ECRONICON OPEN ACCESS

EC GASTROENTEROLOGY AND DIGESTIVE SYSTEM

Review Article

Inguinal Hernias: A Comparison of Surgical Options and Preventive Measures

Nicholas A Kerna[1,2]*, ND Victor Carsrud[3], Uzoamaka Nwokorie[4], Joseph Anderson II[5], Lawrence U Akabike[6], Hilary M Holets[7,8], Kevin D Pruitt[9,10], Sahalia Rashid[11] and Emmanueall O Solomon[12]

[1]*SMC–Medical Research, Thailand*

[2]*First InterHealth Group, Thailand*

[3]*Lakeline Wellness Center, USA*

[4]*University of Washington, USA*

[5]*International Institute of Original Medicine, USA*

[6]*Larrico Enterprises, LLC, USA*

[7]*Beverly Hills Wellness Surgical Institute, USA*

[8]*Orange Partners Surgicenter, USA*

[9]*Kemet Medical Consultants, USA*

[10]*PBJ Medical Associates, USA*

[11]*All Saints University School of Medicine, Dominica*

[12]*Obafemi Awolowo University, Nigeria*

***Corresponding Author:** Nicholas A Kerna, (mailing address) POB47 Phatphong, Suriwongse Road, Bangkok, Thailand 10500. Contact: medpublab+drkerna@gmail.com.

Received: June 24, 2021; **Published:** July 24, 2021

DOI: 10.31080/ecgds.2021.08.00793

Abstract

Inguinal hernia is frequently diagnosed by clinical exam. Imaging tests are recommended in the absence of definitive signs or associated symptoms that indicate complications. Ultrasonography (US) is the most common method used for examination of the various types of hernias. Inguinal hernias are the most prevalent type of hernia. US (grayscale or color Doppler ultrasonography) is suggested for examining inguinal hernias. CT is used to differentiate inguinal and femoral hernia based on the correlation between the hernia sac and pubic tubercle. Magnetic resonance imaging (MRI) is favored for diagnosing occult inguinal hernias when there are constraints associated with US and computed tomography (CT); or a lack of definitive diagnostic results.

Inguinal hernia is an acquired or congenital condition wherein the abdominal cavity contents protrude into the inguinal canal. In men, the testes migrate from the abdomen into the scrotum through the inguinal canal. Thus, men (more than women) are more likely to develop an indirect inguinal hernia. An indirect hernia can occur congenitally. Indirect inguinal hernias present on the lateral side of the Hesselbach triangle and enter the inguinal canal through the deep or internal inguinal ring. Direct inguinal hernias constitute inguinal hernias that protrude through the Hesselbach triangle, remaining medial and caudal to the inguinal canal's origin at the internal inguinal ring. These hernias are common in older males and carry a lower risk of strangulation. The characteristic sign of a direct hernia on CT is a lateral fat crescent.

Developing biologically advanced meshes are part of ongoing hernia treatment and management research. Recently, a novel type of mesh has been developed that releases drugs. Also, "smart biomaterials"—that change shape—are being studied and tested for applications in hernia repair. Conservative management relies on reducing the hernia and applying a belt. Hernia belts or trusses are ordinarily used today as a temporary measure to relieve pain and discomfort. Surgical management is one of the most routine surgeries performed globally. Surgical repair and watchful waiting are generally recommended in asymptomatic or minimally symptomatic patients. Currently, the application of mesh is preferred to direct suturing. There are various types of mesh and corresponding procedures based on the mesh choice and degree, and type of herniation. Complications of surgery include death, infertility, and recurrence—placing limitations for surgical repair.

Keywords: *Hernia Belt; Laparoscopic Repair; Male Infertility; Mesh; Pinchcock; Valsalva Maneuver*

Abbreviations

CT: Computed Tomography; ePTFE: Expanded Polytetrafluoroethylene; NHANES: National Health and Nutrition Examination Survey; PE: Polyester; PP: Polypropylene; SSI: Surgical Site Infection; TAPP: Transabdominal Preperitoneal Procedure; TEP: Total Extraperitoneal Procedure; US: Ultrasonography

Introduction

Inguinal hernia is an acquired or congenital condition in which the abdominal cavity contents protrude into the inguinal canal. Inguinal hernias are classified into three types: direct, indirect, and combined inguinal hernia. In a direct inguinal hernia, the abdominal contents protrude through the external inguinal ring, medial to the inferior epigastric vessels. In an indirect inguinal hernia, the contents protrude through the deep inguinal ring, lateral to the inferior epigastric vessels [1]. Moreover, the hernia sacs are on both sides of the inferior epigastric vessels [2].

History

The term "hernia" is derived from the Greek word "hernios," meaning "bud" or "sprout" [3]. The ancient Egyptians were aware of hernias as early as 1500 BCE. Hernias have been managed using a variety of surgical procedures and instruments for centuries. The followers of Hippocratic medicine were able to differentiate hernia from hydrocele [4].

It is thought that the Egyptian pharaohs repaired hernias. Several mummies show evidence of hernia repair. In ancient times, Alexandrians and Greeks who had inguinal hernias were treated using bandages placed over the groin area. Hippocrates used the term "etru rhexis," meaning "rupture of the abdominal wall". He also mentioned hernias in the pubic and inguinal areas. In the event of a sac rupture, Hippocrates recommended using a "Golden Ligature" [5].

Marcy was the first surgeon to attempt to reduce the hernial orifice in 1871. In 1889, Bassini became the first surgeon to repair the posterior wall of the inguinal canal. In 1890, he introduced tactical surgical principles to repair the posterior wall of the inguinal canal to reduce the internal inguinal ring [6]. Before Bassini's procedure, surgeons used the Czerny procedure, which involved repairing the anterior wall of the groin. The patients who were treated by this surgical procedure had a 100% recurrence rate. The function of fascia transversalis was discovered during 1942–1945, and Shouldice, McVay, and Anson further improved Bassini's technique [7]. Shouldice made inguinal hernia surgeries a daycare (outpatient) procedure by introducing local anesthesia. The end of the 19th century is known as the "era of prosthetic repair [3]".

Ger was the first surgeon to perform a laparoscopic hernia repair in 1982. He closed the peritoneal opening with "herniostat" staples. He did not dissect or ligate the sac, nor did he reduce it. Bogojavalensky later used prosthetic material (polypropylene mesh) to treat indirect hernias in females in 1989. He completed the surgery by suturing the hernia sac [8].

Discussion

Presentation, signs, and symptoms

The most common symptom of an inguinal hernia is groin pain or swelling. These symptoms are mild intermittent, or moderately severe, can be associated with physical activities and can adversely affect daily activities. The abdominal contents usually can be reduced into the cavity from the hernia sac, but in non-reducible conditions, strangulation or ileus can occur.

A reducible mass in the groin with cough impulse is a classic symptom of inguinal hernia. Strangulation of the herniated contents causes tenderness, inflammation, and irreducibility. Acute complications are common in older patients and patients who have had an irreducible hernia for a longer time [9].

For clinical diagnosis, a physical examination must be performed while the patient is standing. Bilateral asymmetries must be ruled out first. The patient should be asked to strain down (Valsalva maneuver) while the physician checks for bulges. Palpation must proceed from the scrotum to the internal inguinal ring—beginning at the spermatic cord and moving upward to the external inguinal ring (lying medial to and just below the pubic tubercle). While palpating the internal inguinal ring, the surgeon asks the patient to cough or perform a Valsalva maneuver. The examining physician feels a bulge that moves in and out with the cough impulse if a hernia is present [10,11].

It is essential to differentiate inguinal hernia from conditions with similar clinical manifestations, such as saphena varix, femoral hernia, hydrocele, lymphoma, testicular torsion, and femoral artery aneurysm.

Incidence and prevalence

Men (27%) have a higher lifetime risk of developing an inguinal hernia than women (3%), and the incidence increases with age [12]. A hernia occurs in women at a later age than in men. It commonly occurs on the right side. The prevalence of hernia increases with varicose veins, prostate hypertrophy, hemorrhoids, and lean body mass [13].

Inguinal hernias are more common in developed countries than in developing countries. A large retrospective study, published in 2013, analyzed a 20-year data set from Minnesota (USA), revealing a hernia repair rate of 217 per 100,000 person-years [14]. On the other hand, as per the National Health and Nutrition Examination Survey (NHANES) study considering low- and middle-income countries, the prevalence of inguinal hernia was lower in Tanzania (244 per 100,000 population) [15] compared to that of the USA (315 per 100,000 person-years) [16].

Inguinal hernias are most common in the world's sub-Saharan African and Western Pacific regions [17]. The majority of studies consider data generated during hernia surgery, resulting in an exaggeration of the actual prevalence. Furthermore, geographical differences exist as a result of surgeons' differing perspectives regarding the best treatment options. A study by Primatesta., *et al*. (1996) supports this observation, which compared data from the USA and the UK [18]. Although inguinal hernia surgery is one of the most frequently performed procedures, there are no pooled data to estimate the exact prevalence. Moreover, chronic cough, heavy weight lifting, smoking, bowel disturbances, and pregnancy are risk factors for inguinal hernia [19].

Pathophysiology

In men, testes migrate from the abdomen into the scrotum through the inguinal canal (deep ring). The canal is more prominent in males (than females), allowing easy passage of abdominal organs. Therefore, men are more likely to develop an indirect inguinal hernia. An indirect hernia often occurs congenitally if the processus vaginalis does not stop after the migration of testes into the scrotum. Generally, due to the pinchcock action of the internal ring musculature, the intestine does not pass the patent processus. However, muscle paralysis or injury, flattening of transversus abdominis aponeurosis due to exercise, higher position of the aponeurotic arch, post-appendectomy and femoral vascular procedures, and surgical procedures involving lower midline abdominal incisions are risk factors for hernia in men [2].

In normal conditions, the abdominal cavity has a 2–20 mm Hg pressure, which can rise to 150 mm Hg during coughing and vomiting. Despite the increased pressure, equilibrium is maintained since the abdominal wall counters it. Failure of this counter-mechanism in specific physiologic or pathologic conditions results in hernia [20,21].

Inguinal hernias that protrude through the Hesselbach triangle and remain medial and caudal to the inguinal canal's origin at the internal inguinal ring are known as direct inguinal hernias. These hernias are common in older males and have a lower risk of strangulation. The characteristic sign of a direct hernia on computed tomography (CT) is a lateral fat crescent, which appears when the typical fat of the inguinal canal is pushed outward, forming a semicircle that resembles a crescent shape [22].

Indirect inguinal hernias occur on the lateral side of the Hesselbach triangle and enter the inguinal canal through the deep or internal inguinal ring. In males, the hernias remain anterior to the spermatic cord, whereas females follow the round ligament into the labia majora [23]. Inguinal hernias of this type are most frequent [24].

Diagnosis

An inguinal hernia is often diagnosed by clinical examination. Imaging tests are recommended in the absence of conclusive signs or the presence of associated symptoms that indicate complications. Ultrasonography (US) is the most common method used for examination. It has a sensitivity of 86% and a specificity of 77%. A detailed examination requires a CT scan, which has a sensitivity of 80% and a specificity of 65% [25]. Results from another systemic review have also favored the US; however, the technique is sensitive, and the technician must have a clear understanding of anatomy [26].

Ultrasonography (US)

Grayscale or color Doppler US is recommended for examining inguinal hernias. For a real-time dynamic evaluation, the patient must ideally perform the Valsalva maneuver while the test is in progress [27]. Location of the neck of the hernia, its connection to the inferior epigastric vessels, and the characteristic movement of the sac contents concerning the transducer during provocative maneuvering help differentiate the type of hernia [28]. Another provocative test is allowing the patient to stand for 30 seconds and then measuring the hernia defect. The patient can also be guided to walk for two minutes and then examined while standing before laying supine [29].

The physician must be aware of the conditions that can lead to a misdiagnosis. Physicians can incorrectly diagnose normal spermatic cord movement as an indirect inguinal hernia and abdominal wall movement as a direct inguinal hernia [28]. Furthermore, the presence of free fluid in the sac, organ edema, and the absence of bowel peristalsis may indicate ischemia. Color and power Doppler US help assess if the contents of the hernia sac are ischemic. The "whirlpool" sign appears when the contents spin on themselves [30].

Computed tomography (CT)

CT is used to differentiate inguinal and femoral hernia based on the relationship between the hernia sac and pubic tubercle (hernia sac remains medial to the pubic tubercle in inguinal hernia) [22]. Furthermore, venous compression is uncommon in inguinal hernias and common in femoral hernias [31]. A CT scan is preferred in a patient if there is tissue fibrosis, obesity, or a contraction of abdominal muscles [29].

Magnetic resonance imaging (MRI)

An MRI is preferred for diagnosing occult inguinal hernias when there are limitations associated with US and CT or a lack of diagnostic results [32].

Management (conservative)

Physicians used various types of customized inguinal belts to retain the hernia sac within the body cavity in earlier times. These procedures included manually reducing the hernia first and then putting the belt on it. Hernia belts or trusses are still used today as a temporary measure to relieve pain and discomfort [33,34]. Previously, the truss was popular in the UK because of the long waiting times

for surgery [9]. It should be noted that prolonged use of hernia belts might result in complications, such as atrophy of the spermatic cord, fusion to the hernial sac, or atrophy of the fascial margins [35].

There is a lack of studies regarding alternative medicine treatment for hernias. Therefore, its role is unknown; however, it can be practiced as palliative therapy. A quasi-experimental study investigated the effect of yoga therapy on non-complicated reversible inguinal hernia. In this study, the patients reported a significant reduction in pain, aggravating factors (exercise, walking, bowel movement, bladder activity, lifting, coughing, and sneezing), and an increase in the relieving factors (sleeping, lying down, and sitting) after three months of the therapy [36].

Management (surgical)

Inguinal hernia repair is one of the most common surgeries performed globally. However, there is no agreement on the exact patient groups that require surgery. About one-third of the patients remain asymptomatic after diagnosed with inguinal hernia. However, patients presenting with symptoms require surgery. Surgical repair and watchful waiting are generally recommended in asymptomatic or minimally symptomatic patients. Fitzgibbons., *et al*. (2006) concluded that keeping a close watch is appropriate, but approximately 40% of femoral hernias present with complications, such as incarceration or strangulation [37].

Such a high complication rate is a cause for concern and necessitates surgical intervention soon after an inguinal hernia is diagnosed [38]. Several clinical trials found previously asymptomatic patients becoming symptomatic after some time [37,39]. According to the literature, nearly 70% of asymptomatic patients require surgery within five years [40,41]. Therefore, it may be appropriate to correct the defect surgically before any complications occur. Moreover, a recurring hernia requires a surgical approach. Different types of surgical interventions are listed in Table 1 (below).

Basis of classification	Type
Surgical approach	• Open • Laparoscopic - TAP/TEPP
Placement of mesh	• Inlay • Onlay • Sublay
Usage of mesh	• Mesh-free • Tension-free

Table 1: *Types of surgical intervention for hernia repair.*

To repair an inguinal hernia, open (Lichtenstein procedure) or laparoscopic procedures are accepted. Both procedures use a mesh to close the abdominal opening. Usher, in 1959, repaired hernias using a non-resorbable polypropylene mesh. The mesh was sutured or attached using tissue glues, tacks, and staples. The advantages of all of these approaches are not universally accepted. Several studies showed that laparoscopic surgery reduces chronic pain, mesh infection, and surgical site infection [42–44], whereas other studies did not find any such benefits [45]. The choice of the optimal method depends on the preferences of the surgeon and patient. Mesh use and proper fixation are likely critical factors that would eventually reduce the complications. There are three distinct techniques to position the mesh [46]:

1. Inlay: Mesh is situated between the edges of the layer of abdominal tissue.

2. Onlay: Mesh is set between the subcutaneous tissue and the anterior rectus sheath.

3. Sublay: Mesh is placed below the rectus muscle on the post-rectus sheath, either between the posterior rectus sheath and the rectus muscle, or between the peritoneum and posterior rectus sheath.

There are two types of laparoscopic repair used for inguinal hernia [11]—the transabdominal preperitoneal procedure (TAPP) and total extraperitoneal procedure (TEP). TAPP involves an intraperitoneal approach and thus is indicated for bilateral hernia repair, significant defects, and recurrences. TEP, as the name suggests, does not involve intraperitoneal penetration. It is a quick and easy procedure but is complicated by a narrow visual field for the operating surgeon.

Laparoscopic repairs have similar recurrence rates to open repairs. Compared to open surgery, the laparoscopic approach has been shown to improve postoperative pain and enable patients to resume normal activities faster. However, laparoscopic repair is associated with higher costs and requires a high technical proficiency. The risk of recurrences is higher if the surgeon is aged 45 years or older and has performed less than 250 laparoscopic inguinal herniorrhaphies [47].

Based on the presence or absence of mesh, there are two types of hernia repair techniques: the conventional mesh-free technique and the tension-free technique using mesh. The conventional technique includes Mayo's surgery involving continuous or single-stitch suture or fascia doubling [7].

Mesh became popular after the inclusion of hernia repair outpatient procedures, particularly after introducing the laparoscopic technique. However, this prosthetic repair is not without side effects. The typical complications are chronic pain, mesh fistulas, and mesh infections [3]. Therefore, the need to develop better prosthetic devices arose. By reducing mesh weight, researchers were able to reduce these complications. It was hypothesized that it would reduce foreign body reactions and thus postoperative pain. Later, composite meshes were added to improve biocompatibility.

Another step forward was the development of meshes that included antibiotics or anti-inflammatory agents. These meshes are used for infected hernias. Biologic meshes derived from porcine or bovine products are indicated [48]. These advances increased the benefits, but they are also associated with increased cost, inherent wound infections, recurrence, graft failure, hematoma, and flap necrosis. There are entirely resorbable meshes available that are composed of vicryl; however, the use of these meshes has a high incidence of recurrences [49].

Various types of mesh

1. **Non-absorbable and synthetic materials:** Polypropylene (PP), polyester (PE), and expanded polytetrafluoroethylene (ePTFE) based meshes. Coated (used outside peritoneal cavity) or uncoated (used intraperitoneally) PP meshes are available. According to a systemic review, PP meshes coated with hyaluronic acid and carboxymethyl cellulose reduced adhesion better than non-coated PP meshes [50]. These meshes are heavy, induce inflammation, cause a thick scar, and shrink. To avoid significant mesh shrinkage, surgeons must measure the surface area to ensure the correct fit. The newer lightweight PP meshes have better compliance than the older versions. If infection occurs, patients can tolerate the effects with the help of appropriate medications, and the mesh does not need to be removed [51].

   PE meshes adapt better to the defect and promote tissue growth. These meshes are superior to PP meshes in terms of inflammation and foreign body reactions [52]. PE mosquito mesh has been associated with low infection rates and seroma [53].

ePTFE meshes cause minimal inflammatory reactions and reduce scar formation [54]. However, these meshes have a long-term susceptibility to infection. On the other hand, recurrence rates are higher since tissue integration is less [55]. Furthermore, the mesh is fragile and requires proper repair [56].

2. **Non-absorbable and synthetic with a barrier:** The barriers on these meshes can be absorbable or non-absorbable. These barriers prevent bowel adhesions and thus the initiation of an inflammatory cascade. The barriers are ePTFE, polyurethane, oxidized regenerated cellulose, omega-3 fatty acids, collagen, or beta-glucan [51].

3. **Synthetic and partially absorbable meshes:** These are less dense but have high mechanical strength. As a result, they maintain long-term wound strength with low inflammatory response. Currently, synthetic meshes are generated by the fusion of non-absorbable (PP) and absorbable materials (polyglactin 910 and poliglecaprone 25) [57].

4. **Combined or composite meshes:** The objective behind creating this type of mesh was to take advantage of the basic materials combined to form the composite. For example, when meshes made of a combination of PE and PTFE are applied, they allow abdominal wall tissue in-growth but prevent intestinal adhesion. Researchers have recently created a mesh with a PP or PET base coated with absorbable polymers. In case of a hernia infection, these absorbable meshes can be placed directly in contact with the intestine. This placement eliminates the need for a second surgery to remove the mesh, and the formation of a collagen layer further strengthens the repair [52]. The visceral side of these meshes is smooth and degradable, preventing adhesion, whereas the opposite side facing the abdominal tissue is rough, which helps in tissue infiltration [58,59]. The basic structure is similar to PP-based mesh with a polymer to enhance its non-adhesive properties. Since the polymer has layers, the mesh must be placed in a specific orientation to interact with different abdominal wall layers [46].

5. **Biological meshes:** Comprised of collagen scaffolds without cellular content and are employed for fibroblast in-growth and collagen deposition. Collagen-rich human or animal tissues are utilized to make these meshes. Fewer inflammatory and immune responses, induced angiogenesis, low rate of infection, and ability to perform even in contaminated and infected areas are some of the advantages of using these meshes [49]. However, a significant disadvantage of biological meshes is forming a resultant weak connective tissue, which leads to recurrence in a patient. Moreover, the mesh is not cost-effective.

With a variety of meshes available, the surgeon's decision and the patient's need directly affect the choice of mesh [46]. As can be seen in the preceding section, each type of mesh has its own set of advantages and disadvantages. No study strongly supported any particular type of mesh. Systematic reviews that included synthetic and biologic meshes have found no evidence that suggests that biological meshes are superior to non-absorbable synthetic meshes [60,61].

Regarding absorbable meshes, the mechanical properties of poly-4-hydroxybutyrate composite mesh are superior to biological meshes [62]. According to the consensus among researchers, synthetic meshes should be used in non-severe, non-infected hernias, whereas biological meshes are recommended in infected hernias [63]. In addition to the materials used, the outcome of hernia repair surgery, like all other surgeries, greatly depends on the surgeon's skills and experience [64].

Complications of surgery

- Death has been recognized as an early complication. Surgeries performed in an emergency setting have a higher mortality rate than those performed electively [9].

- Other surgical complications include surgical site infections (SSIs), postoperative hematoma, urinary retention, and chronic pain [65]. According to specific literature reviews, even prophylactic antibiotics do not reduce the occurrence of SSIs [66].

- Although rare, infertility is a significant drawback to hernia repair. It can occur because of atrophy, resulting from vas deferens injury or a testicular injury [67].

- Recurrence is another common complication (limitation) of hernia repair**.** A 5-year retrospective data review study found that 57% of all inguinal hernia recurrences occurred within ten years after post-surgical repair. The study also found that recurrences could occur after a gap of more than 50 years. Recurrence can occur even after a long time, especially after non-mesh repair [68].

A retrospective study analyzed 10-year follow-up data on 293 hernias. The analysis showed a significantly higher recurrence rate of inguinal hernias compared to primary hernias. Age above 50 years, smoking, and family history of hernia were other independent risk factors for recurrence [69]. Etiologies associated with recurrence in indirect hernias are incomplete dissection or ligation of the sac, wide cord, or inadequate reconstruction of the internal ring [35]. A comparison among open mesh, open sutured, and total extraperitoneal (TEP) techniques revealed a similar recurrence rate after open mesh and opened sutured repair. However, TEP techniques showed early recurrences. Late recurrence rates were lowest in open mesh repairs [70].

Future Direction

There is a need for further research on hernia repair that focuses on the development of biologically advanced meshes while considering the complications and drawbacks of the existing variety of meshes. A new type of mesh has been disclosed recently that releases drugs. PP mesh loaded with degradable polylactide-co-glycolide acid microspheres with rifampicin and carboxymethylcellulose gel loaded with chlorhexidine is an example of drug-releasing mesh. A successful advancement would be the use of "smart biomaterials," which would change shape and release the drug in response to environmental stimuli [46].

Conclusion

Inguinal hernia is an acquired or congenital condition wherein the abdominal cavity contents protrude into the inguinal canal. In men, testes migrate from the abdomen into the scrotum through the inguinal canal. Thus, men (more than women) are more likely to develop an indirect inguinal hernia.

An indirect hernia can occur congenitally. Indirect inguinal hernias present on the lateral side of the Hesselbach triangle and enter the inguinal canal through the deep or internal inguinal ring. Direct inguinal hernias comprise inguinal hernias that protrude through the Hesselbach triangle, remaining medial and caudal to the inguinal canal's origin at the internal inguinal ring. These hernias are common in older males and carry a lower risk of strangulation. The characteristic sign of a direct hernia on CT is a lateral fat crescent.

Inguinal hernias are often diagnosed by clinical examination. Imaging tests are recommended in the absence of conclusive signs or the presence of associated symptoms that indicate complications. US is the most common method used for examination. Of the various types of hernias, inguinal hernias are the most frequent. US (grayscale or color Doppler ultrasonography) is recommended for examining inguinal hernias. CT is used to differentiate inguinal and femoral hernia based on the relationship between the hernia sac and pubic tubercle. MRI is preferred for diagnosing occult inguinal hernias when there are limitations associated with US and CT or a lack of definitive diagnostic results.

Conservative management relies on reducing the hernia and using a hernia belt. Hernia belts or trusses are commonly used today as a temporary measure to relieve pain and discomfort. Surgical management of hernias is one of the most common surgeries performed globally. Surgical repair and watchful waiting are generally recommended in asymptomatic or minimally symptomatic patients. Currently, the application of mesh is preferred to direct suturing. There are various types of mesh and corresponding procedures based on the mesh

choice and degree, and type of herniation. Complications of surgery include death, infertility, and recurrence—establishing limitations for surgical repair.

Developing biologically advanced meshes are part of ongoing hernia management research. Recently, a novel type of mesh has been developed that releases drugs. Also, "smart biomaterials"—that change shape—are being investigated and tested for application in hernia repair.

Conflict of Interest Statement

The authors declare that this paper was written in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

References

1. Chiow AKH., *et al*. "Inguinal Hernias: A Current Review of an Old Problem". *Proceedings of Singapore Health Hcare* 19.3 (2010): 202-211. https://journals.sagepub.com/doi/abs/10.1177/201010581001900306

2. Onuigbo WIB and Njeze GE. "Inguinal Hernia. A Review". *Journal of Surgery and Operative Care* 1.2 (2016): 202. http://www.annex-publishers.co/articles/JSOC/1202-Inguinal-Hernia-A-Review.pdf

3. Basile F., *et al*. "Surgical approach to abdominal wall defects: history and new trends". *International Journal of Surgery* 11.1 (2013): S20-S23. https://pubmed.ncbi.nlm.nih.gov/24380545/

4. Kingsnorth AN. "General Introduction and History of Hernia Surgery.2013". In book: Management of Abdominal Hernias (2013). https://www.researchgate.net/publication/324558981_General_Introduction_and_History_of_Hernia_Surgery

5. Dorairajan N. "Inguinal hernia-yesterday, today and tomorrow". *Indian Journal of Surgery* 66.3 (2004). http://www.bioline.org.br/pdf?is04034

6. Bassini E. "Nuovo metodo sulla cura radicale dell'ernia inguinale [New method for radical repair of inguinal hernia]". Arch Soc Ital Chir 4 (1887): 80.

7. Conze J., *et al*. "Hernias". In: Holzheimer RG, Mannick JA.Surgical Treatment: Evidence-Based and Problem-Oriented.Munich: Zuckschwerdt (2001).

8. Holzheimer RG and Mannick JA. "Surgical Treatment: Evidence-Based and Problem-Oriented". Munich: Zuckschwerdt (2001). https://pubmed.ncbi.nlm.nih.gov/21028753/

9. Jenkins JT and O'Dwyer PJ. "Inguinal hernias". *British Medical Journal* 336 (2008): 269-272. https://pubmed.ncbi.nlm.nih.gov/18244999/

10. LeBlanc KE., *et al*. "Inguinal Hernias: Diagnosis and Management". *American Family Physician* 87.12 (2013): 844-848. https://pubmed.ncbi.nlm.nih.gov/23939566/

11. Hammoud M and Gerken J. "Inguinal Hernia (2021).

12. Kingsnorth A and LeBlanc K. "Hernias: inguinal and incisional". *Lancet* 362.9395 (2003): 1561-1571. https://pubmed.ncbi.nlm.nih.gov/14615114/

13. Park CY., *et al*. "Inguinal hernia repair in overweight and obese patients". *Journal of the Korean Surgical Society* 81.3 (2011): 205-210. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3204546/

14. Zendejas B., *et al*. "Incidence of Inguinal Hernia Repairs in Olmsted County. A Population-Based Study". *Annals of Surgery* 257.3 (2013): 520-526. https://pubmed.ncbi.nlm.nih.gov/23388353/

15. Beard JH., *et al*. "An Estimation of Inguinal Hernia Epidemiology Adjusted for Population Age Structure in Tanzania". *Hernia* 18.2 (2013): 289-295. https://link.springer.com/article/10.1007/s10029-013-1177-5

16. Ruhl CE and Everhart JE. "Risk Factors for Inguinal Hernia among Adults in the US Population". *American Journal of Epidemiology* 165.10 (2007): 1154-1161. https://pubmed.ncbi.nlm.nih.gov/17374852/

17. Beard JH., *et al*. "Essential Surgery: Disease Control Priorities, Third Edition (Volume 1).Washington (DC): The International Bank for Reconstruction and Development / The World Bank (2015).

18. Primatesta P and Goldacre MJ. "Inguinal Hernia Repair: Incidence of Elective and Emergency Surgery, Readmission and Mortality". *International Journal of Epidemiology* 25.4 (1996): 835-839. https://pubmed.ncbi.nlm.nih.gov/8921464/

19. Malviya VK., *et al*. "Demographic study in operated patients with inguinal hernia". *International Journal of Surgery and Orthopedics* 5.1 (2019): 20-26. https://www.semanticscholar.org/paper/Demographic-study-in-operated-patients-with-hernia-Malviya-Sainia/45a8154b9b0fdb86fe0bce2b99cb1481c08135fa

20. Klinge U., *et al*. "Development and pathophysiology of abdominal wall defects". *Chirurg* 68.4 (1997): 293-303. https://pubmed.ncbi.nlm.nih.gov/9206623/

21. Rosch R., *et al*. "Hernia-A collagen disease?" *European Surgery* 35 (2003): 11-15. https://onlinelibrary.wiley.com/doi/abs/10.1046/j.1563-2563.2003.03004.x

22. Wechsler RJ., *et al*. "Cross-sectional imaging of abdominal wall hernias". *American Journal of Roentgenology* 153.3 (1989): 517-521. https://pubmed.ncbi.nlm.nih.gov/2763948/

23. Burkhardt JH., *et al*. "Diagnosis of Inguinal Region Hernias with Axial CT: The Lateral Crescent Sign and Other Key Findings". *Radio Graphics* 31.2 (2011). https://pubs.rsna.org/doi/full/10.1148/rg.312105129

24. Lee GH and Cohen AJ. "CT imaging of abdominal hernias". *The American Journal of Roentgenology* 161.6 (1993): 1209-1213. https://pubmed.ncbi.nlm.nih.gov/8249727/

25. Robinson A., *et al*. "A systematic review and meta-analysis of the role of radiology in the diagnosis of occult inguinal hernia". *Surgical Endoscopy* 27.1 (2013): 11-18. https://pubmed.ncbi.nlm.nih.gov/22733195/

26. Piga E., *et al*. "Imaging modalities for inguinal hernia diagnosis: a systematic review". *Hernia* 24.5 (2020): 917-926. https://pubmed.ncbi.nlm.nih.gov/32328842/

27. Revzin MV., *et al*. "US of the Inguinal Canal: Comprehensive Review of Pathologic Processes with CT and MR Imaging Correlation". *Radio Graphics* 36 (2016): 2028-2048. https://pubs.rsna.org/doi/full/10.1148/rg.2016150181

28. Jamadar DA., *et al*. "Sonography of inguinal region hernias". *American Journal of Roentgenology* 187.1 (2006): 185-190. https://www.ajronline.org/doi/10.2214/AJR.05.1813?mobileUi=0

29. Bedewi MA and El-sharkawy M. "Imaging of Hernias, Hernia, Fethi Derbel, IntechOpen (2021). https://www.intechopen.com/books/hernia/imaging-of-hernias

30. Burlison JS and Williamson MR. "Ultrasonography of hernias". *Ultrasound Clinic* 9.3 (2014): 471-487.

31. Shigeru S., *et al*. "Differentiation of Femoral Versus Inguinal Hernia: CT Findings". *AJR* 189 (2007): W78-W83. https://pubmed.ncbi.nlm.nih.gov/17646443/

32. Light D., *et al*. "The role of ultrasound scan in the diagnosis of occult inguinal hernias". *International Journal of Surgery* 9.2 (2011): 169-172. https://www.sciencedirect.com/science/article/pii/S1743919110004784

33. Komorowski AL. "History of the Inguinal Hernia Repair (2021). https://www.intechopen.com/books/inguinal-hernia/history-of-the-inguinal-hernia-repair

34. Can a hernia truss help an inguinal hernia?Available from : https://www.mayoclinic.org/diseases-conditions/inguinal-hernia/expert-answers/hernia-truss/faq-20058111.[Accessed on 12th April 2021].

35. McIntosh A., *et al*. "Evidence-based management of groin hernia in primary care—a systematic review". *Family Practice* 17.5 (2000): 442-447. https://pubmed.ncbi.nlm.nih.gov/11021907/

36. Alagesan J., *et al*. "Effect of yoga therapy in reversible inguinal hernia: A quasi-experimental study". *The International Journal of Yoga Therapy* 5.1 (2012): 16-20.

37. Fitzgibbons RJ Jr., *et al*. "Watchful waiting vs. repair of inguinal hernia in minimally symptomatic men: a randomized clinical trial". *The Journal of the American Medical Association* 295 (2006): 285-292.

38. Kingsnorth A and Bennet DH. "Hernias, umbilicus, abdominal wall". In: Russel RCG, Williams NS, Bulstrode CJK, eds. Bailey and Lovee's short practice of surgery, 23rd edition. London, England: Arnold Publishers (2000): 1143-1162.

39. O'Dwyer PJ., *et al*. "Observation or operation for patients with an asymptomatic inguinal hernia: a randomized clinical trial". *Annals of Surgery* 244.2 (2006): 167-173. https://pubmed.ncbi.nlm.nih.gov/16858177/

40. Hernia Surge Group. "International guidelines for groin hernia management". *Hernia* 22 (2018): 1-165. https://pubmed.ncbi.nlm.nih.gov/29330835/

41. Fitzgibbons RJ., *et al*. "Investigators of the Original Trial: Long-term results of a randomized controlled trial nonoperative strategy (watchful waiting) for men with minimally symptomatic inguinal hernias". *Annals of Surgery* 258 (2013): 508-515. https://pubmed.ncbi.nlm.nih.gov/24022443/

42. No authors listed. "Laparoscopic versus open repair of groin hernia: a randomized comparison". *The Lancet* 354 (1999): 185-190. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(98)10010-7/fulltext

43. KMF Itani., *et al*. "Comparison of laparoscopic and open repair with mesh for the treatment of ventral incisional hernia: a randomized trial". *Archives of Surgery* 145 (2010): 322-328. https://pubmed.ncbi.nlm.nih.gov/20404280/

44. Gottlieb S. "Open surgery better than laparoscopic for repair of inguinal hernia". *British Medical Journal* 328 (2004): 1033. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC403835/

45. Kumar S., *et al*. "Chronic pain after laparoscopic and open mesh repair of groin hernia". *British Journal of Surgery* 89 (2002): 1476-1479. https://bjssjournals.onlinelibrary.wiley.com/doi/abs/10.1046/j.1365-2168.2002.02260.x

46. See CW., *et al*. "Hernia Mesh and Hernia Repair: A Review". *Engineered Regeneration* 1 (2020): 19-33. https://www.sciencedirect.com/science/article/pii/S2666138120300025

47. Neumayer LA., *et al*. "Proficiency of Surgeons Inguinal Hernia Repair Effect of Experience and Age". *Annals of Surgery* 242.3 (2005): 344-352. https://pubmed.ncbi.nlm.nih.gov/16135920/

48. Smart NJ., *et al*. "Biological meshes: a review of their use in abdominal wall hernia repairs". *Surgeon* 10.3 (2012): 159-171. https://pubmed.ncbi.nlm.nih.gov/22436406/

49. FitzGerald JF and Kumar AS. "Biologic versus Synthetic Mesh Reinforcement: What are the Pros and Cons?" *Clinics in Colon and Rectal Surgery* 27.4 (2014): 140-148. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4477030/

50. Liu H., *et al*. "Comparison of coated meshes for intraperitoneal placement in animal studies: a systematic review and meta-analysis". *Hernia* 24 (2020): 1253-1261. https://link.springer.com/article/10.1007/s10029-019-02071-y

51. Elango S., *et al*. "Mesh materials and hernia repair". *Biomedicine* 7.3 (2017): 16. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5571666/

52. Robinson TN., *et al*. "Major mesh-related complications following hernia repair: events reported to the Food and Drug Administration". *Surgical Endoscopy* 19 (2005): 1556-1560. https://pubmed.ncbi.nlm.nih.gov/16211441/

53. Rouet J., *et al*. "Polyester mosquito net mesh for inguinal hernia repair: A feasible option in limited-resource settings in Cameroon?" *Journal of Visceral Surgery* 155 (2018): 111-116. https://pubmed.ncbi.nlm.nih.gov/29102511/

54. McGinty JJ., *et al*. "Comparative study of adhesion formation and abdominal wall ingrowth after laparoscopic ventral hernia repair in a porcine model using multiple types of mesh". *Surgical Endoscopy* 19 (2005): 786-790. https://pubmed.ncbi.nlm.nih.gov/15776214/

55. Kalaba S., *et al*. "Design Strategies and Applications of Biomaterials and Devices for Hernia Repair". *Bioactive Materials* 1 (2016): 2-17. https://pubmed.ncbi.nlm.nih.gov/28349130/

56. Koehler RH., *et al*. "Minimal adhesions to ePTFE mesh after laparoscopic ventral incisional hernia repair: preoperative findings in 65 cases". *Journal of the Society of Laparoendoscopic Surgeons* 7 (2003): 335-40. https://pubmed.ncbi.nlm.nih.gov/14626400/

57. Bellón JM., *et al*. "Partially absorbable meshes for hernia repair offer advantages over nonabsorbable meshes". *The American Journal of Surgery* 194.1 (2007): 68-74. https://pubmed.ncbi.nlm.nih.gov/17560912/

58. Baylón K., *et al*. "Past, Present and Future of Surgical Meshes: A Review". *Membranes* 7.3 (2017): 47. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5618132/

59. Sezer UA., *et al*. "Polypropylene composite hernia mesh with anti-adhesion layer composed of polycaprolactone and oxidized regenerated cellulose Mater Sci Eng C". *Materials Science and Engineering C: Materials for Biological Applications* 99 (2019): 1141-1152. https://pubmed.ncbi.nlm.nih.gov/30889648/

60. Lee L., *et al*. "A systematic review of synthetic and biologic materials for abdominal wall reinforcement in contaminated fields". *Surgical Endoscopy* 28 (2014): 2531-2546. https://pubmed.ncbi.nlm.nih.gov/24619334/

61. Muysoms FE., *et al*. "Prevention of Incisional Hernias with Biological Mesh: A Systematic Review of the Literature". *Frontiers in Surgery* 3 (2016): 53. https://pubmed.ncbi.nlm.nih.gov/27725931/

62. Scott JR., *et al*. "Evaluation of a fully absorbable poly-4-hydroxybutyrate/absorbable barrier composite mesh in a porcine model of ventral hernia repair". *Surgical Endoscopy* 30 (2016): 3691-3701. https://pubmed.ncbi.nlm.nih.gov/27369286/

63. Costa A., *et al*. "Biological Scaffolds for Abdominal Wall Repair: Future in Clinical Application?" *Materials* 12.15 (2019): 2375. https://pubmed.ncbi.nlm.nih.gov/31349716/

64. Bochicchio GV., *et al*. "Biologic vs. synthetic inguinal hernia repair: 1-year results of a randomized double-blinded trial". *Journal of the American College of Surgeons* 218 (2014): 751-757. https://pubmed.ncbi.nlm.nih.gov/24655865/

65. Mizrahi H and Parker MC. "Management of Asymptomatic Inguinal Hernia A Systematic Review of the Evidence". *Archives of Surgery* 147.3 (2012): 277-281. https://jamanetwork.com/journals/jamasurgery/fullarticle/1107398

66. Aufenacker TJ., *et al*. "Systematic review and meta-analysis of the effectiveness of antibiotic prophylaxis in prevention of wound infection after mesh repair of abdominal wall hernia". *British Journal of Surgery* 93.1 (2006): 5-10. https://pubmed.ncbi.nlm.nih.gov/16775827/

67. Fitzgibbons Jr RJ. "Can we be sure that polypropylene mesh causes infertility?" *Annals of Surgery* 241 (2005): 559-561. https://pubmed.ncbi.nlm.nih.gov/15798456/

68. Köckerling F., *et al*. "How long do we need to follow-up our hernia patients to find the real recurrence rate?" *Frontiers in Surgery* 16.2 (2015): 24. https://www.researchgate.net/publication/279728987_How_Long_Do_We_Need_to_Follow-Up_Our_Hernia_Patients_to_Find_the_Real_Recurrence_Rate

69. Junge K., *et al*. "Risk factors related to recurrence in inguinal hernia repair: a retrospective analysis". *Hernia* 10.4 (2006): 309-315. https://pubmed.ncbi.nlm.nih.gov/16721504/

70. Nixon SJ and Jawaid H. "Recurrence after inguinal hernia repair at ten years by open darn, open mesh, and TEP--no advantage with mesh". *Surgeon* 7.2 (2009): 71-74. https://pubmed.ncbi.nlm.nih.gov/20303898/

Volume 8 Issue 8 August 2021