9 Abdominal Wall Spaces for Mesh Placement: Onlay, Sublay, Underlay

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Introduction

Ventral hernia remains a vexing problem for the surgeon and the public alike. Laparotomy is associated with an incisional hernia rate of 3–23% [1, 2]. Despite contemporary efforts to understand and implement best practice techniques in fascial closure, the rate of ventral herniorrhaphy continues to rise. In the United States, where this health problem is compounded by an obesity epidemic, 384,000 ventral hernia repairs were performed in 2006 at a staggering cost of 3.2 billion dollars [3]. Hernia recurrence rates also remain unacceptably high, particularly considering the healthcare and societal costs. Mesh repair has decreased the longterm rate of recurrence from 63% for primary repair to 32% [4], but questions remain as to the optimal positioning of the prosthetic for reduction in hernia recurrence and other complications (Fig. 9.1).

Herein, onlay, sublay, and underlay mesh placement are explored and an algorithm based on the available evidence is proposed. Uniformity in the definition of the positions of mesh is imperative and the European proposed guideline is employed [5]. Inlay (interposition) mesh placement by which the mesh fills the defect and is attached to the fascial edges of the defect is discouraged due to the prohibitive risk of hernia recurrence and is not discussed further [6–8].

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Technique

Onlay Mesh Placement

Onlay repair involves placement of the mesh on the anterior rectus fascia below the subcutaneous layer after approximation of the anterior rectus fascia. The advantage of this technique is its ease of application. Depending on the degree of bowel adhesions and the chronicity and thickness of the hernia sac, limited subfascial and intraabdominal dissection may be possible. For small hernias where the fascia is more easily approximated, this is an attractive option. Onlay mesh placement is associated with a shorter operative time compared to sublay positioning [9]. Additionally, the mesh is not directly in contact with the intraabdominal contents limiting the risk for bowel adherence and erosion. In contrast, there is at least a theoretical increased risk for infection from skin flora related to contact of the mesh with the skin during placement or potential for dissemination of infection from a superficial site infection to this anteriorly placed mesh. Because this technique involves subcutaneous dissection to develop the space for mesh placement, it is suspected that the risk for seroma is elevated compared to deeper mesh placement. However,

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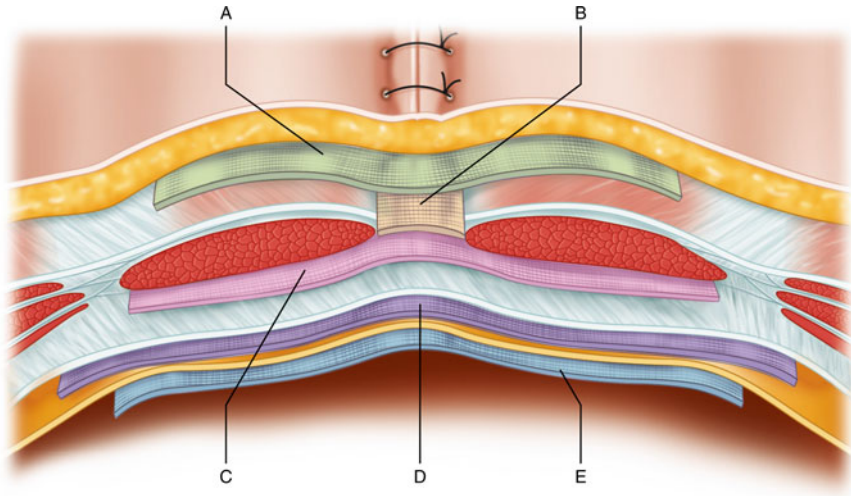

Fig. 9.1 Diagram of ventral hernia and mesh positioning (**a**) Onlay mesh (**b**) Inlay mesh (**c**) Retrorectus sublay mesh (**d**) Underlay preperitoneal (**e**) Underlay intraperitoneal

the clinical significance of sterile seroma formation is questionable.

In onlay repair, the hernia sac is dissected free and reduced. The hernia sac may be left intact though the necessity of inspection of the herniated contents may warrant opening of the sac. The anterior, subcutaneous space is developed through blunt and sharp dissection typically aided by cautery just above the anterior fascia. The anterior fascia is reapproximated in the midline. When this is not possible due to tension on the closure, components separation is employed. The optimal mesh size for this technique relative to the hernia size is not well established. The mesh is affixed widely with transfascial sutures. Self-adhering mesh or fixation with adhesives are alternative options. Drain placement, with careful handling and prompt removal as permitted, is recommended to address the expected seroma in the dissected subcutaneous space.

Sublay Mesh Placement

Sublay repair refers to placement of the prosthetic in the retromuscular space posterior to the rectus abdominis and anterior to the posterior rectus fascia. The retrorectus repair, popularized by Rives and later Stoppa and Wantz, revolutionized hernia repair by offering a robust treatment of complicated incisional hernias with a low recurrence rate [10, 11]. Contemporary series of the Rives-Stoppa repair have reaffirmed the value of the repair with reports of a low hernia recurrence rate of 5% while demonstrating an improved wound infection rate of 4% [12].

The retrorectus repair addresses the attenuation and lateralization of the rectus abdominis muscles and recreates the natural tension of the lateral obliques on the abdominal wall. The retrorectus space is well vascularized offering a favorable environment for tissue incorporation of the mesh. As with the onlay repair, the mesh is not in direct contact with the viscera if the posterior fascial closure is complete; however, the dissection associated with the retrorectus repair is decidedly more challenging than the onlay repair, particularly for recurrent hernias.

In the retrorectus Rives-Stoppa repair (Chapter 12), the midline skin is opened and the hernia sac is exposed and dissected free from the fascial edges as with the onlay repair. The sac may be adherent to overlying thin and sometimes ulcerated skin and may require excision of both. After opening of the sac, the bowel in inspected and adhesiolysis is performed to free the intestinal

loops from the abdominal wall. The abdominal wall is inspected for additional fascial defects. After completion of the intraabdominal dissection and irrigation, the posterior rectus fascia is opened at its medial edge on each side sharply with or without cautery and the space between the posterior rectus sheath and the rectus abdominis is developed in this avascular plane primarily with blunt dissection. The dissection is continued laterally to the margin of the rectus muscle where the landmark of the neurovascular bundles marks the extent of the dissection. Of note, below the arcuate line, the dissection is performed in the preperitoneal space of Retzius and of Bogros laterally, and thus the prosthetic mesh will only be separated from the peritoneal cavity by the peritoneum inferior to the arcuate line. The posterior layers are reapproximated in the midline and the mesh is placed in the retrorectus space. The anterior fascia is then reapproximated in the midline. For large defects where midline fascial approximation is not possible, separation of components may be needed either with external oblique release or transversus abdominis muscle release. Drains are placed at the surgeon's discretion. While frequently placed in the subcutaneous space, drain placement in the retrorectus space adjacent to the mesh should be done only after weighing the benefit of tissue apposition versus the risk of infection. An advantage of the retrorectus repair, compared to the onlay approach, is that the subcutaneous dissection is limited, made possible by the suture passing devices for the lateral transfascial mesh fixation sutures.

Underlay Mesh Placement

Underlay mesh placement describes mesh positioning in the preperitoneal subfascial space or the intraperitoneal space deep to the fascia and peritoneum. The intraperitoneal repair may be performed with either an open or laparoscopic approach, the latter associated with a lower infection risk [13, 14]. Compared to suture repair, both laparoscopic and open underlay mesh placement decreased recurrence risk without increasing the risk of serious mesh infection or fistula formation [7]. Underlay repair spares the perforating vessels compared to a wide onlay repair and avoids skin and musculofascial flaps potentially lessening the risk for ischemia and wound complications. In contrast to overlay repair, underlay may be more difficult and lengthy but more straightforward than sublay mesh positioning. Underlay mesh repair for incisional hernias may require extensive dissection and adhesiolysis to allow a clear space for a widely overlapping mesh repair. Additionally, if the overlying fascia cannot be reapproximated, a bridging mesh repair will not restore the midline. For some active patients, the functionality of such a repair is not optimal. Careful selection of the prosthetic mesh is critical to the longterm success of intraperitoneal underlay repair due to the exposure of the intestines to the mesh and potential for adhesions or erosion.

Similar to the other described techniques, underlay mesh placement involves freeing the hernia sac from the fascial edges and adhesiolysis of any adherent bowel or omentum. For preperitoneal underlay repair, the hernia sac is left intact if possible and the preperitoneal space is widely developed to allow adequate overlap of the mesh repair. Because preservation of the peritoneum can be difficult due to its thin nature, this technique is utilized primarily for smaller ventral defects such as umbilical or epigastric hernia repairs. These preperitoneal repairs are typically performed with open technique though laparoscopic repair has been reported [15].

Open intraperitoneal mesh placement is conducted in similar fashion but extensive adhesiolysis may be needed to identify all ventral hernia defects and to clear a wide berth for placement of the prosthetic with wide overlap of the hernia(s). Close abdominal wall inspection is essential for avoidance of the early hernia recurrence which may actually be a missed hernia defect. The intestine must be protected from the synthetic mesh with use of an adhesion-barrier coated polyester or polypropylene mesh or an expanded polytetrafluoroethylene mesh. Alternatively, in cases of contamination, biologic mesh is favored although its longterm durability is limited due to eventual eventration and reherniation, especially

in cases of where the overlying fascia cannot be closed. [16] The mesh is secured with transfascial mattress sutures and may be supplemented by absorbable or permanent tacks in between sutures to reduce the risk of bowel slippage anterior to the mesh in between the transabdominal sutures. Another common example of an intraperitoneal underlay mesh use is the Laparoscopic ventral hernia repair [17], described in detail in Chapters 21–22.

Evidence-based Surgery: The Best Position for Mesh Placement in Ventral Hernia Repair

Review of the available evidence does not yield a superior positioning technique for all aspects of ventral hernia repair. Much of the published literature is restricted to single-center retrospective series. However, some themes have emerged from the literature and are highlighted.

Mesh Position, Recurrence, and Seroma

Laparoscopic intraperitoneal repairs and retrorectus sublay repairs have the lowest reported hernia recurrence rates. A 2013 systematic review of 62 articles of ventral hernia repair and mesh positioning and over 5800 patients determined that the rate of hernia recurrence was highest for onlay (17%) or interposition (17%) compared to retrorectus (5%) or underlay mesh implantation (7.5%) [18]. In this systematic review, bridging interposition mesh repair was associated with the highest rate of overall complications, such as seromas. Of note, there were many more underlay repairs ($N=3641$) than retrorectus repairs ($N=743$) in this review. Additionally, the underlay group was heterogeneous in that it included both open and laparoscopic repairs and intraperitoneal and subfascial repairs.

The retrorectus repair may be the safest option in contaminated hernia cases. Rosen et al evaluated the surgical outcomes for biologic mesh repairs in contaminated fields [19]. In this post hoc analysis of a retrospective multicenter trial with short term follow up (1 year), the recurrence risk favored retrorectus repair despite larger defects in the intraperitoneal mesh repairs. A multicenter group also reported a low recurrence rate of 7% in contaminated ventral hernia repairs with macroporous lightweight polypropylene, with over half of the recurrences involving recurrent parastomal hernias [20]. The repairs in this study were heterogeneous but mesh was placed in the retrorectus space in 94% of the patients.

Laparoscopic repair compares favorably with open mesh repair in uncontrolled series. Helgstrand reported that laparoscopic repair decreased the risk of recurrence compared to open (15 versus 21%) [21]. Open repair, hernia defects larger than 7 cm, and open repair with onlay or intraperitoneal mesh were found to be risk factors for poor late outcomes. In another study, 50 unselected laparoscopic repair patients were compared to those with Rives-Stoppa herniorraphy [22]. The laparoscopic group had larger hernia defects, shorter hospital stay, fewer complications (24% versus 30%) and a lower rate of hernia recurrence (2% versus 10%) over a mean follow up of almost 21 months.

In contrast, a Cochrane review highlighted the limited conclusions that can be drawn from available randomized trials due to the short-term follow-up [23]. This review included ten randomized control trials with 880 patients and found that the hernia recurrence rate was the same for laparoscopic and open repair of various mesh positioning but half of the trials had less than two-year follow up. An earlier Cochrane review of eight trials concluded that open repair was superior to suture repair in terms of recurrence but insufficient evidence as to which mesh position or type was best [24]. Another metaanalysis of eight randomized controlled trials comparing laparoscopic and open incisional or ventral hernia repair found no difference in recurrence [14].

Mesh Position and Subsequent Surgery

The positioning of the mesh in ventral herniorraphy holds implications for future surgery. The best operative repair should be performed for the problem at hand without undue influence of the mere possibility of future surgery. However, there are subgroups of patients, such has Crohn's patients who have required prior surgery, for whom the possibility of future intraabdominal surgery and implications of intraperitoneal mesh should enter into the preoperative discussion with the patient while considering the options for repair and prosthetic type. Abdominal surgery after ventral hernia repair is not uncommon. In the United States, the Veterans Affairs National Surgical Quality Improvement Program data demonstrated that 25% of patients required subsequent abdominal surgery after ventral incisional hernia repair, with almost two-thirds of these involving recurrent repair [25]. Underlay or inlay polypropylene mesh repair was associated with increased operative time in subsequent abdominal surgery but without increased risk of inadvertent enterotomy.

In the Netherlands, Halm et al found that intraperitoneal polypropylene mesh repair complicated subsequent laparotomy in 76% compared to 29% with preperitoneal mesh and led to small bowel resection in 26% compared to 4% [26]. This learned group of European hernia experts recommended that intraperitoneal polypropylene mesh should be avoided.

Infection

Laparoscopic repair appears to be favored in terms of surgical site infection. While the systematic review by Albino et al concluded that surgical site infection was lowest for sublay retrorectus repair at 4%, the underlay group was heterogeneous including both open and laparoscopic repairs [18]. Another metaanalysis of 15 observational studies found that laparoscopic repair resulted in shorter length of stay, operative time, and a significant reduction in wound abscess and superficial site infection with a trend towards reduced hernia recurrence rate [13]. Systematic reviews of randomized controlled trials comparing laparoscopic and open ventral hernia repairs supported a decreased risk of wound infection in the laparoscopic group with a relative risk of 0.22–0.26 [14, 23].

Summary

The lack of a definitive solution to ventral herniorraphy in terms of the ideal mesh positioning underscores the complexity of this problem. No hernia patient or hernia defect is the same. Additional evidence is needed. Collaborative evaluation of the outcomes of various repairs and prosthetics is imperative. On an individual basis, the types of repairs within a given surgeon's armamentarium should be matched to the goals of the patient tempered by the characteristics of the hernia defect and the co-morbidities of the patient which might affect the surgical outcome. The shortcomings and benefits of the myriad of mesh products, both biologic and permanent synthetic, must be considered. This is an ever-changing environment in which the hernia surgeon must be vigilant and knowledgeable. The author's personal algorithm is outlined in the accompanying table and flowchart (Table 9.1 and Fig. 9.2). While such algorithms are based on available evidence, the decision ultimately is made between the patient and surgeon through thoughtful discussion and examination of the value of hernia repair for that individual patient.

Table 9.1 Author's approach to ventral hernia repair and mesh placement

Concern	Author's preferred approach based on available evidence	Author's reasoning
Contaminated ventral hernia repair	Open retrorectus repair with biologic graft or bioabsorbable synthetic mesh. Bridging or partially bridging repair may be needed depending on hernia defect size	While there are published reports of use of lightweight polypropylene mesh in the setting of contamination, the lower risk of hernia recurrence associated with the permanent prosthetic must be weighed against the risk of chronic infection and need for subsequent procedures particularly with combined colon surgery. If a recurrence occurs (higher risk with a bridging repair), recurrent hernia repair could then be performed laparoscopically or open with presumably less bioburden of infection
Chronically infected mesh with recurrent hernia with wide defect	Open repair and removal of foreign body with retrorectus or underlay biologic or bioabsorbable mesh reinforcement +/- components separation if midline closure or partial fascial closure can be achieved. Otherwise bridging underlay repair reserving definitive treatment after infection is cleared	Addresses chronic infection which is likely the main complaint. Thorough preoperative discussion and education is vital to patient satisfaction especially if staged repair beginning with bridging biologic mesh repair is indicated. Components separation can be performed but if it is apparent that midline closure is not achievable, this should be reserved for later definitive repair
Chronically infected mesh with recurrent small defect	Open repair and removal of foreign body with retrorectus or underlay biologic or bioabsorbable mesh +/- components separation	Addresses chronic infection which is likely the main complaint. Of the open repair options, rectorectus repair appears favorable in terms of infection risk
Obesity	Preoperative risk modification (weight loss) and laparoscopic underlay intraperitoneal mesh repair with primary closure of smaller defects	Lower risk of wound infection compared to open repair and allows for wide overlapping mesh repair
Healthy active patient with ventral hernia and main complaint of laxity	Open retrorectus repair with permanent synthetic mesh	Addresses laxity issue and functionality through reconstruction of the midline with a lower risk of hernia recurrence and skin complications compared to onlay or underlay mesh placement
Ventral incisional hernia without infection with undesired redundant skin and wide scar	Open retrorectus repair with permanent synthetic mesh with or without components separation depending on defect size combined with plastic surgery	Addresses patient priorities of repair of symptomatic hernia and scar revision/panniculectomy with lowest infection risk for open repair
Recurrent ventral hernia after failed open repair	Laparoscopic repair if failed open repair (onlay repair, components separation with/without mesh, or primary repair)	Avoids prior operative field and repair associated with equivalent recurrence risk but lower infection risk. Caution should be exercised with adhesiolysis after prior intraperitoneal mesh
Ventral incisional hernia with expectation of subsequent laparotomy (e.g., Crohn's disease)	Open retrorectus repair with permanent synthetic mesh (lightweight macroporous polypropylene mesh)	Intraperitoneal mesh may complicate future surgery and could become the site of infection with subsequent bowel surgery. Lightweight polypropylene mesh may be salvageable after surgical site infection

Concern	Author's preferred approach based on available evidence	Author's reasoning
Atypically located ventral hernia (high epigastric, suprapubic, lateral or flank)	Laparoscopic repair with bony mesh fixation for suprapubic and lateral or flank hernias	Allows wide mesh overlap even under rib margin and bony/ligamentous fixation
Morbid obesity bariatric surgery candidate with non-obstructed ventral hernia	Bariatric surgery first (laparoscopic sleeve gastrectomy if bowel herniation or extensive adhesions); If hernia does not need to be addressed (e.g., herniated omentum) then the defect is left unrepaired. If the defect is disturbed (contents reduced), it is repaired with underlay bridging biologic mesh deferring definitive repair until after weight loss	Addresses underlying problem and patient prioritized problem of morbid obesity while allowing the most effective hernia repair optimally performed after weight loss

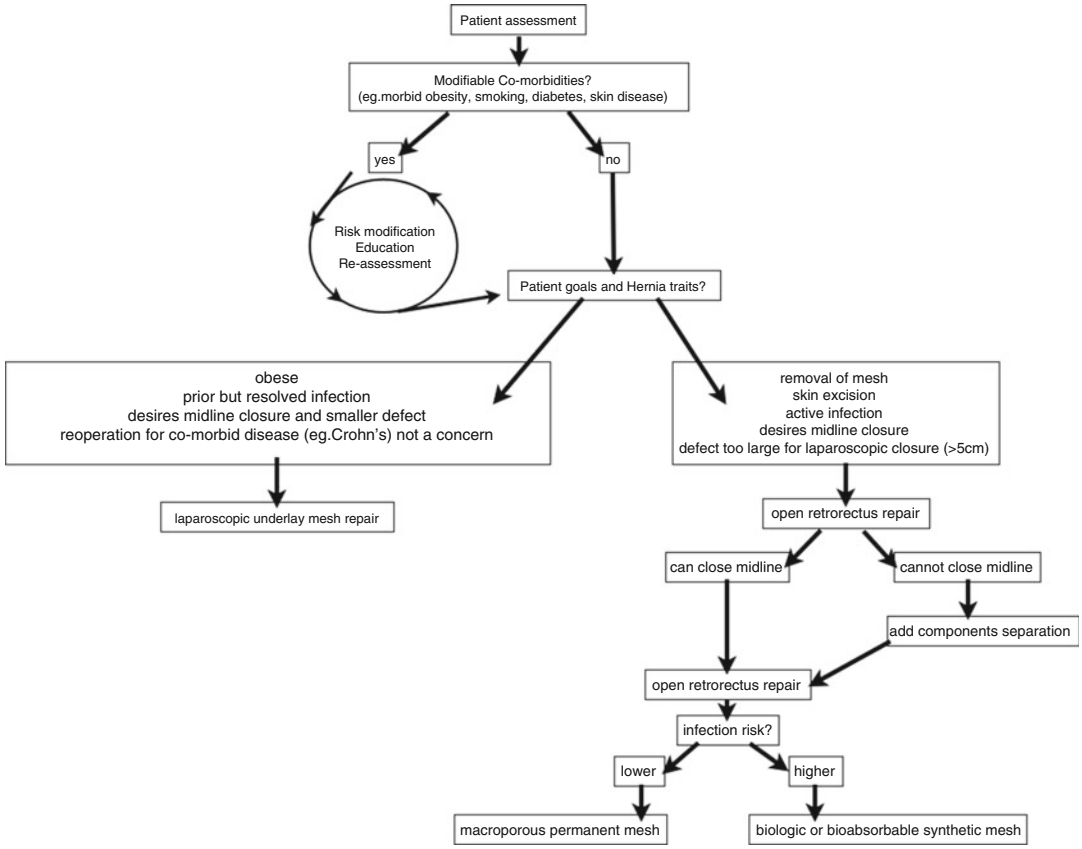

Fig. 9.2 Algorithm for technique/mesh selection

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