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EVIDENCE-BASED CURRENT SURGICAL PRACTICE

Controversies and Techniques in the Repair of Abdominal Wall Hernias

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Abstract

Abdominal wall hernia repair is one of the most common operations done by general surgeons today. Patients with incisional hernias can be extremely challenging to manage due to a number of factors that include obesity, prior hernia repairs, previous mesh placement, loss of domain, and other variables. The approach to patients with incisional hernias has evolved considerably over the last 20 years due to both advances in mesh technology and surgical approaches. Key factors in a successful outcome include modification of risk factors prior to surgery such as smoking cessation and weight reduction, selection of mesh appropriate to the hernia type and planned location of the mesh, and broad overlap of mesh beyond the margins of the hernia defect. Newer techniques such as transabdominis release and component separation with retrorectus mesh placement and robotic approaches to abdominal wall hernia are being increasingly utilized in these patients. This article reviews these aspects of abdominal wall hernia repair with a discussion of recent results and the importance of quality improvement and monitoring of outcomes.

Keywords Abdominal wall hernia · Mesh · Component separation

The treatment of abdominal wall hernias has evolved considerably over the last two decades and presents a challenging problem for surgeons to manage. In this review, considerations will be given to the clinical presentation of abdominal wall hernias, a review of the various surgical approaches including open versus laparoscopic, retrorectus and component separation techniques, and mesh options available for abdominal wall hernia repair. In addition, strategies for managing patients with incisional hernias in contaminated fields as well as newer approaches such as robotic hernia repair will be reviewed.

CME questions for this article are available to SSAT members at http://ssat.com/jogscme/

Learning Objectives:
1. Discuss different surgical options for repair of abdominal wall hernias and the role of modifiable risk factors for surgery.
2. Review the various mesh options available for abdominal wall hernia repair.
3. Identify newer methods for abdominal wall reconstruction that includes transverse abdominus release and robotic retrorectus repair.

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Demographics

In the USA, approximately 350,000 ventral hernia repairs are performed annually. While the majority of these are primary umbilical or epigastric hernias, approximately 150,000 are incisional hernias. This frequency of cases places a substantial burden on the healthcare system. Outcomes have been reported to be less than ideal with reoperation rates of 12.3% at 5 years and up to 23% at 10 years.[1]

In the past, many incisional hernias were done as primary sutured repairs. In a landmark prospective, randomized controlled trial that was reported by Burger in 2004,[2] outcomes of primary suture versus mesh repair of incisional hernia were evaluated. There were 97 patients in the suture repair group and 84 in the mesh repair group. Recurrence rates at 10 years were 67% in the suture repair group versus 32% in the mesh group. On a univariate analysis, risk factors for recurrence included prior

abdominal aortic aneurysm repair and wound infection. Of note in this study is that recurrences appeared at up to 10 years after repair including with the mesh repairs. The conclusions from this study were that mesh should be used in the vast majority of patients undergoing incisional hernia repair today.

Prosthetic Mesh

With the rise of usage of mesh for repair of incisional hernias, a wide variety of mesh products are now available for consideration.[3] In general categories, these consist of synthetic meshes, composite meshes, absorbable meshes, biologic meshes, and hybrid meshes as shown in Table 1. In the synthetic mesh group, the products include polypropylene, polyester, and polytetrafluorethylene (PTFE). In addition, synthetic meshes may be categorized according to the density of the mesh construction into lightweight, mid-weight, and heavyweight meshes and also on the basis of their pore size. Composite meshes are those in which a barrier coating is incorporated into one side of the mesh to minimize adhesion formation on the visceral side. This coating can be made from either a permanent material such as PTFE or an absorbable material such as omega-3 fatty acid or collagen-based coating. The advantages, disadvantages, and relative costs within these various mesh categories are also given in Table 1.

In recent years, an increase in the number of biologic meshes available for abdominal wall hernia repair has been seen. Biologic meshes typically consist of human, porcine, or bovine-derived materials. They undergo a process in which the material is decellularized and further processed. The rationale for the use of biologic meshes is that they may act like a scaffold for native tissue ingrowth. In addition, there are absorbable synthetic meshes that are designed to have properties similar to that of the biologic meshes, but with theoretically less associated risk since they are not derived from an animal or human source.

The choice of mesh for ventral hernia depends on a variety of factors that includes both the mesh properties and the location such as whether it is to be placed intraperitoneal, preperitoneal, or retrorectus. A guiding principle is that one should avoid placement of uncoated polypropylene mesh in an intraperitoneal location where it can be in direct contact with the viscera. In addition, the type of hernia defect is another factor such as whether the wound is clean versus clean contaminated or contaminated and whether a bridged or buttressed repair is being done. In general, one should avoid lightweight or biologic meshes for bridging a defect because of the increased failure rate.[4]

Diagnosis and Patient Preparation

When evaluating a new patient with hernia, a combination of focused history and a detailed abdominal exam is important to

Table 1 Outline of currently available mesh categories including key features, advantages, disadvantages, and relative cost

	Permanent synthetic	Composite synthetic	Biologic	Absorbable synthetics	Hybrid meshes
Key features	Permanent material Various strength and weight profiles	Absorbable or permanent barrier-coated permanent mesh designed to minimize adhesions and allow for intra-abdominal placement	Decellularized, allows for cellular ingrowth and regeneration	Made of absorbable materials Can have various absorption times (rapid or slow)	Features a permanent synthetic mesh coated in a biologic substrate
Base material	Polypropylene Polyester PTFE*	Polypropylene Polyester PTFE* (Barrier material examples: omega 3 fatty acid, collagen, cellulose)	Human dermis Porcine dermis Porcine small intestine submucosa Porcine pericardium Bovine pericardium	Polyglactin Polyglycolic acid/trimethylene carbonate Poly-4-hydroxybutyrate	Permanent synthetic substrate covered with a biologic material
Advantages	Provides long-standing strength	Can be placed intraperitoneal	No permanent foreign material	Provides reinforcement during healing period of primary repair	Permanent mesh is not exposed at time of implantation
Disadvantages	Permanent material has risk for infection, dense adhesions to viscera if intraperitoneal	Barrier coating may increase risk for infection	High Cost Non-porous design	No long-term material strength	Permanent synthetic material
Cost	$	$$	$$$	$$$	$$$

*PTFE = polytetrafluoroethylene; $ = Relative cost for each mesh type (depent on contractural agreements)

establish the size and characteristics that influence the appropriate method for repair. However, in obese patients, and those with a complex surgical history including previous hernia repairs, the addition of imaging is vital. Ultrasound has shown success in determining the presence of hernia at a similar rate with CT scan with the benefit of no radiation and bedside interpretation.[5] However, the use of cross-sectional imaging can provide increased information including location of secondary defects and information about the abdominal wall musculature such as width of separation of the rectus muscles. The use of CT scan has also been shown to help predict wound complications and the need for more complex repair techniques.[6]

Patient optimization has also become of increasing importance prior to surgical repair as certain patient factors have been shown to result in increased perioperative morbidity and hernia recurrence rates. Two of the most important modifiable factors that most surgeons agree on are smoking cessation and weight management. Recent literature has suggested that a body mass index (BMI) $\geq$ 40 kg/m^2 is associated with significantly higher rates of perioperative complications and hernia recurrence.[7] Smoking is associated with increased wound complications and should be stopped a minimum of 4–6 weeks in advance of surgery with preoperative testing for nicotine in advance. In addition to smoking cessation and weight loss, patients with poorly controlled diabetes also suffer from worse outcomes and should have surgery delayed until their blood sugars can be better optimized.[8]

The role of watchful waiting for patients with incisional hernia has not been clarified. In one uncontrolled retrospective study, patients who underwent watchful waiting ($N = 104$) were compared to those who had elective operative repair ($N = 151$).[9] Although more patients in the watchful waiting group were asymptomatic (23.4 vs 1.2%), a number of patients in the WW group (7.7%) required emergency surgery due to acute incarceration events. In those patients, the rate of unexpected intestinal perforation (13 vs 2%) and postoperative fistula (7 vs 0%) was significantly higher compared to primary operative treatment.

Surgical Approaches

A variety of surgical approaches have been described as outlined in Table 2. The decision as to which approach is best for a given patient depends on factors specific to both the hernia and the given patient characteristics. In addition, there may be considerations as to which mesh type is preferred that can influence the approach, as well as specific contraindications for certain techniques. Finally, cost is another factor that should be weighed in choosing the optimal repair and mesh for a given patient. The current status of laparoscopic, open, and robotic approaches are reviewed below.

Laparoscopic Repair

In the 1990s, laparoscopic approaches to ventral hernia repair gained in popularity. In a pooled data analysis of laparoscopic versus open ventral hernia repair published series from 1996 to 2006, over 5300 cases were analyzed from 45 series. These included 4582 done laparoscopically and 758 open. The results of this analysis show that laparoscopic ventral hernia repair was associated with fewer complications (wound/infection 3.8% versus 16.8% open, total complications 22.7% versus 41.7% open, and hernia recurrences 4.3% versus 12.1% open. However, there was an increased rate of prolonged procedure site pain in the laparoscopic group (2.0% versus 0.92%).[10]

Table 2 Summary of currently performed repair techniques used for ventral and incisional hernia

	Laparoscopic repair	Robotic repair	Open repair
Hernia factors	Smaller, isolated defects	Small to medium-sized defects	Larger defects
Patient factors	Less physically active Factors that increase risk for perioperative infection (obesity, DM, immunosuppression, etc.)	Need to reconstruct the abdomen, restore functional abdominal wall	Known complex abdomen Need to reconstruct the abdomen Need for a more functional abdominal wall
Mesh types and locations	Barrier-coated mesh if placed intra-peritoneal	Barrier coated if placed intra-peritoneal Uncoated mesh if placed extra-peritoneal (e.g., retrorectus)	Barrier coated if placed intra-peritoneal Uncoated mesh if placed extra-peritoneal (retrorectus)
Relative contraindications	Significant skin changes Extensive previous surgical history Loss of domain Large defects with a need to reconstruct abdominal musculature	Extensive previous surgical history Very large defects	Increased risk for post-op infection
Procedural Cost	$$	$$$	$

DM = diabetes mellitus; $ = Relative operative cost for each surgical approach

Currently, the primary indications for laparoscopic incisional hernia repair are patients with multiple small defects, small to moderate size hernias, or a prior history of infection. The laparoscopic approach can also be used for suprapubic or flank hernias in selected cases. For large defects with wide separation of the rectus muscles, an open approach is generally preferred.

Initial access for this procedure can be obtained either in a closed or open fashion. For midline defects, the ports should be placed laterally to allow adequate and anticipated overlap of the mesh beyond the defect; usually placement of ports on both sides of the abdomen are required for fixation of the mesh. The principles of this approach, after establishing laparoscopic access, entail adhesiolysis with minimal use of energy, overlap of the defect with the mesh by 5 cm or more, and use of a barrier-coated mesh. Recently, techniques for primary closure of large defects using a suture passer type device and figure of eight sutures (Fig. 1) to provide a more functional abdominal wall result have been advocated.[11] Finally, the mesh should be broadly fixed with sutures or tacks or a combination thereof. It is important that the mesh be placed without wrinkles or folds as shown in Fig. 2.

Failures after laparoscopic incisional hernia repair can be due to inadequate mesh fixation, inadequate mesh overlap beyond the defect (Fig. 3), use of a mesh of inadequate strength for the repair such as a lightweight bridged or biologic mesh, as well as patient factors such as obesity and continued smoking.

A disadvantage of a laparoscopic approach to incisional hernia is that it may not result in a functional abdominal wall, especially for larger hernia defects. This aspect may be especially important for younger patients and for physically active individuals or laborers. An additional disadvantage is that it results in an intraperitoneal mesh which can increase the difficulty of subsequent abdominal surgery. For an in depth analysis of the literature on laparoscopic treatment of ventral and incisional hernias, published society guidelines on this topic are available.[12,13]

Open Posterior Mesh Repair

The open retrorectus approach to incisional hernia repair was first developed and popularized by Rives and Stoppa. In this approach, the posterior rectus sheath is separated from the midline and the rectus muscles and is dissected widely to the lateral border of the rectus. The posterior sheath is closed separately with a running suture and the mesh is placed posterior to the rectus muscles and

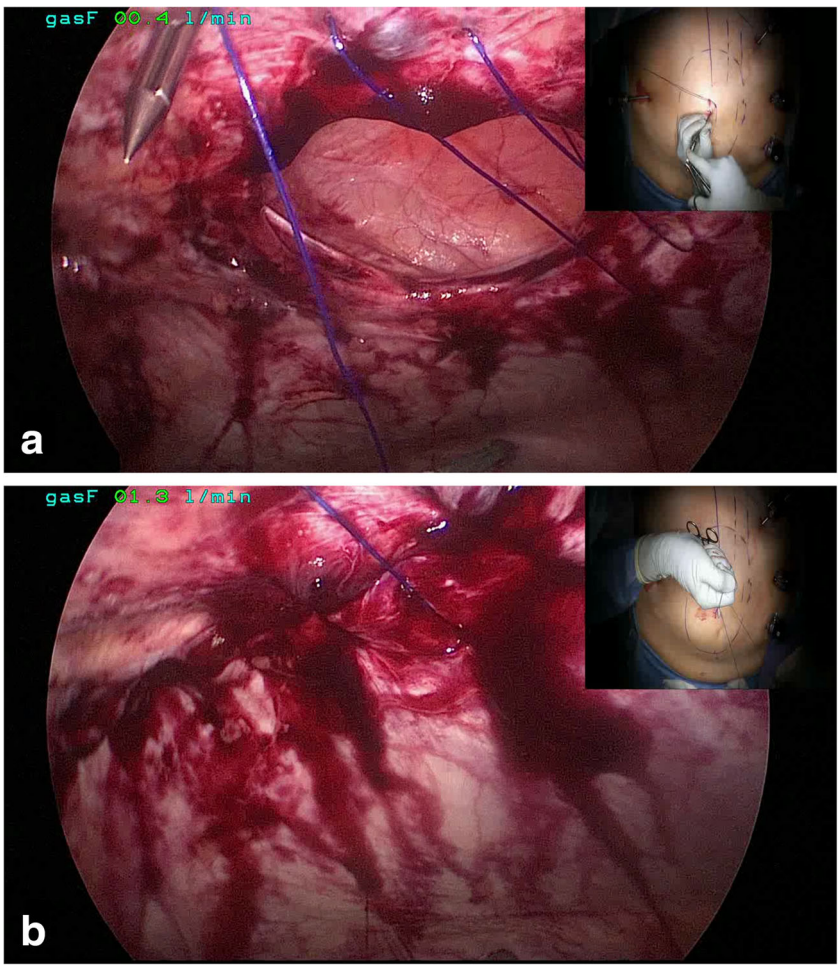

Fig. 1 Primary suture closure technique in laparoscopic incisional hernia repair. A figure of eight suture is performed using a suture pass device (**A**) inserted through a small stab incision (inset). The suture is then tied down to approximate the defect under reduced CO2 insufflation pressure (**B**)

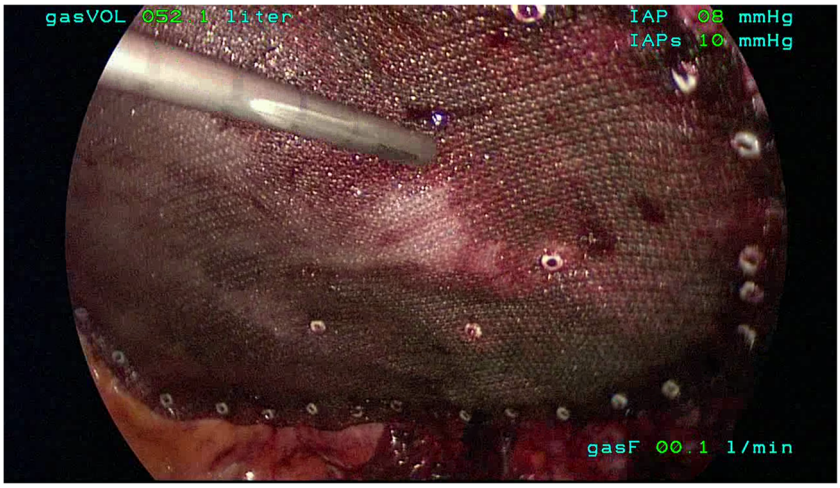

Fig. 2 Laparoscopically placed barrier-coated mesh demonstrating broad fixation with several cm of overlap beyond the fascial closure and a flat configuration of the mesh

anchored in place with a number of sutures which are often placed with a Reverdin needle-type technique. This approach minimizes the risk of recurrence at the lateral edge of the defect and essentially sandwiches the mesh in between the abdominal wall muscles. The anterior fascia is then closed over the top of the mesh.

This technique is relatively straight forward, avoids development of skin flaps, and allows midline closure in many hernias. It also allows use of less expensive meshes such as uncoated polypropylene and avoids the need for costlier barrier-type meshes. The disadvantage of this approach is that narrow or atrophied rectus muscles limit the mesh overlap and it is difficult to do if the retrorectus space has been violated previously. In addition, large midline hernias may not come together without increased tension.

Despite more widespread adoption of this technique, there are no significant amounts of data available on outcomes. In a recent study comparing underlay repair versus sublay (retrorectus) repair, the authors found that sublay was associated with a significant reduction in recurrence rate (10.7% versus 25.0%) compared with underlay.[14]

Transverse Abdominis Release (TAR) Component Separation

The transverse abdominis release component separation procedure is based on the principle of enlarging the circumference of the abdominal wall by moving muscle layers to bridge a fascial defect. This approach allows one to reconstruct the midline and achieve a more functional abdominal wall result and can be used for large and complex hernias. It also avoids development of large muscle flaps that accompany external component release and allows wide placement of mesh out even to the psoas muscles. In this approach, the mesh is seated between the posterior rectus sheath and rectus muscles and anterior sheath similar to the Rives-Stoppa approach, except the mesh extends much more widely.

The basic steps in this technique are:

1. Incise posterior sheath and develop the retrorectus plane
2. Divide the posterior rectus sheath and transversus abdominis muscle on one or both sides

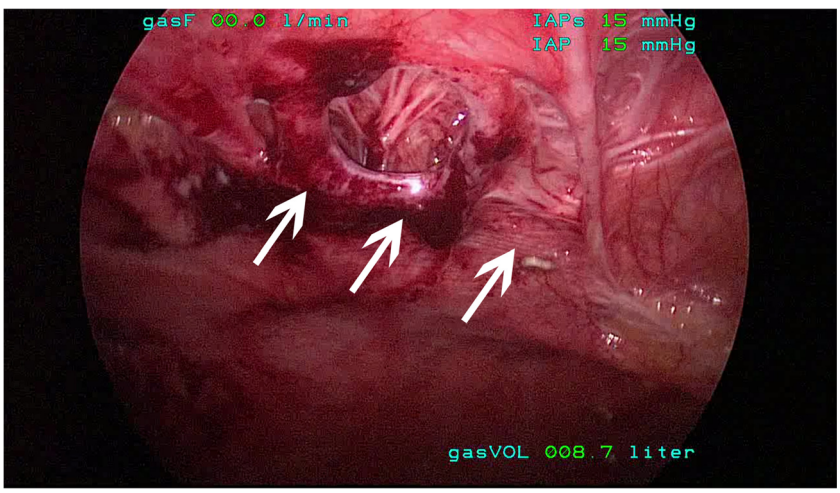

Fig. 3 Recurrent hernia at the lateral margin of prior mesh placement due to insufficient overlap or inadequate fixation of mesh or both. Arrows indicate the edges of the prior mesh repair

3. Develop the plane out laterally to the psoas muscles if necessary
4. Midline advancement and closure of the posterior sheath with a running absorbable suture
5. Placement of mesh widely with minimal suture fixation and
6. Closure of the anterior sheath[15]

The disadvantages of the open posterior TAR component separation technique are that one can violate the abdominal wall neurovascular supply if care is not taken to avoid the neurovascular perforators to the rectus muscle which travels through the transversus abdominis muscle. Additionally, it is more technically challenging than other techniques and has the potential for dissection in the wrong plane.

The largest series of posterior component separation with the TAR procedure was recently reported: 428 consecutive TAR procedures were done, 26 of which were clean contaminated and 8% in contaminated wounds. The hernias were large with a mean width of 15.2 cm and area of 606 cm^2. Outcomes showed surgical site event occurrence rate of 18.7% and surgical site infection of 9.1%. However, there were no mesh explantations in this series. At a mean follow-up of 31.5 months with a minimum 1 year follow-up in 347 patients, recurrence rates were only 3.7%.[16]

In one recent report, a comparative radiographic analysis was done that looked at changes in abdominal wall musculature morphology after laparoscopic ventral hernia repair as a bridged repair compared to open posterior component separation. CT scans were done at 6 months postop in 50 patients undergoing these procedures. The authors found that significant increases in rectus, external oblique, and internal oblique muscle area occurred postoperatively in the open posterior component separation group only.[17]

Robotic Approaches to Abdominal Wall Hernia Repair

Increasing interest has evolved in the application of robotic assisted surgery for abdominal hernia repair. Initially, the robotic approach has been used for primary abdominal wall hernias and uncomplicated incisional hernias basically mimicking the standard laparoscopic approach, potentially reducing postoperative pain and length of stay.[18] Recently, however, techniques have been developed for performing a TAR robotically. An advantage of the robot in this setting is the wristed instrumentation that allows suturing upwards toward the abdominal wall which is very difficult to do with conventional laparoscopic instrumentation. This approach thus converts a procedure that is normally done open to a minimally invasive approach. In this approach, robotic ports are placed laterally and the retrorectus plane is developed on the contralateral side and a TAR is performed on that side. Ports are then placed into the opposite side and the mesh is inserted. The mesh is secured to that side with 2–3 sutures to the lateral abdominal wall. The robot is then deployed to the opposite side working back toward the side of original access and the retrorectus space and TAR procedure are performed on that side. The posterior rectus sheath is then closed in the midline with a barbed suture. The anterior rectus fascia is then also closed with a barbed suture. Finally, the mesh is unrolled across the abdomen, and secured on the opposite side. A drain can be left to prevent fluid accumulation similar to when performed in an open fashion.

Outcomes of laparoscopic versus robotic retromuscular ventral hernia repair were recently compared.[19] There were 103 patients in the laparoscopic group versus 53 in the robotic group. Hernia widths were similar between the groups (6.9 vs 6.5 cm). The fascial closure rate was 96% in the robotic group versus 50.5% in the laparoscopic group. Mesh placement was extraperitoneal in 96% robotic versus 9.7% laparoscopic. Operative times were twice as long in the robotic group (245 verses 122 min). Surgical site infection rates were similar (1 vs 3.8%) but median length of stay was only 1 day in the robotic group compared to 2 days in the laparoscopic. Costs, however, were 50% greater in the robotic group. This field continues to evolve and requires further study to identify the indications and benefits of robotic abdominal wall hernia repair.

Robotic laparoscopic inguinal hernia repair with a transabdominal preperitoneal (TAPP) laparoscopic approach is also being employed by some groups.[20–22] The main advantage of this approach is to facilitate suturing of the mesh in place and thereby eliminate the use of a tacking device. To date, no differences in pain, complication rates, and hernia recurrences have been shown, although the cost may be somewhat higher than conventional laparoscopic repair.

Contaminated Setting

Patients with contaminated or clean-contaminated wounds such as the presence of an enterocutaneous fistula from prior hernia repair are a challenging group of patients to manage. Recently, evidence has emerged that many of these patients can be repaired with a synthetic mesh and avoid the risk of a two or more staged procedure. If a permanent synthetic mesh is to be used in this setting, it should be done preferably in a retrorectus fashion and the mesh should be a lightweight polypropylene mesh. PTFE mesh should be avoided in this situation because of the high rate of infection. A recent meta-analysis of the literature found no benefit of biologic over synthetic mesh for repair of potentially contaminated hernias.[23]

In one series of 100 patients with clean contaminated (n = 42) and contaminated (n = 58) wounds, the surgical site occurrence rate was 26.2 and 34%, respectively.[24] Thirty-day surgical site infection (SSI) rates were 7% in clean contaminated and

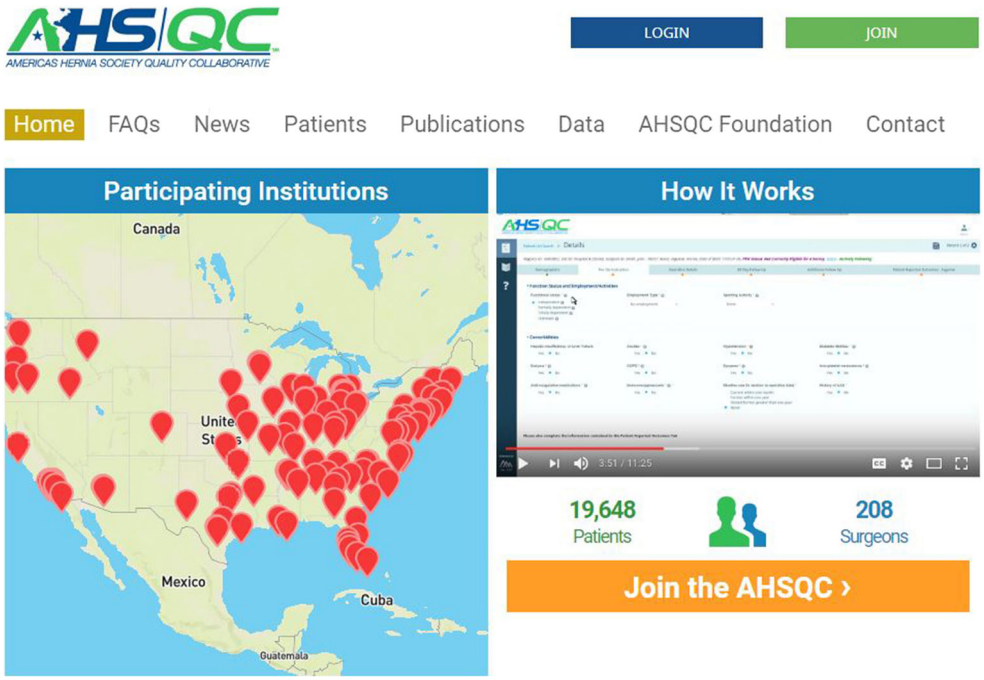

Fig. 4 Americas Hernia Society Quality Collaborative (AHSQC) illustrating map of institutions enrolled and basic web site functions

19% in contaminated wounds. The recurrence rate was 7% and mesh removal was necessary in only four patients. In another study of 126 patients who underwent major incisional hernia repair using synthetic versus biologic mesh in clean contaminated and in contaminated field, outcomes were worse in the biologic mesh group.[25] The surgical site event rate was 22.8% in 67 patients who has synthetic mesh versus 42% in 69 who had biologic mesh. SSI rates in those groups were 12.3 and 31.9%, respectively, and recurrence rates were also higher in the biologic mesh group, 8.9% versus 26.3%. These results suggest that consideration should be given to the use of a lightweight macroporous mesh in appropriately selected patients with clean contaminated and contaminated fields.

Quality Improvement in Hernia Repair

Awareness of surgeon outcomes is an important component of quality around abdominal wall hernia repair. The Americas Hernia Society has developed a quality collaborative (AHSQC) that allows disease based continuous quality improvement for abdominal wall hernia.[26] This initiative allows incorporation of demographic, OR/surgeon entered, and postoperative follow-up and patient centered data. To date, over 12,000 patients have been enrolled from 180 surgeons. The AHSQC is a qualified clinical data registry and qualifies for part 4 maintenance of certification. Within this database, one can compare outcomes to other surgeons or institutional outcomes to data that is in the overall collaborative. In order to participate, one must be a member of the Americas Hernia Society (Fig. 4).

Finally, social media has been increasingly utilized for addressing difficult problems and consultations related to hernia surgery. The International Facebook collaborative is a Facebook group for discussion and consultation developed by Dr. Brian Jacobs.[27] In this group discussion, cases are presented with history, exam, and imaging findings and input is then obtained from other surgeons who participate in the collaborative. This process provides a method to practitioners for input on management of difficult cases and is a novel method for enhancing education and awareness around such problems in abdominal wall hernia repair.

Summary

In summary, abdominal wall hernia is a common problem in surgical practice with numerous options for repair both in terms of technique and mesh choices. Increasingly, open approaches with posterior component separation with transversus abdominus release and retrorectus mesh placement are being utilized for patients with complex hernias. Robotic techniques may allow performance of these procedures laparoscopically in selected patients though outcomes to date are limited. Monitoring of outcomes through collaboratives like the AHSQC will be increasingly important for surgeons who commonly perform these procedures.

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CME Questions

1. Which of the following is an advantage of a robotic approach to laparoscopic inguinal hernia repair over conventional laparoscopic techniques?

a. Lower hernia recurrence rates

b. Less postoperative pain

c. Fewer complications

d. Enhanced ability to suture mesh

2. A 56 year old male with a BMI of 35 presents with a large incisional hernia from a midline laparotomy for a left colon resection 5 years previously. The hernia is cantaloupe size and on CT contains multiple loops of small intestine and the rectus muscles are separated by a distance of 7cm. The most suitable approach for management of this patient is?

a. Laparoscopic incisional hernia repair with barrier coated mesh

b. Open incisional hernia repair with onlay mesh

c. Open incisional hernia repair retrorectus approach with transversus abdominis release and permanent synthetic mesh placement

d. Open incisional hernia repair retrorectus approach with transversus abdominis release and biologic mesh

3. Which of the following mesh choices would not be appropriate for a sublay repair with intraperitoneal mesh placement for an incisional hernia?

a. Barrier coated synthetic mesh

b. Uncoated polypropylene mesh

c. PTFE mesh

d. Composite mesh

4. Which of the following factors is most likely to be associated with increased complications after incisional hernia repair.

a. Well controlled diabetes

b. Obese patient with BMI 31

c. Moderate alcohol use

d. Currently smoking

5. Which of the following is an advantage of laparoscopic incisional hernia repair over open repair for a patient with a moderate sized periumbilical incisional hernia?

a. Reduced risk of infection

b. Less prolonged procedure site pain

c. Lower rate of seroma formation

d. Achieves a more functional abdominal wall

6. The precise location of the mesh in a retrorectus incisional hernia repair is which of the following?

a. Intraperitoneal

b. Preperitoneal deep to the posterior rectus sheath

c. Anterior to the posterior rectus sheath and completely covered by the rectus muscle

d. Superficial to the anterior rectus sheath

7. Which of the following meshes could be considered in repair of a large incisional hernia in the setting of an accompanying enterocutaneous fistula?

a. PTFE mesh

b. Heavyweight polypropylene mesh

c. Polyester mesh

d. Lightweight polypropylene mesh

8. Which of the following databases currently captures surgeon and patient reported outcomes for abdominal wall hernia repair?

a. ACS-NSQIP

b. Nationwide Inpatient Sample

c. AHSQC

d. Vizient