Nanotechnology has enabled the strengthening and resistance to degradation of biological meshes. Due to the enhancement of biological meshes through nanotechnology, biological meshes will be more adaptable and effective in usage. Therefore, surgeons will also have more flexibility, while tailoring hernia repair more towards each patient [82]. Next generation biologic meshes present an even brighter opportunity that promises better clinical outcomes, fewer complications, and increased cost-effectiveness, thus making it an essential resource in this evolving world of hernia repair.

Minimally Invasive Hernia Repair Techniques: It is indeed true that minimally invasive techniques in hernia repair have to a certain extent revolutionized surgical practice, providing patients with accelerated recovery periods, less postoperative pain and fewer complications and more established open surgical techniques. It includes laparoscopic and robotic-assisted interventions through small incisions with specially designed instruments, high-resolution imaging technologies, and accurately opposing the layers and sutured hernia defect with minimal tissue damage. As such, patients have shorter hospital stays and sooner returns to their lifestyles, and these interventions are gaining greater acceptance as hernia treatment modalities. The most commonly used minimally invasive procedures, one is laparoscopic hernia repair, which involves making an incision through which a thin tube containing a camera-a laparoscope-is inserted [83]. A display provides the surgeon with a view of the hernia defect and allows him to repair it using various specialized instruments through several small incisions. It is more commonly applied in cases of inguinal, ventral, and incisional hernias. Robotic assisted hernia repair is relatively more modern that provides surgeons with better dexterity because of robotic arms. Robotic systems can allow for more accurate placement of sutures and meshes, potentially reducing the complications associated with hernia recurrence. Such procedures tend to be more feasible in complex scenarios, for instance large or recurrent hernias where greater precision is a requirement. Most importance in noting is that this kind of hernia repair minimal invasiveness does not suit every patient. Among these factors, dimensions and location of the hernia, anatomical features of the patient, and the presence of comorbid conditions have been shown to influence the surgical approach taken [84]. Continuous research and development in technology can be expected to improve the outcomes of these interventions, which then are likely to become available to a larger number of patients.

Laparoscopic Hernia Repair: Due to its minimal invasiveness, laparoscopic hernia repair has become one of the most common approaches to treat all kinds of hernias. In this procedure, the surgeon makes three to four small incisions within the abdominal wall through which both the laparoscope and the surgical instruments he needs will be inserted. The interior is shown magnified by means of the laparoscope, helping the surgeon locate the defect of the hernia so that either mesh or sutures can be used to correct it. Another crucial benefit from laparoscopic repair is postoperative reduced pain due to more minor incisions with lesser tissue damage [85]. Patients recover much faster after the surgery. Most of them are discharged within the same day or within 24 hours after the procedure. Laparoscopic repair is certainly more effective with bilateral and recurrent inguinal hernias since it would enable one to repair several defects through one minor incision. However, this procedure demands a high level of surgical expertise and thus cannot be used in all patients, especially those who have a big or complicated hernia. The skill to undergo laparoscopic hernia repair has a steep learning curve, which affects the outcome when it is performed by less skilled surgeons [86]. However, along with education acquired by surgeons, advancements in laparoscopic technology are making this method increasingly popular among surgeons as well as patients.

Robotic-Assisted Hernia Repair: Robotic-assisted hernia repair is an advanced minimally invasive surgery, with the use of robotic technology to improve accuracy in surgery. The technique is very similar to laparoscopic surgery but allows for superior dexterity and control because the robotic arms simulate the surgeon's hand movements with precision. The surgeon operates from a console, looking at a 3D magnified view of the surgical

field, which enhances visualizations of the hernia defect. The main advantage of robotic-assisted repair is the ability to carry out complex that apparently easily, as in delicate suturing and precise mesh placement, that are often difficult within the context of traditional laparoscopic surgery [47]. Its use is especially beneficial with large ventral or recurrent hernias where fine dissection and reconstruction are necessary. Although robotic-assisted hernia repair has many benefits, it is very expensive due to the costly machines and time-consuming surgery duration. However, diminished complication rates and better patient outcomes make it worth consideration for certain situations[87]. With more facilities taking up the technology and making it economical, this robotic technology will certainly become a part of standard practice in hernia repair, particularly in complex cases requiring a higher level of accuracy.

Advantages of Minimally Invasive Techniques: There are numerous advantages involved with the minimally invasive techniques of hernia repair as compared with traditional open surgical approaches. The foremost benefit is lesser amounts of tissue damage, thus resulting in minimal postoperative discomfort, due to smaller incisions. This contributes towards shorter recovery times and permits patients to quickly regain their life and work functions much earlier than those opting for open surgery. Not only this, but it also cuts down the cases of surgical site infections. It is because the incisions are smaller; therefore, the inside tissues are less exposed to the spread of pathogens [88].

Such patients who in the past have experienced other medical conditions or treatments that had taken place within infected zones are especially relevant. Moreover, in this minimally invasive method, the technology of advanced imaging and fine instruments in the process prevents complications such as hernia recurrences or continued pains. Cosmetically, outstanding results have also been reported in patients who received laparoscopic or robotic-assisted hernia repair since less scarring is left since the incisions are significantly smaller. This makes the minimally invasive approach a very attractive option for safer and more effective treatments of hernia repair in patients [89].

Limitations and Challenges: Despite all these benefits available in these minimally invasive techniques, they suffer with several challenges. The most crucial one among them is that the steep learning curve comes with laparoscopic and robotic-assisted techniques. The surgeons would require proper training and expertise to achieve ideal results; scaling up proves to be a challenge, especially in resource-constrained areas. A higher cost is another issue related to minimally invasive approaches, especially those with robotic-assisted surgery because they require expensive equipment and longer operative times. Such high economic costs might greatly affect the healthcare systems on a limited budget, therefore limiting access to more advanced techniques [90].

Patient selection is also important as not all hernias are ideal for minimally invasive repair. Large complex or incarcerated hernias might require open surgical intervention for suitable repair. These will present challenges for working with patients who have previous histories of abdominal surgeries or major comorbidities due to possible complications resulting from further challenges [91]. However, the continued advancements in education for surgeons, technology, and developments of procedures are expected to reduce such challenges and make minimally invasive hernia repair accessible to a broader population.

Future Trends in Minimally Invasive Hernia Surgery: Pretty promising is the future of minimally invasive hernia surgery with fast-paced continued research and emerging technology to assist in patient safety. Artificial intelligence and machine learning could integrate into robotic surgery to help surgeons make better decisions, increase precision, and reduce the time it takes for surgeries, further enhancing the safety and efficiency of hernia repair surgeries. The development of advanced imaging modalities, including augmented reality and 3D imaging, helps provide surgeons with a clearer vision to detail not only the hernia defect itself but also the surrounding structures [92]. Such techniques may contribute to further refinement of preoperative planning and intraoperative navigation for more precise repairs and better outcomes. Minimally invasive hernia surgery continues the development of even smaller, more dexterous instruments for

surgeons to minimize the number of invasions with minimal scarring. Current research in this field is also being conducted in the area of micro-laparoscopic techniques that can make cuts as small as 3 mm to minimize patient trauma further [93]. Technological advances will make the least invasive repair technique for hernias accessible, friendly to patients, and successful, even more so than better results and quality of life for patients suffering from hernias.

Role of Imaging in Hernia Diagnosis and Repair: Imaging plays a crucial role in the proper diagnosis and treatment of hernias, especially in challenging or recurrent cases. Even though physical examination alone is the basis of the initial approach, various modern imaging modalities have now become highly important for confirming the diagnosis of a hernia, measuring the size of the defect, and planning surgery. Ultrasound is generally the first modality used in hernia imaging due to its access and cost-effectiveness and the real-time demonstration of the hernia sac, contents, and surrounding structures. It's most useful in assessing inguinal and umbilical hernias. Anatomical details would be better ascertained by CT scans, particularly with abdominal wall hernias. CT imaging provides high-quality cross-sectional views that are highly sensitive to subtle hernias, differentiate between types, and are useful for complications such as bowel obstruction or strangulation [94]. MRI, not as commonly employed, offers excellent soft tissue contrast and is valuable in the evaluation of complicated or recurrent hernias; in those patients in whom radiation exposure is undesirable. MRI can be helpful in differentiating hernias from other abdominal or pelvic pathologies, which helps with differential diagnosis. However, imaging plays an important role not only in making the final diagnosis but also in surgical planning so that surgeons can choose the best technique to repair and anticipate which complications may be expected. With evolving imaging technology, newer modalities and techniques are coming into the forefront, including 3D imaging and dynamic MRI, which provide higher precision in hernia evaluation and treatment planning [95].

Ultrasound in Hernia Diagnosis: Among the most applied imaging modalities in hernia diagnosis are ultrasound imaging, which does not invade and therefore cannot cause ionizing radiation, combined with real-time imaging. The modality is applied primarily in the diagnosis of soft tissue hernias, especially of the inguinal and umbilical types. During an ultrasound examination, the probe is placed on the skin overlying the region suspected of harbouring the hernia; it then emits sound waves that form the internal views of the anatomy [96].

A major advantage of ultrasound is that it will be able to outline the contents of hernias, such as bowel loops or omentum with assessment for their possible reducibility. This becomes an advantageous feature in the detection of occult hernias that might otherwise not be seen by physical examination on obese patients. Complications like strangulation or incarceration can also be identified and suspected using the features of reduced blood circulation or bowel obstruction. Moreover, dynamic ultrasounds whereby the scan is done during exercise such as coughing or straining can actually detect hernias that would go unnoticed by a static scan [97]. However, accuracy in ultrasounds is highly dependent on the operator, so it basically means the skill of the technologist determines the quality of images obtained.

Computed Tomography (CT) Scans: CT scans represent the gold standard for evaluation of complex abdominal hernias, especially in patients with non-specific clinical features. It provides cross-sectional views of the abdomen and helps in delineating the hernia defect and its contents well. It is particularly useful for the detection of ventral, incisional, and Spigelian hernias besides the evaluation of complications such as bowel obstruction or strangulation. Perhaps the largest advantage of CT scans is the ability to allow differentiation between and among various types of hernias and other abdominal pathologies, such as those that may mimic symptoms of hernias [98]. For instance, CT can differentiate a hernia from disorders such as abscesses, tumours, or lymphadenopathy which may present with similar clinical features. More than anything else, CT scans are very helpful in preoperative planning. Surgeons may use the CT image to map the hernia defect, identify surrounding anatomical structures, and have a good plan for the most effective approach to

the surgery. This is extremely important in recurrent hernias, in which scar tissue can greatly complicate repair. A very big limitation in using ionizing radiation in the CT imaging is especially in children or in cases requiring multiple scans [99].

Magnetic Resonance Imaging (MRI): Magnetic resonance imaging (MRI) is a state ofart imaging technique that demonstrates better contrast resolution for soft tissues, therefore exceptionally good in dealing with the complex and recurrent hernias. Moreover, MRI does not use ionizing radiation, unlike CT scan, therefore safer for pregnant patients and other patients who have to undergo recurrent imaging. MRI is highly valuable when ultrasounds and CT scans cannot clearly depict any opinion since it offers detailed views of both soft tissues and contents within the hernia sac [100]. It may further distinguish among types of hernias or complications like nerve entrapment or mesh migration, which cannot always be clearly visualized by ultrasound or CT scan. As a matter of fact, one of the unique advantages of MRI is that it makes possible dynamic imaging, or the capturing of changes in the hernia with patient motion or straining. It would thus be ideal for detecting sports hernias, or minimal groin pain which perhaps cannot be discerned through static imaging techniques. Higher cost and time are involved as compared to other imaging methods, and only may it permit its use when some extensive soft tissue evaluation is required [101].

Emerging Imaging Technologies: Emerging technologies in imaging promise a revolution in hernia diagnosis and management as they tend to make the diagnosis more accurate and efficient. For instance, with 3D imaging, one can obtain very detailed reconstructions of anatomy that might help a surgeon visualize the hernia defect in three dimensions. This might improve both preoperative planning and reduce surgical complications in complex or recurrent hernia repair. Another interesting innovation is dynamic MRI, which captures images of the hernia at movement, like coughing or straining. This especially will be useful in clarifying intermittent or clinically small hernias that cannot be visualized with more conventional static imaging [102]. Dynamic MRI also assists in diagnosing athletic pubalgia or sports hernia because it often is associated with visualization of movements of muscles and tendons. Now, artificial intelligence penetrates more and more the medical imaging sphere, where there are developed algorithms to automatically detect and classify hernias within imaging studies. AI might improve diagnostic accuracy, reduce the time for interpretation of images, and aid during decision-making in complex cases. Such technical progress in imaging shall contribute to better outcomes after hernia repairs by producing more precise diagnoses and tailored surgical interventions [103].

Role of Imaging in Postoperative Assessment: Imaging is a component of the evaluation process for diagnosis and planning of hernia repair, but it also contributes to the postoperative assessment of patients. Imaging postoperatively often aids in evaluating the integrity of the repair, identifying the presence of complications such as seromas or hematomas or problems with mesh placement, and confirming there is no recurrence. These include ultrasound studies that are quite commonly used for early postoperative evaluation because they are non-invasive and can detect fluid collections or infections at the surgical site. Others include CT scans of choice in assessing deep-seated complications or recurrent hernias, providing detailed information regarding integration of the mesh and the surrounding tissues [95]. MRI is of utmost use in chronic pain following hernia repair as it could have entrapment of nerves, shrinkage of mesh, or adhesions that caused symptoms in the patient. Advanced imaging in postoperative care ensures detection and management of complications in time, which has potential to improve the patient's outcome. An important development is introducing technologies for imaging with future prospects for artificial intelligence observation of postoperative changes that might enhance the management of hernia repairs by offering real-time feedback and management of every patient [100].

Postoperative Complications and Management: Postoperative complications are a significant issue after hernia repair, as they can interfere with patient recovery and long-term outcomes. Even though overall complications have decreased due to improvements in surgical techniques and materials, infections, chronic pain, recurrence, and mesh-related complications remain.

It is therefore essential to understand these complications, including their management, for further improvement of patient outcomes and the recovery process. The commonest complications encountered postoperatively include those related to the surgical site-infection. With open hernia repairs, infection risk is much higher than with laparoscopic methods; this is probably due to the fact that the wounds are much larger. Such infections may be limited and superficial to the wound itself, but in some cases, there can even be an infection of the mesh, which requires patients to receive prolonged antibiotic therapy or even surgical removal of the mesh [14]. Infection should, however, be prevented with standardized sterile precautions and prophylactic antibiotics. The second significant complication is chronic postoperative pain, which is usually due to nerve entrapment and occurs in about 10-15% of the patients. Pain can become incapacitating and lowers the quality of life of the patient. Thus, it has been a motivation to introduce long-term pain management modalities in hernia surgery. Recurrence of the hernia still remains a concern with inappropriate positioning of the mesh, especially with obese or very active patients. Early diagnosis and proper management of these complications are crucial in helping the best recovery for the patients [104].

Surgical Site Infections (SSI): One of the most common complications following hernia repair is SSI. These can be through contamination, failure of proper sterilization of instruments, or colonization by bacteria of the mesh implant. They often occur more frequently in obese patients, diabetics, and those whose immunity has been compromised. Common presentations of superficial infections include redness, swelling, and pain around the surgical site within the first few days post operatively. These are usually managed with oral antibiotics and good wound care. Deep infections involving the mesh are more demanding to manage with intravenous antibiotics or even surgical removal of the infected mesh. Preventive measures such as prophylactic antibiotics before surgery, proper use of aseptic technique, and minimally invasive procedures, when possible, could prevent the occurrence of SSIs [105]. Further innovations in meshes, such as antibiotic-coated meshes, will also give more opportunities to reduce the infection rate.

Chronic Postoperative Pain: Chronic postoperative pain is a serious complication of hernia repair operations, which occurs significantly in patients, particularly those who have undergone open surgery. This can often cause a person a permanent suffering related to pain in the groin, thigh, or scrotum significantly lowing his quality of life. Multidisciplinary treatment is required to manage chronic pain, involving drugs for analgesia, blocks and physiotherapeutic practices. For more severe cases that do not respond to conservative management, surgical intervention may be required to remove the offending mesh or perform a nerve release [106]. Recent advances in mesh technology also include lighter weight and larger pore sizes designed to minimize chronic pain due to reduced inflammatory responses and nerve irritation. One of the preventive approaches offered by surgeons for chronic pain is the utilization of minimally invasive techniques such as laparoscopic or robotic-assisted hernia repairs involving minimal incision and decreased nerve trauma. It would be very helpful in raising outcomes if patients who have a history of chronic pain disorders were identified, and by using individually designed surgical strategies [88].

Hernia Recurrence: Recurrence can occur in both open and minimally invasive hernia repairs, with recurrence rates ranging from 1% to 15%, again depending upon patient, type of hernia, and the technique of the repair. This may be due to improper fixation of mesh and poor surgical technique but also due to significant patient-dependent critical factors, like obesity, smoking, and strenuous physical activity. The most critical technique probably for reducing recurrence has been reinforcement by mesh, whereby the recurrence rate is substantially less when compared to a suture-only repair [107]. Even in the mesh-reinforced cases, recurrence can occur in those with poor positioning or migration of the mesh post-surgery. Newer mesh fixation techniques are employed by the surgeons that increase the strength of the repair and, as a result, the recurrence rates often tend to reduce; for recurrent hernia, imaging studies like CT or MRI may be necessary for assessment of defect and for planning of reoperation. It may also be difficult because of the scar tissue that will be present from the hernia repair, so patients may need a very experienced surgeon for such cases.

Preventive measures would also involve educating the patient on lifestyle modification, such as weight and smoking management, to decrease the risk for recurrence [108].

Mesh-Related Complications: Although mesh repair of hernias has generally been combined with lower recurrence rates, it is still not free of complications. The complications involving mesh, including migration, erosion, and rejection, may lead to significant morbidity and require further surgical intervention. Mesh migration occurs due to the displacement of mesh placed at the initial time point. Such a complication may cause pain, obstruction, or fistula formation due to the possibility of penetration of the mesh into adjacent organs. The type of mesh used may significantly determine whether complications can be likely to happen. For instance, heavyweight, non-absorbable meshes have been associated with elevated risks of chronic pain and development of adhesions; whereas large pore lightweight meshes have been developed specifically to lower some those risks [109]. However, new mesh designs notwithstanding, complications may still happen. Usually, mesh complication treatment involves medical treatments or even surgical interventions while combining various imaging techniques. Mesh extraction may become unavoidable in serious cases. However, this process is usually associated with a higher risk of recurrence of hernia. Present studies are focused toward the design of biocompatible, absorbable, and smart meshes that can mimic the body's tissues to reduce these complications [110].

Strategies for Optimizing Postoperative Outcomes: To optimize postoperative outcomes after hernia repair, patient selection, surgical technique, and postoperative care must all be part of a holistic approach. Preoperative interventions such as treating comorbid conditions like diabetes, optimization of nutrition, and smoking cessation have been found to significantly reduce the incidence of complications. Thus, the specific technique chosen-open, laparoscopic, or robotic assisted should be tailored according to the needs of the patient as well as the nature of the hernia for treatment. Another aspect of results improvement is with more sophisticated imaging in preoperative planning and in choice of appropriate mesh type. Just as much care issues postoperatively should be devoted to an issue of ensuring early mobilization, effective pain control, and monitoring for evidence of complications [111]. ERAS protocols are an excellent example of interventions that bring together multimodal pain management and early ambulation to improve time to recovery and shorten hospital stays. The most likely new trends in hernia repair would be personalized medicine approaches, with genetic and biomarker profiles that can predict patient outcomes, tailoring surgical techniques. Continued study and innovation regarding surgical techniques, materials, and postoperative care are fundamental aspects of delivery of improved quality of life to those being treated through hernia repairs [112].

Patient-Centered Approaches in Hernia Management: The landscape of hernia repair progressively shifts towards patient-centered methodologies, emphasizing personalized care and shared decision making and placing greater focus on enhancing patient satisfaction and quality of life. Traditionally, hernia repair protocols mainly followed a standardized routine. However, advances in medical research have pushed forth for a reality wherein the care that is delivered should be individualized to provide specific requirements of each patient. One of the most basic principles of patient-centered care is shared decision-making, where health care providers and patients share in the process to make informed decisions regarding the most appropriate treatment [113]. This increases patient engagement in addition to bringing a better relationship between surgical interventions with patient values and expectations for improved outcomes and satisfaction. Anticipation of an individual's lifestyle, professional experience, and general pre-existing medical conditions provide surgeons with better scope in tailoring the treatment strategy, choosing appropriate surgical technique, mesh type, and the postoperative care protocol. Another relevant patient-centered approach in hernia management is proper preoperative counselling. Instructing patients on potential risks, advantages, and possible complications related to various options of hernia repair allows them to take informed decisions [114]. On the contrary, PROMs are increasingly used to measure effectiveness from the patient's point of view and to help the clinician understand the patient's fears, and alter care appropriately.

Shared Decision-Making in Hernia Repair: SDM is the base of the patient-centered care for hernia. What is beautiful about SDM is that it enables patients and their healthcare providers to do collaborative work together toward decisions, making several options irrelevant against the backdrop of a patient's values, preferences, and lifestyle. A case where job requirement calls for much labour may prompt swift return to work as an imperative for the patient, which may influence the choice in favour of a minimally invasive approach over traditional open surgery. SDM not only increases the level of satisfaction among the patients but also adherence to their treatment plans for because the patient is going to implement decisions, they were actively involved in making [115]. Studies demonstrate that patients who are involved with SDM are lower in anxiety, have higher confidence in their treatment decisions, and general better overall outcomes. This method proves most effective where other alternatives for treatment are provided. For instance, herniorraphy could be done either open procedure, laparoscopic procedure, or robotic-assisted procedure. Clinicians suggested that outstanding SDM should include a clear description and unbiased with the inclusion of decision aids like printed pamphlets, video, and Internet-based decision aids. These will lead the patient towards helping her to understand her decisions and possible impacts on quality of life towards a more patient-centered hernia management [116].

Preoperative Counselling and Education: Preoperative counselling is one of the integral components of patient-centered care for hernia, involving education of the process, risks, benefits, and expected outcomes of the surgery. Adequate counselling empowers the patient with information on what to expect before, during, and after the surgery while reducing the anxiety he or she needs to have built upon realistic expectations. Through the counselling process, surgeons provide detailed information regarding the particular types of hernia repair, the benefits and drawbacks associated with the mesh, and possible complications, along with the nature of the time course of recovery [117]. Such Candor fostered confidence and enables the patient to assume a very active part in his health care. Lifestyle modification, such as quitting smoking and controlling weight, is taught to the patients before the surgery since these will minimize the risks of the surgery and improve the outcome of recovery. Other visual aids, like diagrams and videos can help them understand the process especially for those who are not in the field of health. Today, many hospitals and healthcare systems are launching preoperative education programs providing group classes or online learning modules that ensure a patient is well prepared for surgery [118]. Evidence also shows that better-educated patients have an easier recovery, fewer complications occur, and they also report greater satisfaction with their care.

Patient-Reported Outcome Measures (PROMs): Today, patient-reported outcome measures (PROMs) are a significant tool in the evaluation of outcomes of hernia repairs from the viewpoint of the patient. Compared to the traditional clinical outcomes focused on complication rates and recurrence, PROMs measure the impact of surgery on the quality of life, severity of pain, and ability to function. The value of PROMs, therefore, lies in capturing the patient's experience of symptoms and recovery and overall satisfaction in relation to the effectiveness of different hernia repair techniques [119]. In addition, by using PROMs in clinical practice, surgeons can address their areas for improvement and tailor interventions to allow better adherence to patients' needs. For instance, if patients report high levels of chronic pain after surgery, it may lead to reviewing the surgical techniques or perhaps the specific mesh type used. Comparability of outcomes between open and laparoscopic hernia repairs - PROMs are equally helpful in determining which set of patients would be recommended to benefit from evidence-based practice better. Moreover, integrating PROMs into standard follow-ups ensures the well-being of a patient is dealt with comprehensively, where the recovery of the patient physically could include the emotional and psychological well-being of the individual [120]. This approach is extremely relevant to the value-based health care with a focus on patient satisfaction and quality of life as key success metrics.

Personalized Surgical Strategies: Personalized medicine is slowly revolutionizing hernia care because it will align with having customized surgical approaches according to individual patient

characteristics, such as age, gender, physique, health conditions, and even individual patient preferences that would better improve surgical outcome. Examples include older adults or patients with significant comorbidities who may benefit particularly from being managed by minimally invasive repair methods, such as laparoscopic or even more robotic-assisted repair, which leads to faster recovery and fewer complications [121]. Improvements in genetic testing and biomarkers also provide scope for intensification; that is, making the approach more targeted to identify patients more likely to experience complications or recurrence due to their predisposition genetically that might affect surgeons to change their technique or explore other treatment options. Personalized surgical planning using 3D imagery and computer-aided design may have the potential of increased precision of hernia repair, especially concerning complex or recurrent hernias. Such monumental goals in patient-specific surgery include better results, a reduced rate of complications, and greater patient satisfaction regarding hernia repair surgical interventions. Entering into personalized care meant leaving behind the traditional "one-size-fits-all" approach or methodology and adopting instead another uniqueness related to each patient's particular health profile [122].

Future Directions in Patient-Centered Hernia Care: Continued innovation in practice for patient-centeredness will continue to change the future of hernia management through integration with technology, enhanced education of patients for better optimization of recovery, and others. Examples of such innovations may include the use of telemedicine in preoperative and postoperative consultations, which may significantly improve patients' access to health care, particularly in more poverty-stricken or less accessible communities. At the research level, VR and AR technologies are under evaluation for patient education with both visualization of surgical interventions and subsequent stages of recovery [123]. These technologies have much potential for allowing better patient understanding and reducing anxiety and thus make for a better surgical experience. Another major driver of influence on postoperative care is likely to be AI in applied patient monitoring. These algorithms can process the data coming from these wearable devices to track patient recovery, detect complications early, and provide real-time feedback to healthcare providers so interventions can move forward more quickly with better results [124]. Continuing the patient-centered approach will enhance the patient experience, improve surgical outcomes, and produce high-quality hernia care. The years ahead will witness a cure integration of technologies, personalized medical interventions, and active participation by patients that revolutionize the management of hernias.

CONCLUSION: New developments in mesh technology, as well as surgical methods, have revolutionized the hernia repair field over the last decade. Innovative materials, designs, and operative strategies transformed what was once a simple procedure into an advanced, patient-centered surgery discipline. These improvements not only have enhanced clinical outcomes but also allowed improvement in the quality of life in thousands of patients worldwide. Most advances in hernia repair lay in a shift towards new sophisticated mesh technologies. From heavyweight, rigid meshes to more light and biocompatible variants, this indicates a better understanding of how bodies react to foreigners in their interior.

Synthetic meshes have been crafted such that complications related to infection, chronic pain, and adhesions are minimized. Biologic and hybrid mesh do contribute to options in challenging clinical scenarios, such as contaminated or high-risk fields. Biologic meshes are known to be integrated into natural tissue with gradual resorption by the body with minimal long-term foreign body reactions. The use of 3D printing and customized mesh implants is the cutting edge for personalized medicine in hernia repair. These advancements mean a much better fit for each patient, by means of the anatomy in question. Chances for complications such as migration or bulging of mesh are less likely. These are compounded by the increasing tendency towards using greater robotic and laparoscopic techniques, as these permit a level of precision and delicacy not previously attained by minimally invasive surgery. Such advances translate into shorter hospital stays, quicker recovery times, and less perioperative pain. All of these are articulated in the overall trend toward patient-centric care.

The development of antiadhesive coatings and bioactive meshes that deliver anti-inflammatory or antimicrobial agents stands as an example of the continued effort to better the outcome for the patient. These advancements may reduce recurrence and improve durability as they address problems commonplace with hernia repair surgeries. Moreover, the anti-adhesion properties itself become particularly beneficial in complex situations where the mesh comes into contact with the internal organs, which would otherwise reduce the possibility of bowel obstruction and several complications arising due to adhesions. Despite these technological developments, challenges continue to exist in the hernia repair arena. The type of hernia, comorbidity in the patient, and the potential for complication should dictate both the operative technique and the choice of mesh material when treating each individual. In addition to better strategies in prevention of recurrences and complications, more research is needed in order to enhance longevity as well as biocompatibility of mesh material. The biggest challenge to increased utilization, in resource-poor settings especially, is the high cost of these expensive mesh materials, particularly biologic and hybrid meshes. Hopefully, in the future of hernia repair, much hope lies in mesh innovations, minimal access surgical techniques, and a personalized approach to patient care. Improved research and development will continue to focus on optimizing patient results while easing the burden of complications. Innovative fervour in this field greets the dawning of a new era in hernia repair, safety, effectiveness, and personalization towards specific patient needs to bring about qualitative improvement in health at an international level. This all-inclusive approach towards modern hernia repair calls for increased joint effort between surgeons, researchers, and makers of medical instruments to stimulate further progress and create a new standard in surgical practice.

ACKNOWLEDGEMENT: Nil

CONFLICTS OF INTEREST: The Authors declare no conflict of interest.

REFERENCES:

1. Larco Coloma J, Larco Noboa N and Rumazo Zambrano A: Abdominal Wall Hernias: different types of classifications and complications. International Journal of Medical and Surgical Sciences 2022; 1–11.
2. Macchini F, Raffaeli G, Amodeo I, Ichino M, Encinas JL, Martinez L, Wessel L and Cavallaro G: Recurrence of Congenital Diaphragmatic Hernia: Risk factors, management, and future perspectives. Front Pediatr 2022; 10: 823180.
3. Grover TR, Weems MF, Brozanski B, Daniel J, Haberman B, Rintoul N, Walden A, Hedrick H, Mahmood B, Seabrook R, Murthy K, Zaniletti I and Keene S: Children's Hospitals Neonatal Consortium (CHNC) Congenital Diaphragmatic Hernia Focus Group. Central line utilization and complications in infants with congenital diaphragmatic hernia. Am J Perinatol 2021; 29: 1524–32.
4. Hider AM, Bonham AJ, Carlin AM, Finks JF, Ghaferi AA, Varban OA and Ehlers AP: Impact of concurrent hiatal hernia repair during laparoscopic sleeve gastrectomy on patient-reported gastroesophageal reflux symptoms: a state-wide analysis. Surg Obes Relat Dis 2022; 19: 619–25.
5. Yamaguchi N, Morioka D, Izumisawa Y, Toyoda J, Yamaguchi K, Horii N, Ohyama N, Asano F, Miura M, Matsuyama R, Sato Y and Endo I: A classification system specific for recurrent inguinal hernia following open hernia surgery. *In-vivo* 2021; 35: 3501–8.
6. Coelho JCU, Hajar FN, Moreira GA, Hosni AVE, Saenger BF, Aguilera YSH, Costa MAR da and Claus CMP: Femoral hernia: Uncommon, but associated with potentially severe complications. Arq Bras Cir Dig 2021; 34: 1603.
7. Kaur M, Grandpierre V, Oltean I, Weir A and Nasr A: Predictors of spontaneous resolution of umbilical hernia in children. World J Pediatr Surg 2021 4: 000287.
8. Ortega-Deballon P, Renard Y, de Launay J, Lafon T, Roset Q and Passot G: Incidence, risk factors, and burden of incisional hernia repair after abdominal surgery in France: a nationwide study. Hernia 2023; 27: 861–71.
9. Perisetla N, Doyle WN, Ladehoff L, Natarelli N, Nemov V, Pittala K, Sujka J, Saad AR, DuCoin C and Velanovich V: Effects of spinal deformities on hiatal hernia occurrence and recurrence. J Gastrointest Surg 2023; 27: 2718–23.
10. Wang TN, An BW, Wang TX, McNamara M, Sweigert PJ, Yuce TK, Heh V, Collins CE, Haisley KR and Perry KA: The effect of frailty and age on outcomes in elective paraesophageal hernia repair. Surg Endosc 2023; 37: 9514–22.
11. Chan DL, Chern TY, Iliopoulos J, Hennessy A, Wong SKH, Ng EKW and Talbot ML: Accuracy of high-resolution manometry in hiatal hernia diagnosis in primary and revision bariatric surgery. Obes Surg 2021; 31: 2906–12.
12. Jisova B, Wolesky J, Strizova Z, de Beaux A and East B: Autoimmunity and hernia mesh: fact or fiction? Hernia 2023; 27: 741–9.
13. Elabbassi T, Zouhair A, Elkarouachi A, Amine B and Lefriyekh MR: Spiegel's hernia, a rare weakness of the abdominal wall. Ann AfrMéd 2022; 15: 4843–5.
14. Alzatari R, Hassanein R, Doble J, Huang LC and Poulose BK: Determining the impact of individual ventral hernia repair complications on patient-reported quality of life. Hernia 2023; 27: 687–94.
15. Grodno State Medical University, Grodno, Belarus, Zhuk SA and Smotryn SM: Grodno State Medical University, Grodno, Belarus. The effectiveness of open surgical interventions for inguinal hernias in elderly patients. J Grodno State Med Univ 2023; 21: 161–71.

16. Mercado M, Diab J and Loi K: A delayed diagnosis of obturator hernia hoodwinked by previous laparoscopic inguinal hernia repair. J Surg Case Rep 2021; 2021: 07.
17. Zou Z, Zhang D, Liu Y and Wang M: Postoperative compression in preventing early complications after groin hernia repair. Hernia 2023; 27: 969–77.
18. Stabilini C, van Veenendaal N, Aasvang E, Agresta F, Aufenacker T, Berrevoet F, Burgmans I, Chen D, de Beaux A, East B, Garcia-Alamino J, Henriksen N, Köckerling F, Kukleta J, Loos M, Lopez-Cano M, Lorenz R, Miserez M, Montgomery A, Morales-Conde S, Oppong C, Pawlak M, Podda M, Reinpold W, Sanders D, Sartori A, Tran HM, Verdaguer M, Wiessner R, Yeboah M, Zwaans W and Simons M: Update of the international Hernia Surge guidelines for groin hernia management. BJS Open 2023; 7.
19. Beckers Perletti L, Spoelders F and Berrevoet F: Association between surgical hernia repair techniques and the incidence of seroma: a systematic review and meta-analysis of randomized controlled trials. Hernia 2021; 26: 3–15.
20. Jiao Y, Li C, Li S, Liu X, Yu S, Liu X, Li Y, Wang F, Tang J and Wang L: Hernia mesh with biomechanical and mesh–tissue interface dual compliance for scarless abdominal wall reconstruction. Adv Funct Mater 2023; 33.
21. Reistrup H, Fonnes S and Rosenberg J: No reason to use mesh in groin hernia repair in adolescents. J Abdom Wall Surg 2024; 2: 12336.
22. Coelho R, Dhanani NH, Lyons NB, Bernardi K, Askenasy EP, Millas S, Holihan JL, Ali Z and Liang MK: Hernia prevention using biologic mesh and/or small bites: A multispecialty 2 × 2 factorial randomized controlled trial. J Am Coll Surg 2023; 237: 309–17.
23. Mack J, Hyde GA, Giles WH and Stanley JD: Robotic repair of a symptomatic perineal hernia with self-fixating synthetic mesh. Am Surg 2022; 88: 2223–4.
24. Corduas F, Lamprou DA and Mancuso E: Next-generation surgical meshes for drug delivery and tissue engineering applications: materials, design and emerging manufacturing technologies. Biodes Manuf 2021; 4: 278–310.
25. Bokhari N, Yasmeen A, Ali A, Khalid H, Wang R, Bashir M and Sharif F: Silk meshes coated with chitosan-bioactive phytochemicals activate wound healing genes in vitro. Macromol Biosci 2023; 23: 2300039.
26. Sivaraj D, Henn D, Fischer KS, Kim TS, Black CK, Lin JQ, Barrera JA, Leeolou MC, Makarewicz NS, Chen K, Perrault DP, Gurtner GC, Lee GK and Nazerali R: Reinforced biologic mesh reduces postoperative complications compared to biologic mesh after ventral hernia repair. Plast Reconstr Surg Glob Open 2022; 10: 4083.
27. Greco Lucchina A, Koleva Radica M, Costa AL, Mortellaro C, Soliani G and Zavan B: Mesh-tissue integration of synthetic and biologic meshes in wall surgery: brief state of art. Eur Rev Med Pharmacol Sci 2022; 26: 21–5.
28. Tao Y, Han JG and Wang ZJ: Comparison of perineal morbidity between biologic mesh reconstruction and primary closure following extralevator abdominoperineal excision: a systematic review and meta-analysis. Int J Colorectal Dis 2021; 36: 893–902.
29. Goetz M, Jurczyk M, Junger H, Schlitt HJ, Brunner SM and Brennfleck FW: Semiresorbable biologic hybrid meshes for ventral abdominal hernia repair in potentially contaminated settings: lower risk of recurrence. Updates Surg 2022; 74: 1995–2001.
30. Saha T, Sarker SR, Dekiwadia C, Padhye R, Wang X and Houshyar S: A biocompatible dual-sided hernia mesh with side-specific properties. Adv Mater Technol 2023; 8.
31. Maskal SM, Ellis RC, Mali O, Lau B, Messer N, Zheng X, Miller BT, Petro CC, Prabhu AS, Rosen MJ and Beffa LRA: Long-term mesh-related complications from minimally invasive intraperitoneal onlay mesh for small to medium-sized ventral hernias. Surg Endosc 2024; 38: 2019–26.
32. Abdulagatov IM, Ragimov RM, Khamidov MA, Maksumova AM and Abdullaeva NM: ALD coated polypropylene hernia meshes for prevention of mesh-related post-surgery complications: an experimental study in animals. Biomed Mater 2021; 17.
33. Wagner V, Levy BE, Castle JT, Plymale M, Roth JS and Totten C: Absorbable mesh in a contaminated field: hernia repair outcomes. Updates Surg 2022; 75: 1337–42.
34. Grossi JVM, Martins de Oliveira FM, Parra-Davila E, Ballecer C and Cavazzola LT: Robotic-assisted onlay technique: new approach using anterior mesh positioning in ventral hernia repair-an easy way to spread robotic surgery. Robot Surg 2021; 15: 971–4.
35. Pahwa HS: Current trends in laparoscopic groin hernia repair: A review. World J Clin Cases 2015; 3: 789.
36. Almutairi H, Alshammari RS, Alharbi MJ, Althobaiti DM, Alghamdi RS, Alsamiri S, Mawash SW, Ahmed DA, Alamoudi AA, Arif FY, Albrahim FM, Alfehaid M and Alanzy HW: Laparoscopic management of inguinal hernia: A systematic review and updated network meta-analysis of randomized controlled trials. Cureus 2024; 16: 54192.
37. Ozel Y and Kara YB: Comparison of clinical outcomes of laparoscopic totally extraperitoneal (TEP) and transabdominal preperitoneal (TAPP) techniques in bilateral inguinal hernia repair: A retrospective study. Cureus 2024; 16: 69134.
38. Gallyamov EA, Agapov MA, Busyrev YB, Kakotkin VV, Kubyshkin VA, Donchenko KA, Gadlevskiy GS and Wu Z: Outcomes of various techniques of mesh prosthesis fixation in laparoscopic hernia repair. Khirurgiia (Mosc) 2021; 34–41.
39. Brucchi F, Ferraina F, Masci E, Ferrara D, Bottero L and Faillace GG: Standardization and learning curve in laparoscopic hernia repair: experience of a high-volume center. BMC Surg 2023; 23.
40. Nakae A, Kodama M, Kobayashi E, Hashimoto K, Tominaga Y and Kimura T: Benefits of laparoscopic surgery for bleeding events in patients with implantable left ventricular assist devices during antithrombotic therapy. Gynecol Minim Invasive Ther 2022; 11: 110–3.
41. Pang NQ, Ng CSY and Wong CJH: Laparoscopic versus open groin hernia repair in older adults: a systematic review and meta-analysis. ANZ J Surg 2022; 92: 2457–63.
42. Solaini L, Cavaliere D, Avanzolini A, Rocco G and Ercolani G: Robotic versus laparoscopic inguinal hernia repair: an updated systematic review and meta-analysis. J Robot Surg 2021; 16: 775–81.
43. Dhanani NH, Lyons NB, Olavarria OA, Bernardi K, Holihan JL, Shah SK, Wilson TD, Loor MM, Kao LS and Liang MK: Robotic versus laparoscopic ventral hernia repair: Two-year results from a prospective, multicenter, blinded randomized clinical trial. Ann Surg 2023; 278: 161–5.
44. Li J: Comment on: association between surgical hernia repair techniques and the incidence of seroma. Hernia 2022; 26: 1215–6.
45. Liu N, Stalter LN, Fletcher EL and Lidor AO: Laparoscopic transabdominal vs. totally extraperitoneal

inguinal hernia repair: outcomes, healthcare utilization, and cost differences. SurgEndosc 2024; 39: 319–26.
46. Helgstrand F, Rietz G, Törnqvist B, Lambrecht JR, Gaupset R, Rautio T and Vironen J: Robotic assisted hernia repair in four Nordic countries - status and challenges. J Abdom Wall Surg 2024; 3.
47. Peñafiel JAR, Valladares G, Cyntia Lima Fonseca Rodrigues A, Avelino P, Amorim L, Teixeira L, Brandao G and Rosa F: Robotic-assisted versus laparoscopic incisional hernia repair: a systematic review and meta-analysis. Hernia 2023; 28: 321–32.
48. Elissavet S, Ioannis G, Panagiotis P, Konstantinos M and Apostolos K: Robotic-assisted versus laparoscopic paraesophageal hernia repair: a systematic review and meta-analysis. J Minim Invasive Surg 2023; 26: 134–45.
49. Plitzko GA, Stüben B-O, Giannou A, Reeh M, Izbicki JR, Melling N and Tachezy M: Robotic-assisted repair of incisional hernia-early experiences of a university robotic hernia program and comparison with open and minimally invasive sublay technique (eMILOS). Langenbecks Arch Surg 2023; 408: 396.
50. Ma L, Luo H, Kou S, Gao Z, Bai D, Qin X, Ouchi T, Gong L, Hu J and Tian Y: Robotic versus laparoscopic surgery for hiatal hernia repair: a systematic literature review and meta-analysis. J Robot Surg 2023; 17: 1879–90.
51. Lekarczyk A, Sinha H, Dvir D, Goyert J, Airhart A, Reddy RM. Similar hospital profits with robotic-assisted paraesophageal hiatal hernia repair, despite higher or supply costs. Surg Endosc 2022; 37: 3952–5.
52. Vitiello A, Abu Abeid A, Peltrini R, Ferraro L, Formisano G, Bianchi PP, Del Giudice R, Taglietti L, Celentano V, Berardi G, Bracale U and Musella M: Minimally invasive repair of recurrent inguinal hernia: Multi-institutional retrospective comparison of robotic versus laparoscopic surgery. J Laparoendo Adv Surg Tech A 2022; 33: 69–73.
53. Bigolin AV, Fonseca MK, Grossi J, Iaroseski J and Cavazzola LT: Robotic repair of post-oesophagectomy hiatal hernia. Ann R Coll Surg Engl 2021; 104: 171–3.
54. Amundson JR, Attaar M, Forester B, Francis S, Kuchta K, Denham W, Linn J, Ujiki MB and Haggerty SP: Laparoscopic and robotic inguinal hernia repair are safe and effective after prior pelvic or low abdominal surgery. Am J Surg 2022; 225: 252–7.
55. Qabbani A, Aboumarzouk OM, ElBakry T, Al-Ansari A and Elakkad MS: Robotic inguinal hernia repair: systematic review and meta-analysis. ANZ J Surg 2021; 91: 2277–87.
56. Dewulf M, Aspeslagh L, Nachtergaele F, Pletinckx P and Muysoms F: Robotic-assisted laparoscopic inguinal hernia repair after previous transabdominal prostatectomy. Surg Endosc 2021; 36: 2105–12.
57. Saito T, Fukami Y, Kurahashi S, Yasui K, Uchino T, Matsumura T, Osawa T, Komatsu S, Kaneko K and Sano T: Current status and future perspectives of robotic inguinal hernia repair. Surg Today 2021; 52: 1395–404.
58. Warren JA, Blackhurst D, Ewing JA, Carbonell AM. Open versus robotic retromuscular ventral hernia repair: outcomes of the ORREO prospective randomized controlled trial. Surg Endosc 2024; 38: 7466–74.
59. Hu Q, Wu J, Zhang H, Dong W, Gu Y and Liu S: Designing double-layer multimaterial composite patch scaffold with adhesion resistance for hernia repair. Macromol Biosci 2022; 22: 2100510.
60. Wang Y, Jing W, Huang Y, Wei P, Ma S, Yuan Z and Zhao B: Biodegradable all-natural hydrogel–mesh composite for wet tissues adhesion and infected wound healing. Mater Des 2024; 241: 112902.
61. Ditzel M, Deerenberg EB, Grotenhuis N, Harlaar JJ, Monkhorst K, Bastiaansen-Jenniskens YM, Jeekel J, Lange JF. Biologic meshes are not superior to synthetic meshes in ventral hernia repair: an experimental study with long-term follow-up evaluation. Surg Endosc 2013; 27: 3654–62.
62. Bokhari N, Ali A, Yasmeen A, Khan R, Haider S and Sharif F: Fabrication of bioactive silk composite meshes for hernia repair and guided soft tissue remodeling: *In-silico*, *in-vitro* and *in-vivo* models. Appl Mater Today 2024; 38: 102261.
63. Dufay M, Jimenez M, Casetta M, Chai F, Blanchemain N, Maton M, Cazaux F, Bellayer S and Degoutin S: Abdominal PP meshes coated with functional core-sheath biodegradable nanofibers with anticoagulant and antibacterial properties. Biomater Adv 2025; 169: 214163.
64. Zeinali R, Del Valle LJ, Torras J and Puiggalí J: Recent progress on biodegradable tissue engineering scaffolds prepared by thermally-induced phase separation (TIPS). Int J Mol Sci 2021; 22.
65. Clapp B, Kara AM, Nguyen-Lee PJ, Annabi HM, Alvarado L, Marr JD, Ghanem OM and Davis B: Does bioabsorbable mesh reduce hiatal hernia recurrence rates? A meta-analysis. Surg Endosc 2022; 37: 2295–303.
66. Najm A, Niculescu AG, Gaspar BS, Grumezescu AM and Beuran M: A review of abdominal meshes for hernia repair current status and emerging solutions. Materials (Basel) 2023; 16: 7124.
67. Cunha MNB da, Rynkevic R, Silva MET da, Moreira da Silva Brandão AF, Alves JL and Fernandes AA: Melt electrospinning writing of mesh implants for pelvic organ prolapse repair. 3D Print Addit Manuf 2022; 9: 389–98.
68. Gonzalez Matheus I and Phua Y: Three-dimensional printed Polycaprolactone mesh in pediatric cranial vault remodeling surgery. J Craniofac Surg 2023; 34: 1403–6.
69. Xu W, Gao X, Zhang M, Jiang Z, Xu X, Huang L, Yao H, Zhang Y, Tong X, Li Y, Lin J, Wen C and Ding X: Electrospun polycaprolactone-chitosan nanofibers on a zinc mesh as biodegradable guided bone-regeneration membranes with enhanced mechanical, antibacterial, and osteogenic properties for alveolar bone-repair applications. Acta Biomater 2024; 187: 434–50.
70. MacCraith E, Joyce M, do Amaral RJFC, O'Brien FJ and Davis NF: Development and *in-vitro* investigation of a biodegradable mesh for the treatment of stress urinary incontinence. Int Urogynecol J 2022; 33: 2177–84.
71. Sivaraj D, Henn D, Fischer KS, Kim TS, Black CK, Lin JQ, Barrera JA, Leeolou MC, Makarewicz NS, Chen K, Perrault DP, Gurtner GC, Lee GK and Nazerali R: Reinforced biologic mesh reduces postoperative complications compared to biologic mesh after ventral hernia repair. Plast Reconstr Surg Glob Open 2022; 10: 4083.
72. Luan F, Cao W, Cao C, Li B, Shi X and Gao C: Construction and properties of the silk fibroin and polypropylene composite biological mesh for abdominal incisional hernia repair. Front Bioeng Biotechnol 2022; 10: 949917.
73. Finch D, Mehmood S and Varghese J: Abdominal wall reconstruction using biosynthetic absorbable mesh in high-risk complex ventral hernia. Swiss Med Wkly 2021; 151: 20449.
74. Semen G, Ulyana C, Elisaveta P, Alina L, Alexander M, Alexey G and Evgeny B: Single-channel and multi-channel electrospinning for the fabrication of PLA/PCL tissue engineering scaffolds: comparative study of the

materials physicochemical and biological properties. arXiv [q-BioTO] 2024.
75. Bloemendaal ALA: Robotic retromuscular (recurrent) parastomal hernia repair (r-Pauli-repair) with synthetically reinforced biological mesh; Technique, early experience, and short-term follow-up. J Abdom Wall Surg 2023; 2.
76. Zaheer Ahmad N, Abbas MH, Al-Naimi NMAB, Parvaiz A. Meta-analysis of biological mesh reconstruction versus primary perineal closure after abdominoperineal excision of rectal cancer. Int J Colorectal Dis 2021; 36: 477–92.
77. Mäkäräinen EJ, Wiik HT, Kössi JAO, Pinta TM, Mäntymäki L-MJ, Mattila AK, Kairaluoma MVJ, Ohtonen PP and Rautio TT: Synthetic mesh versus biological mesh to prevent incisional hernia after loop-ileostomy closure: a randomized feasibility trial. BMC Surg 2023; 23.
78. Drissi F, Rogier-Mouzelas F, Fernandez Arias S, Podevin J and Meurette G: Moving from laparoscopic synthetic mesh to robotic biological mesh for ventral rectopexy: Results from a case series. J Clin Med 2023; 12.
79. Saiding Q, Chen Y, Wang J, Pereira CL, Sarmento B, Cui W and Chen X: Abdominal wall hernia repair: from prosthetic meshes to smart materials. Mater Today Bio 2023; 21: 100691.
80. Miserez M, Lefering R, Famiglietti F, Mathes T, Seidel D, Sauerland S, Korolija D, Heiss M, Weber G, Agresta F, Steup W-H, Śmietański M, Ribeiro R, Cuccurullo D, Catena F, Rudroff C, Rosanelli G, Schön F, Smet B, Wenger F, Saad S, Naver L and Neugebauer E: Synthetic versus biological mesh in laparoscopic and open ventral hernia repair (LAPSIS): Results of a multinational, randomized, controlled, and double-blind trial. Ann Surg 2021; 273: 57–65.
81. Olanrewaju OA, Saleem A, Ansah Owusu F, Pavani P, Ram R and Varrassi G: Contemporary approaches to hernia repair: A narrative review in general surgery. Cureus 2023; 15: 51421.
82. Grillo A, Hyder Z, Mudera V and Kureshi A: *In-vitro* characterisation of low-cost synthetic meshes intended for hernia repair in the UK. Hernia 2022; 26: 325–34.
83. Owei L, Swendiman RA, Torres-Landa S, Dempsey DT and Dumon KR: Impact of body mass index on minimally invasive ventral hernia repair: an ACS-NSQIP analysis. Hernia 2019; 23: 899–907.
84. Glanzer R, O'Neil B and Turaihi H: Pararectal hernia: literature review and surgical repair techniques in the era of robotic surgery. J Surg Case Rep 2021; 2021: 378.
85. Ergenç M and Gülşen T: Laparoscopic inguinal hernia repair: A comparison of transabdominal preperitoneal and total extraperitoneal techniques Results of initial experiences. Int J Abdom Wall Hernia Surg 2023; 6: 166–70.
86. Qabbani A, Aboumarzouk OM, ElBakry T, Al-Ansari A, Elakkad MS. Robotic inguinal hernia repair: systematic review and meta-analysis. ANZ J Surg 2021; 91: 2277–87.
87. Schubert A, Ramos MG. Robotic assisted transabdominal preperitoneal approach for repair of Morgagni hernia in elderly female. J Surg Case Rep 2023; 2023: 486.
88. Khan Z, Krishna D, Daga S, Rastogih N, Rekha M and Patel K: Advancements in minimally invasive surgery: A comprehensive analysis of robotic surgery, endoscopic techniques, and natural orifice translumenal endoscopic surgery. Georgian Med News 2023; 87–92.
89. Xu TQ and Higgins RM: The minimally invasive inguinal hernia: Current trends and considerations. Surg Clin North Am 2023; 103: 875–87.
90. Tazeoğlu D, Benli S, Tikici D, Esmer AC and Dirlik MM: Can minimally invasive surgical techniques reduce the incidence of postoperative adhesions? Pol Przegl Chir 2022; 94: 23–30.
91. Madion M, Goldblatt MI, Gould JC and Higgins RM: Ten-year trends in minimally invasive hernia repair: a NSQIP database review. Surg Endosc 2021; 35: 7200–8.
92. Crepaz L, Sartori A, Podda M, Ortenzi M, Di Leo A, Stabilini C, Carlucci M and Olmi S: SICE/ISHAWS collaborative group. Minimally invasive approach to incisional hernia in elective and emergency surgery: a SICE (Italian Society of Endoscopic Surgery and new technologies) and ISHAWS (Italian Society of Hernia and Abdominal Wall Surgery) online survey. Updates Surg 2023; 75: 1671–80.
93. Cheverie JN, Neki K, Lee AM, Li JZ, Dominguez-Profeta R, Matsuzaki T, Broderick RC, Jacobsen GR, Sandler BJ and Horgan S: Minimally invasive paraesophageal hernia repair in the elderly: Is age really just a number? J Laparoendosc Adv Surg Tech A 2021; 32: 111–7.
94. Li H, Cao X and Kong L: Case report: Obturator hernia: Diagnosis and surgical treatment. Front Surg 2023; 10.
95. Yadav T, Rajagopal R. Functional assessment with fetal cardiac MRI in congenital diaphragmatic hernia. Radiology 2021; 302: 275.
96. Wu WT, Chang KV, Lin CP, Yeh CC and Özçakar L: Ultrasound imaging for inguinal hernia: a pictorial review. Ultrasonography 2022; 41: 610–23.
97. Johnson KN, Criss CN, Hirschl RB, Ladino-Torres M, Yang D and Jarboe MD: Ultrasound-guided pediatric inguinal hernia repair. J Pediatr Surg 2021; 56: 1240–5.
98. Adams ST, Slade D, Shuttleworth P, West C, Scott M, Benson A, Tokala A, Walsh CJ. Reading a preoperative CT scan to guide complex abdominal wall reconstructive surgery. Hernia 2022; 27: 265–72.
99. Elhage SA, Kao AM, Katzen M, Shao JM, Prasad T, Augenstein VA, Heniford BT and Colavita PD: Outcomes and CT scan three-dimensional volumetric analysis of emergent paraesophageal hernia repairs: predicting patients who will require emergent repair. Surg Endosc 2021; 36: 1650–6.
100. Emam D, Aertsen M, Van der Veeken L, Fidon L, Patkee P, Kyriakopoulou V, De Catte L, Russo F, Demaerel P, Vercauteren T, Rutherford M and Deprest J: Longitudinal MRI evaluation of brain development in fetuses with congenital diaphragmatic hernia around the time of fetal endotracheal occlusion. AJNR Am J Neuroradiol 2023; 44: 205–11.
101. Ilicak E, Thater G, Ozdemir S, Zapp J, Schad LR, Schoenberg SO, Zöllner FG and Weis M: Functional lung imaging of 2-year-old children after congenital diaphragmatic hernia repair using dynamic mode decomposition MRI. Eur Radiol 2023; 34: 3761–72.
102. Vassalou EE, Vardas K, Dimitriadis E and Perysinakis I: The role of imaging in the pre- and postoperative evaluation of inguinal hernia. J Ultrasound Med 2023; 42: 2425–38.
103. Zang C, Turkcan MK, Narasimhan S, Cao Y, Yarali K, Xiang Z, Szot S, Ahmad F, Choksi S, Bitner DP, Filicori F and Kostic Z: Surgical phase recognition in inguinal hernia repair-AI-based confirmatory baseline and exploration of competitive models. Bioengineering (Basel) 2023; 10. https://doi.org/10.3390/bioengineering10060654.
104. Soare AM, Cârţu D, Nechita SL, Andronic O and Șurlin V: Complications of intraperitoneal mesh techniques for incisional hernia - A systematic review. Chirurgia (Bucur) 2021; 116: 36–42.
105. Bontekoning N, Huizing NJ, Timmer AS, Groenen H, de Jonge SW and Boermeester MA: Topical antimicrobial

treatment of mesh for the reduction of surgical site infections after hernia repair: a systematic review and meta-analysis. Hernia 2024; 28: 691–700.
106. Widder A, Reese L, Lock JF, Wiegering A, Germer CT, Kindl GK, Rittner HL, Dietz U, Doerfer J, Schlegel N and Meir M: Postoperative analgesics score as a predictor of chronic postoperative inguinal pain after inguinal hernia repair: Lessons learned from a retrospective analysis. World J Surg 2023; 47: 2436–43.
107. Fowler B and Hughes D: Infection and recurrence rates in rural inguinal hernia repair. Kans J Med 2023; 16: 65–8.
108. Whittaker R, Lewis Z, Plymale MA, Nisiewicz M, Ebunoluwa A, Davenport DL, Reynolds JK and Roth JS: Emergent and urgent ventral hernia repair: comparing recurrence rates amongst procedures utilizing mesh versus no mesh. Surg Endosc 2022; 36: 7731–7.
109. Weyhe D, Tabriz N, Sahlmann B and Uslar VN: Risk factors for perioperative complications in inguinal hernia repair - a systematic review. Innov Surg Sci 2017; 2: 47–52.
110. Sapiyeva ST, Abatov NT, Aliyakparov MT, Badyrov RM, Yoshihiro N, Brizitskaya LV, Yesniyazov DK and Yukhnevich YA: Non-mesh inguinal hernia repair: Review. Asian J Surg 2024; 47: 4669–73.
111. da Silveira CAB, Rasador AC, Lima DL, Kasmirski J, Kasakewitch JPG, Nogueira R, Malcher F and Sreeramoju P: The impact of smoking on ventral and inguinal hernia repair: a systematic review and meta-analysis. Hernia 2024; 28: 2079–95.
112. Sæter AH, Fonnes S, Li S, Rosenberg J and Andresen K: Mesh versus non-mesh for emergency groin hernia repair. Cochrane Database Syst Rev 2023; 11: 015160.
113. Rogers MP, Velanovich V and DuCoin C: Narrative review of management controversies for paraesophageal hernia. J Thorac Dis 2021; 13: 4476–83.
114. Gong JH, Bajaj A, Lin Y, Luhrs A and Giorgi M: Implications of declining medicare reimbursement of hernia repair for surgeons and patients. Am J Surg 2023; 226: 291–3.
115. Koszalinski RS, Khojandi A and Ramshaw B: Improving shared decision-making and treatment planning through predictive modeling: Clinical insights on ventral hernia repair. Comput Inform Nurs 2020; 38: 227–31.
116. Kushner B, Holden T, Politi M, Blatnik J and Holden S: A practical guideline for the implementation of shared decision-making in complex ventral incisional hernia repair. J Surg Res 2020; 259: 387–92.
117. Croghan SM, Mohan HM, Breen KJ, McGovern R, Bennett KE, Boland MR, Elhadi M, Elliott JA, Fullard AC, Lonergan PE, McDermott F, Mehraj A, Pata F, Quinlan DM, Winter DC, Bolger JC, Fleming CA and Retainer I: Study Group of the Irish Surgical Research Collaborative. Global incidence and risk factors associated with postoperative urinary retention following elective inguinal hernia repair: The retention of Urine After Inguinal Hernia Elective Repair (RETAINER I) study. JAMA Surg 2023; 158: 865–73.
118. Hernandez A and Petersen R: Laparoscopic ventral hernia repair. Surg Clin North Am 2023; 103: 947–60.
119. Adeghe EP, Okolo CA and Ojeyinka OT: The influence of patient-reported outcome measures on healthcare delivery: A review of methodologies and applications. Open Access Res J Biol Pharm 2024; 10: 013–21.
120. Churruca K, Pomare C, Ellis LA, Long JC, Henderson SB, Murphy LED, Leahy CJ and Braithwaite J: Patient-reported outcome measures (PROMs): A review of generic and condition-specific measures and a discussion of trends and issues. Health Expect 2021; 24: 1015–24.
121. Anoldo P, Manigrasso M, D'Amore A, Musella M, De Palma GD and Milone M: Abdominal wall hernias-state of the art of laparoscopic versus robotic surgery. J Pers Med 2024; 14.
122. Gofin Y and Scott DA: Evidence-based genetic testing for individuals with congenital diaphragmatic hernia. J Pediatr 2022; 248: 13–4.
123. Hanna NM, Kumar SS, Collings AT, Pandya YK, Kurtz J, Kooragayala K, Barber MW, Paranyak M, Kurian M, Chiu J, Abou-Setta A, Ansari MT, Slater BJ, Kohn GP and Daly S: Management of symptomatic, asymptomatic, and recurrent hiatal hernia: a systematic review and meta-analysis. Surg Endosc 2024; 38: 2917–38.
124. Wang G, Liu Q, Chen G, Xia B, Zeng D, Chen G and Guo C: AI's deep dive into complex pediatric inguinal hernia issues: a challenge to traditional guidelines? Hernia 2023; 27: 1587–99.

How to cite this article:
Rajesh S, Akash R, Deepa S and Kumar KS: Modern solutions for hernia repair: a review of mesh innovations and emerging surgical trends. Int J Pharm Sci & Res 2025; 16(6): 1494-18. doi: 10.13040/IJPSR.0975-8232.16(6).1494-18.