Abdominal wall reconstruction

Abdominal wall hernias can be challenging and complicated to manage. The techniques to deal with them are evolving rapidly with increasing adaptation and utilization in general surgery.

Over the last decade there have been significant advances in the treatment of large abdominal wall hernias with a concurrent exponential increase in the number and type of prosthetic materials available for repair. The management has changed little, however, with the only two options of either surgical repair or conservative treatment being polar opposites. For many patients conservative treatment with a supportive garment is unacceptable because of the symptoms of pain, discomfort, physical appearance and lifestyle limitations that they suffer.

Historically many of these patients were treated conservatively because of concerns over the magnitude of the operation, risk of complications and frankly because many surgeons lacked the expertise to deal with such challenging problems (*Figure 1*). Increasingly that is changing as more general surgeons become familiar with abdominal wall reconstruction techniques. The principles of successful reconstruction include tension-free approximation of well-vascularized tissues, reconstruction of the linea alba (the central tendon of the abdomen), with or without separation of components, reinforcement of the repair with a suitable prosthetic and the avoidance of surgical site infection.

Figure 1. Complex abdominal wall defect with fistula after necrotizing fasciitis.

These principles were well established within plastic surgery and described by Ramirez 25 years ago (Ramirez et al, 1990) but are increasingly being adapted and used in general surgical practice. The explanation for this is simple; abdominal wall hernias complicate between 11 and 23% of all laparotomies (Cengiz and Israelsson, 1998; Cassar and Munro, 2002; Fink et al, 2014). Additionally, incisional herniation remains a significant cause of morbidity and a burden on our health-care system's resources. The large number of techniques described in the literature for the repair of incisional hernias suggests that no single technique has stood out as being significantly better than any other. Reported recurrence rates of more than 10% are unacceptable. In a comparative, retrospective review of over 400 operations over a 25-year period Langer et al (2005) estimated that the most important prognostic factor was the experience of the operating surgeon. It stands to reason, therefore, that any general surgeon contemplating abdominal wall reconstruction has to have mastery of all of the following: knowledge of prosthetic materials, both synthetic and biological, and when and where to use them, anterior and posterior separation of components, vacuum-assisted closure devices and when to involve a plastic surgeon.

Prevention is obviously better than cure. Incisional herniation and surgical site infection are significantly reduced by using a fastidious midline closure technique with a 2/0, slowly absorbing, continuous suture, achieving a suture to wound length ratio of 4:1 which effectively avoids undue tissue tension (Millbourn et al, 2009).

Risk reduction

Preoperative assessment and risk reduction has also evolved over the last decade and is essential in ensuring

Mr Nicholas Stylianides is Consultant General and Colorectal Surgeon in the National Intestinal Failure Centre, Salford Royal NHS Foundation Trust, Salford

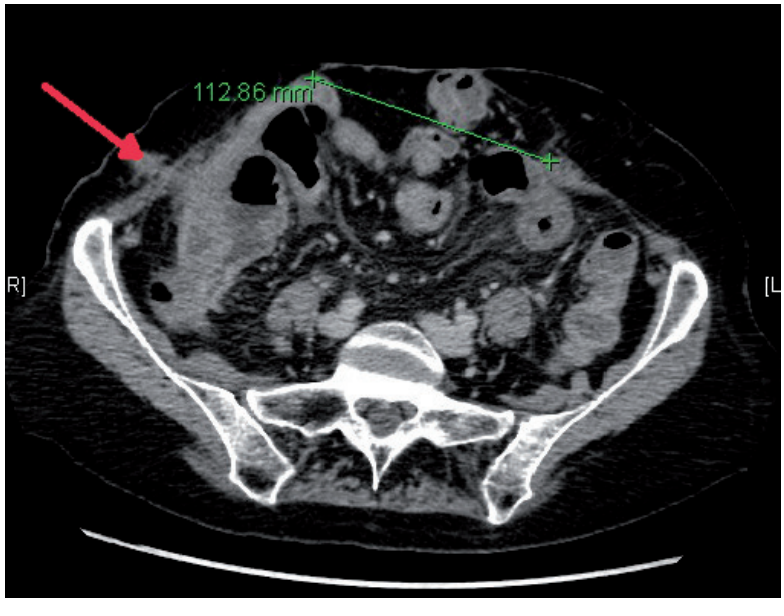
Mr Dominic AJ Slade is Consultant General Colorectal and Intestinal Failure Surgeon in the National Intestinal Failure Centre, Salford Royal NHS Foundation Trust, Salford M6 8HD

Correspondence to: Mr DAJ Slade (dominic.slade@srft.nhs.uk)

successful surgical repair of large abdominal wall defects. Any surgeon considering an abdominal wall repair must have an appreciation of the magnitude and range of surgical techniques required to repair these defects and the potential for significant harm. He/she must understand the impact of comorbidities on recurrence rates and, in conjunction with the preoperative assessment clinic and anaesthetist, conduct a detailed assessment to identify potential risk reduction strategies. Managing preoperative factors such as obesity, smoking and diabetes both in the causation and recurrence of incisional hernias is essential. The risk of recurrence following abdominal hernia repair increases with increasing body mass index. Patients with a body mass index of 50 kg/m^2 or higher have an unacceptably high risk of hernia recurrence (Martindale and Deveney, 2013). Other factors such as perioperative glycaemic control to reduce surgical site infection and preoperative cessation of smoking at least 30 days before surgery have been shown to halve the risk of total complications.

Preoperative computed tomography imaging of the abdomen and pelvis is essential in planning the most appropriate technique for abdominal wall reconstruction. It allows assessment of the size, number and relationship of abdominal wall defects and hernia sacs to the viscera and abdominal wall musculature. Computed tomography also helps to identify the position and size of previously placed prosthetic mesh(es) and any associated infection or sinus tracts (*Figure 2*). Finally it can be used to assess loss of domain by calculating the volume of the hernia as a percentage of the peritoneal cavity volume. This gives a value to the quantity of the viscera existing outside its normal residence. Values equal to or exceeding 20% predict postoperative problems of abdominal compartment syndrome and respiratory embarrassment if the hernia contents were to be replaced into the peritoneal compartment.

Figure 2. Computed tomography scan of lower abdomen showing (red arrow on left side) a right iliac fossa enterocutaneous fistula track arising from Crohn's disease in the neoterminal ileum. There is a significant abdominal wall defect at this level from a previous laparostomy (line with measurement denoting 112 mm abdominal wall defect).



Open techniques

Suture repair

Simple suture repair

Successful wound healing by primary intention requires the tension-free approximation of clean, well-vascularized wound edges. Solitary hernias that are less than 2 cm in diameter should be primarily closed with a slowly or non-absorbable sutures. There is no evidence to suggest that the Mayo technique of overlapping fascial edges in umbilical hernias increases or improves the strength of the repair and in fact may weaken it (Farris et al, 1959; Paul et al, 1998). Defects larger than 3 cm in size do not allow simple suture repair alone and require reinforcement with a suitable mesh with a 5 cm overlap of the fascial edges.

Near and far suture technique

This tension-relieving suture technique (Malik and Scott, 2001) has been used to approximate widely separated fascial edges. By alternating between small and large bites of sheath on opposite sides of the defect, a modified vertical mattress suture can be inserted to achieve midline closure. The attraction of this closure technique in contaminated or dirty wounds is that it avoids the use of a prosthetic mesh and the possibility of subsequent mesh infection. Initially believed to be a robust technique, suture repair alone without mesh reinforcement is associated with unacceptable recurrence rates of in excess of 50% at long-term follow up (Korenkov et al, 2002; Flum et al, 2003). There is conflicting evidence around other associated morbidity including seroma formation, which is possibly as low as 4% (Shukla et al, 2005).

Deep tension sutures

Usually only used in the extreme situation of a burst abdomen, this technique uses a series of interrupted, non-absorbable sutures passed through all layers of the anterior abdominal wall, 2–4 cm away from the wound edges. The sutures are then passed through short sections of drain tubing over the wound surface before tying under tension to prevent damage to the underlying skin. In the authors' opinion there is no place for this technique as it has no evidence base, usually fails, generates terrible skin scarring and causes pressure necrosis of the underlying muscle making subsequent definitive repair markedly more difficult.

Prosthetic mesh repair

Inlay technique

The inlay method does not approximate the fascial edges and places the prosthetic mesh in the peritoneal cavity in direct contact with the underlying viscera where it may form extensive adhesions. The mesh therefore has the potential

to erode into the intestines and produce a chronic mesh infection associated with an enterocutaneous fistula. This is often the preferred position for laparoscopic hernia repair (see below) and consequently newer prosthetics have been created with anti-adhesion barriers to minimize this risk. In a retrospective comparison of inlay, sublay and onlay techniques, inlay was the poorest by far, with recurrence rates of 44% and two out of 23 patients developing a fistula (De Vries Reilingh et al, 2004). Open inlay techniques are not recommended routinely.

Onlay technique

The onlay technique is the simplest procedure where a mesh placed in the subcutaneous prefascial space reinforces the closure. The mesh is anchored directly to the underlying fascia with sutures and is versatile, allowing repair of lateral abdominal wall defects. Owing to its simplicity it was widely adopted and an initial report suggested relatively low 5-year recurrence rates of 15% (San Pio et al, 2003). A systematic review of just two suitable randomized controlled trials did not identify a difference in recurrence rates between the onlay and sublay techniques but suggested an increased risk of seroma with the former (Den Hartgog et al, 2008). However, a more recent meta-analysis has shown a lower recurrence and infection rate with the sublay technique (Timmermans et al, 2014).

Sublay technique (Rives–Stoppa–Wantz retrorectus repair)

The sublay technique involves positioning a mesh over the closed posterior rectus sheath and peritoneum. The rectus abdominis muscles are then returned to their anatomical position and the anterior sheath closed, reconstructing the linea alba. The mesh is effectively enclosed in a fascial pocket. It is understandably the more technically demanding repair of the three open approaches. It was popularized by three independent surgeons whose names are synonymous with the technique. It has a superior track record and was adopted as the gold standard approach by the American Hernia Society in 2004. The retrorectus space is limited, however, and as such hernia defects greater than 10 cm cannot be repaired with this method alone as it does not permit adequate mesh overlap. In the lower third of the repair a frequently tenuous layer of peritoneum covers the viscera and this is difficult to reconstruct when dealing with stomas and their associated defects. Finally it is not possible to use this approach for laterally placed incisional hernias. The sublay technique is the authors' preferred method of repair but has been associated with a recurrence rate of up to 10% (Bauer, 2002; Yaghoobi Notash et al, 2007).

Anterior abdominal wall anatomy

A thorough understanding of the anatomy of the abdominal musculature, its innervation and blood supply is essential before attempting any form of complex abdominal wall reconstruction. Armed with this working knowledge the surgeon can create a well-vascularized, normally innervated and biomechanically advantageous reconstruction. Exhaustive anatomical detail is beyond this review but a brief overview is described below.

The key structures in terms of operative anatomy are the two vertically orientated rectus abdominis muscles taking their origin from the symphysis pubis and inserting into the costal cartilages of the 5th–7th ribs. Medially they fuse to make the linea alba and disruption of this allows unopposed lateral pull on the defect by the muscles, increasing the size of a midline hernia. Laterally three, flat layered muscles are found, starting superficially with the external oblique, then the internal oblique and the deepest layer the transversus abdominis muscle. All three muscles contribute or fuse to form the rectus sheath; the number varying in the upper, mid and lower thirds of the abdomen. At the edge of the recti the external oblique and the rectus sheath fuse to form the linea semilunaris, an important landmark for both anterior and posterior component separation.

Anterior separation of components (Ramirez)

This is a fascial release of the rectus abdominis muscles by performing a fasciotomy of the external oblique aponeurosis at the lateral edge of each rectus and then dissecting a plane between the external and internal oblique aponeuroses. It allows up to 10 cm of medial advancement for each flap. It can be used to close central defects up to 20 cm in size but practically in the upper abdomen defects are usually smaller than this because of a more modest mobilization limited by attachments as the costal margin is crossed. The midline can also be reinforced with an onlay or sublay mesh. Anterior component separation necessitates the creation of large lipocutaneous flaps bilaterally to allow visualization of the linea semilunaris and leads to the transection of the deep epigastric perforating blood vessels leaving the central abdominal skin without its blood supply. This can contribute significantly to midline wound dehiscence and necrosis (Clarke, 2010).

Techniques to reduce wound ischaemia include preservation of the periumbilical perforating vessels by performing a closed fasciotomy (PUPS repair) and laparoscopic release (Cox et al, 2010). It also has the disadvantage of weakening the lateral sidewall at the point of fascial release and the authors' preference is to reinforce these weak points with onlay mesh sutured to the fascial edges to prevent subsequent lateral hernias developing.

Since its original description by Ramirez, it has been refined many times and has gained wide acceptance as a technique that is relatively easy to master and successfully closes most hernia defects. Wound complications are common – significant wound morbidity was reported in 24%, and incisional hernia in 18.2% of the 354 cases reported in the largest meta-analysis reported to date (De Vries Reilingh et al, 2004). It is less successful in dealing with subcostal, subxiphoid, suprapubic and laterally placed hernias or stomal defects. Separation of components may create particular problems when an associated gastrointestinal reconstruction requires creation of stomas

through an abdominal wall that has been weakened or distorted by the dissection required for separation of the external and internal oblique muscles. It is unclear whether this results in a significantly greater incidence of parastomal hernia, although that would certainly seem likely.

Posterior separation of components and transversus abdominis release (TAR)

This operation starts as a Rives–Stoppa–Wantz repair within the retrorectus space (*Figure 3*). As described this space is limited laterally by the linea semilunaris which prevents satisfactory mesh placement, overlap and a tension-free repair for larger incisional hernias. Enlarging this space can be achieved either through extending the preperitoneal dissection, intramuscular plane formation, or release of the transversus abdominis muscle (*Figures 4–6*) (Krpata et al, 2012). Division of the transversus releases the circumferential 'hoop' tension allowing for expansion of the abdominal cavity and significant medial advancement of the posterior rectus fascia. This approach allows placement of a very large prosthetic with wide overlap, which can treat incisional hernias off the midline and those close to bony margins, and is consistently associated with recurrence rates well below 10% (Pauli and Rosen, 2013).

Figure 3. Posterior component separation: step 1 – incising the posterior rectus sheath. The right rectus muscle fibres are visible. Note also the remnant suture material from a previous failed inlay repair.

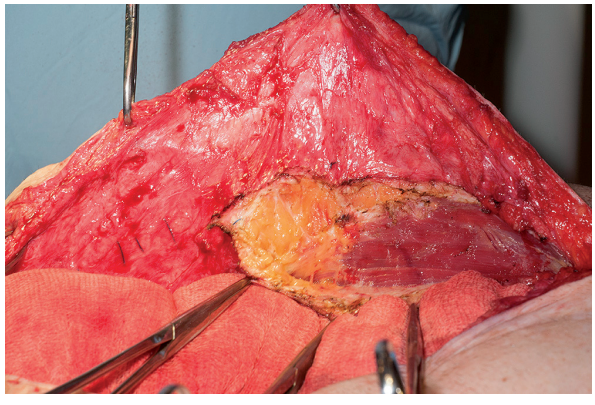
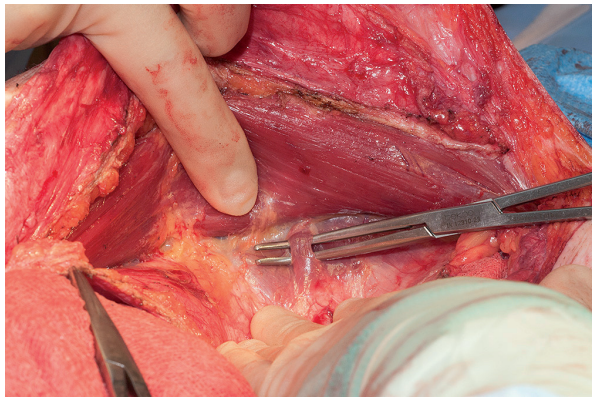


Figure 4. Posterior component separation: step 2 – division and release of the transversus abdominis belly.



Published series show similar rates of wound complications as anterior component separation but the severity of these complications was less.

Laparoscopic ventral hernia repair

Minimal access surgery approaches can deliver reduced wound infection rates, shorter hospital stays, reduced perioperative pain and quicker return to work at the cost of longer operating times when compared to open surgery. Laparoscopic ventral hernia repair differs in that postoperative pain remains a significant factor and current randomized controlled trial data are too heterogenous to confirm shorter hospital stays. A literature review of laparoscopic ventral and incisional hernia in over 3000 patients showed the two commonest complications were seroma formation (5.45%) and postoperative pain (2.75%) (Bedi et al, 2007), while the reported wound or port cellulitis rates were just 1.56%. A Cochrane review from 2011 did not support laparoscopic repair over open approaches but overwhelmingly demonstrated a four-fold reduction in wound infections (Sauerland et al, 2011). The hernia sac is usually left in place and consequently most patients develop a seroma postoperatively but this is often asymptomatic and resolves spontaneously.

It is interesting to note that only 27.4% of all such repairs are performed laparoscopically (Colavita et al, 2012). The complexity of the technique, the difficulty in approximating the midline in larger defects and the

Figure 5. Posterior component separation: step 2 continued.

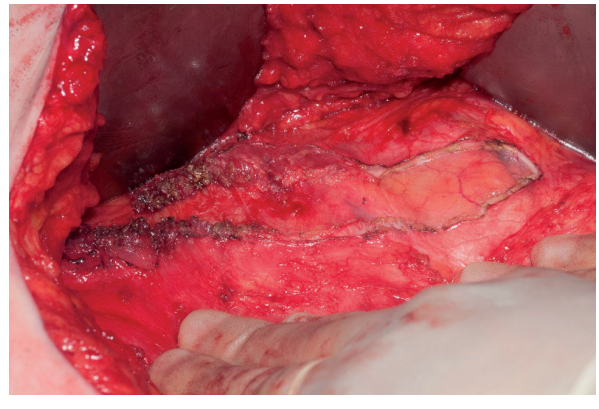
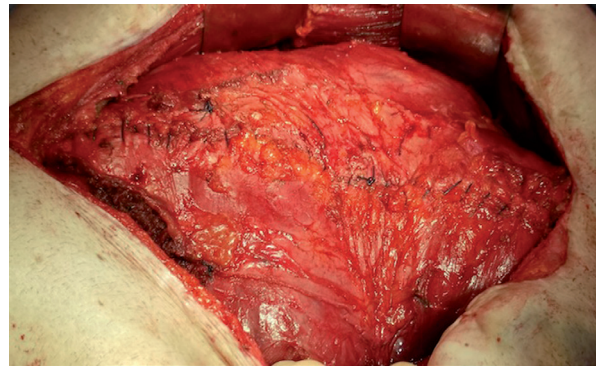


Figure 6. Posterior component separation: step 2 completed bilaterally.



1–3% risk of incidental enterotomy, which is higher than that for open repair, may all be relevant factors (LeBlanc et al, 2007). The technique involves mesh placement in a retrorectal, preperitoneal or intraperitoneal position, reinforcing the abdominal wall on the high-pressure side of the defect with at least 5 cm of overlap to allow for mesh shrinkage. Placement of an intraperitoneal mesh, even with an anti-adhesion barrier, can still lead to bowel adhesions at the fixation points and even with omental interposition may affect up to one third of patients (Bingener et al, 2004). There remains controversy around restoring midline apposition of the abdominal wall musculature and concerns that bridging the gap may increase the risk of subsequent recurrence. The laparoscopic approach is absolutely contraindicated in emergency laparotomies involving strangulated bowel, and in patients with coagulopathy, and relatively contraindicated in patients with hostile adhesions, incarceration, and loss of domain or infected or contaminated fields. A meta-analysis comparing eight randomized controlled trials following laparoscopic or open ventral hernia repair showed recurrence rates to be similar at 3.4% and 3.6% respectively (Forbes et al, 2009).

Myofasciocutaneous flaps

Plastic surgical flaps are probably best reserved for large defects (>200 cm^2) in fit patients. In the authors' practice they are reserved for patients with significant tissue loss as occurs after necrotizing fasciitis. Pedicled flaps based upon the lateral circumflex femoral artery, such as the subtotal lateral thigh flap, are technically demanding but allow virtually the entire abdominal wall (800 cm^2) to be replaced. This flap is a myofasciocutaneous flap and allows reconstruction of the abdominal wall skin as well as muscle, with a reasonable cosmetic result (*Figure 7*). The donor site usually requires covering with a split skin graft taken from the contralateral thigh. The complexity and high complication rates associated with such procedures probably limit their applicability to specialized centres (Lambe et al, 2012).

Conclusions

The literature demonstrates considerable variation and often unacceptable recurrence rates for abdominal wall reconstruction in excess of 10%, while at the same time showing that surgical expertise is associated with better outcomes. It follows that the operating surgeon is trained in a range of abdominal wall reconstruction techniques, particularly because not all hernias can be repaired the same way. Abdominal wall reconstruction is associated with a significant complication rate mainly comprising wound morbidity which in itself requires expert management. **BJHM**

Conflict of interest: Mr N Stylianides – none; Mr DAJ Slade receives educational honoraria from Cook.

KEY POINTS

- Preoperative assessment, planning and risk reduction are essential to ensure good outcomes.
- Computed tomography scanning should be considered for all patients undergoing abdominal wall reconstruction.
- Defects greater than 3 cm should be reinforced with a prosthetic mesh.
- The principles of successful repair include protection of the viscera, reconstruction of the linea alba and placement of retrorectus prosthetic mesh with a minimum of 5 cm overlap of the repair.
- Any surgeon performing abdominal wall reconstruction should be trained in a range of techniques including separation of components.

Figure 7. Abdominal wall defect reconstructed with myofasciocutaneous pedicled flap derived from right thigh tensor fascia lata (same patient as *Figure 1*).

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