

Preventing incisional ventral hernias: important for patients but ignored by surgical specialities? A critical review.

## MAIN TEXT

### Introduction

Incisional hernia is defined as “any abdominal gap with or without a bulge in the area of a postoperative scar perceptible or palpable by clinical examination or imaging” (1). Incisional ventral hernias (IHs) following surgery to the abdomen, pelvis, and retroperitoneum are a major public health issue with appreciable morbidity and occasional mortality (2-6). Recurrence after repair and mesh-related complications are also meaningful (7, 8). Approximately one-third undergo further surgery (9). Patients who have suffered an IH will likely recognise the impact on their quality of life. Apart from hernia, some incisions on the abdomen may also lead to severe problems like the denervation of the abdominal muscles (10).

Despite much having been written, IHs appear to generate little interest; indeed, the attitude among some surgeons seems complacent. ‘Closing time’ is sometimes viewed as ‘coffee time’ for senior staff while inexperienced trainees are left to close the wound (11). The problem persisting to such a degree is perhaps surprising in these days of cost containment, increasing scrutiny, and surgical sophistication (12).

Various solutions have been advocated, such as optimising wound selection, small bites (SBs) closure, and prophylactic mesh augmentation (PMA)(13). While the latter is increasingly popular, concerns about mesh have reached the lay press (14). Other proposals include dedicated wound closure teams and financial penalties for IH occurrences (15). Many assume IHs are primarily a complication after digestive surgery, with generalists being called upon to repair the defect.

This is a critical review focused on the importance of incisional hernias across different surgical disciplines (16, 17). We have reviewed literature, since 1980 to December 2019, from the following databases: Medline, Embase and Journals@Ovid Full Text. We have discarded conference abstracts, posters, symposia, oral sessions, comments notes, animal studies and patents. The key-concepts searched in each field were: incisions, hernia, incidence and complications. Additional articles were collected by cross referencing from the primary literature search. Only articles rated as acceptable or high quality according to SIGN checklist were included (17). We have not attempted to make a systematic review of the literature, as it will be certainly too ambitious to cover all disciplines, their incisions and incisional hernia rates. The objective of this article is to raise awareness of IHs and plead for greater collective efforts to reduce the frequency to a realistic goal of <10% across disciplines.

### An underestimated complication

IHs are reported to occur following 5–20% of conventional laparotomies (18). Emergency procedures are at greater risk (19). These figures increase to over 30% in subjects with obesity and significant comorbidity (20).

IHs are encountered across all surgical procedures requiring access through the abdominal wall. In a radiological study of IHs in 491 oncological patients, Baucom et al. reported that 62% developed a defect after hepatectomy, 45% after cystectomy, and 23% after open

nephrectomy (21). In colonic stomas sites, parastomal hernias have even been considered as an inevitable complication.

Diagnosis is complicated by the lack of a standardised IH definition. The methods, clinical or radiological, to assess IH also may contribute to the incidence, as oligosymptomatic or asymptomatic patient may not be diagnosed in clinical or phone follow-ups. Consequently, a short follow-up, limitations of physical examinations, and omission of ultrasound or CT scanning contribute to missed diagnoses (13). Also, patients treated by one discipline are frequently referred to generalists for treatment, with no communication between teams. Further, some patients die of their disease before an IH is recognised or treated (e.g. following pancreatic resection for cancer (22)). Finally, hospital coding issues may contribute to inaccurate incidence figures.

#### Incisional hernia across different specialties

##### Digestive surgery

Access to the abdominal gastrointestinal tract traditionally involves an open midline approach, though laparoscopic techniques are rapidly gaining ground.

Compared with results obtained from randomised controlled trials (RCTs), registry data suggest a surprising lower frequency of IHs. Data from the Swedish Colorectal Cancer Registry showed that the cumulative incidence of hospital-diagnosed IHs five years after 28 913 open resections via predominantly midline incisions was 5.3% (23). Meanwhile, a South Korean claims data analysis recorded 1.5% IH incidence (24), and the US inpatient Healthcare Cost and Utilization Project reported an 8.3% repair rate at a mean of 27 months (25). By comparison, recent European RCT on prevention after open midline laparotomy suggest IH rates following open surgery of 18.5–46.8% after 2–5 years' follow-up (3, 26-29).

Laparoscopic procedures are associated with lower IH frequency. Aetiological factors include patient comorbidity, site location, and dimensions of the specimen extraction site (30). In a meta-analysis of comparative trials of laparoscopic versus open colorectal surgery involving 6540 patients, laparoscopic had a 7.1% IH rate, compared with 13.6% after a conventional approach (31). Lee et al. examined the occurrence of IHs at specimen extraction sites (32), finding 10.6% for midline approaches, 3.7% for transverse incisions, and 0.9% for Pfannenstiel incisions. In the Spanish registry of IHs, trocar hernias were encountered in 16% of registrants.(33).

Regarding trocar site hernias, an interesting study of a national registry showed a cumulative risk for trocar site hernias of 1.3% (34). However, in a RCT focused on trocar site hernia prevention in high risk patients undergoing laparoscopic cholecystectomies, the incidence of trocar site IH was much higher: 31.9% in the non-mesh prevention group versus 4.4% in the mesh prevention group (35).

##### Hepato-pancreato-biliary surgery

Nilsson et al. reported that 30.5% of patients developed an IH after an open resection for colorectal liver metastases, usually via extended right subcostal or Mercedes incision (36). The hernia was in the midline in 84.6%. Other hybrid incisions favoured by hepato-pancreato-biliary surgeons are also at risk. In a Japanese study, 21.7% of patients undergoing a reverse-T

incision were diagnosed with an IH (37). By comparison, an IH was detected in 6.3% of median incisions, 4.7% of J-shaped incisions, and 5.4% of right transverse incisions with a vertical extension. The only case-control study on IH prevention in this field reported a much higher incidence of 17.5% after bilateral subcostal incisions (38). Once again, the midline component appears to be most vulnerable.

## Urology

An extraperitoneal approach to the pelvis via a Pfannenstiel incision is associated with IH rates as low as 3.5%.(39) However, in Southern Californian patients undergoing radical cystectomy and urinary diversion followed up for a median of 57 months, 21 of 92 were diagnosed with a parastomal hernia (23%) and 125 of 670 (18.7%) were found to have an IH.

The incision to the flank deserves particular attention. True herniation and/or bulging between the 10th rib, iliac crest, paraspinal muscles, and edge of the rectus abdominis is encountered after surgery for renal/ureteric, aortic, and spinal disease, and after living donor nephrectomy. Access usually involves incising the 3 layers of the external, internal, and transversus abdominis muscles. Between the internal and transversus abdominis run the intercostal nerves responsible for innervation of the abdominal wall. Cadaveric dissections revealed that the most significant intercostal nerve contributions to the anterolateral abdominal wall arise from T11 and T12 (40). They can be easily damaged during lumbotomy, resulting in musculoaponeurotic atrophy, bulging, and chronic pain. Although a bulging has been defined as flank weakness or laxity that produces a bulge without an obvious fascial defect (10), this differentiation could be quite difficult to assess despite an appropriate radiological study. In the review published by Zhou and Carlson, an IH incidence of 17% was calculated. This figure is probably an underestimation, as the many of the reports included do not differentiate between a true hernia sac and bulging. Additionally, in a more recent study of patients undergoing kidney surgery, Osman et al. found 6 months postoperatively that 10% had a lumbar hernia and 14% a bulge.(41). We have not found any study on prevention for this challenging flank incision.

## Obstetrics and gynaecology

Gynaecological surgery is generally associated with a low risk of herniation. In a Swedish population-based study, Bewo et al. reported a cumulative incidence of 2.0% following all types of open procedures via midline, Pfannenstiel, or Joel-Cohen incisions (42). Tecce et al. examined the risk of IH in 2145 women undergoing an open hysterectomy and found an IH repair rate of 3.5% (43). Spencer et al. reported a 9.8% IH rate at 1 year following laparotomy for ovarian cancer (44), and Franchi et al. encountered a 16.9% IH rate at 10 years' follow-up after an extended hysterectomy and bilateral salpingo-oophorectomy for malignant disease via a midline incision (45).

Caesarean sections are also at low risk for IHs. In a review comprising 275 878 women followed for between 6 months and 10 years, the IH frequency was 0.0–5.6%.(46). There is no data available focusing on incisional hernia prevention in gynaecological surgery

## Vascular surgery

The vascular surgery landscape has been revolutionised by endovascular procedures. The conventional approaches for open aortic surgery have been via midline, transverse, or

flank/thoracoabdominal incisions. Outcomes depend on whether the operation is for an aortic aneurysm or aortoiliac disease, with the former being shown to have a threefold risk for IHs (47).

Elective aneurysm surgery via a midline approach was previously believed to result in more IHs. A recent review, however, found no significant difference in IH rates between transverse, off-midline, and midline incisions (48). A RCT on incisional hernia prevention after midline laparotomies for abdominal aortic aneurysm (AAA) disclosed a 28% incisional hernia rate at 2 years in the conventional closure group. No hernias were detected in the retromuscular prophylactic mesh group (49). Despite the clinical evidence shown in meta-analysis (50), the recent guidelines from the European Society of Vascular Surgery on AAA surgery only recommends to use prophylactic mesh in “patients at risk” (51), and the NICE guidelines did not even mention recommendations on incisions or abdominal wall closure (52).

### Transplantation

Patients undergoing transplantation are at greater risk because of comorbidity, immunosuppression, and incision types. Overall, Garmpis et al. reported a lifetime risk of developing an IH after liver transplantation of 1.7–43%, with some researchers detailing rates of <5% for Mercedes and bilateral subcostal incisions (53). Janssen et al. reported that, when detected, IHs are commonly located at the junction of transverse and midline incisions (54).

In contrast, renal transplantation commonly involves a retroperitoneal approach via a curved Gibson incision in the iliac fossa. This approach appears to have a lower IH formation risk of 3.2% at a median follow-up of 59 months (55). To date, there has been only 1 report of case series on the use of a prophylactic mesh in renal transplantation (56).

### Morbidity and cost implications

Surgical repair is generally recommended for patients with symptomatic IHs (57). Around 153 000 IH repairs are performed annually in the United States (5). During 2006, over \$3.2 billion was spent on ventral hernia repairs of all types (58). A 1% reduction could save \$32 million annually. In France, Gillion et al. report that 13000 IH repairs are performed per year at a global cost of around €84 million (4). This is not only expensive for providers, but also those undergoing surgery, some of whom may not appreciate the implications of an IH. Based on these figures, a 5% reduction in IHs across France could save €4 million annually. Tecce et al. demonstrated that the combined cost of caring for patients who developed an IH after open hysterectomy was 3 times higher than for those who did not (43).

### Issues associated with repair

Repairing IHs is more challenging than operating on primary ventral hernias (59). Regrettably, some patients die (60). As we aforementioned, surgery does not guarantee that the patient will be free from recurrence or suffer other complications (6, 7, 9).

### What is a successful outcome?

An issue after IH repair is sometimes a mismatch between what surgeons and patients consider a good outcome. While the wound may be recorded as ‘well-healed’, some patients will be left with discomfort, hardness, altered sensation, and poor cosmesis. True ‘success’ is often unknown because researchers have failed to systematically record patient-reported

outcome measures. Combined, these factors add to the necessity of preventing IHs from occurring in the first place (9).

#### Proposed measures to reduce the risk of incision hernias

As the causes of IHs are likely to be multifactorial, their prevention will depend on several improvements (Table 1).

#### Preoperative conditioning

Measures typically include prehabilitation to build muscle mass and improve exercise tolerance, comorbidity management, immunosuppression reduction, smoking cessation, weight/diet/nutrition optimisation, and anaemia correction. Whether enhanced recovery protocols prevent IHs is unknown, but improving patients' fitness seems a sensible place to start (61).

#### Incision planning

The traditional open midline approach is quick to perform, provides good access to most organs with little risk of nerve or vascular damage, and is convenient to close. Unfortunately, it is at risk of disruption due to strong lateral forces and relative avascularity of the linea alba (5). Good vascularisation and support from the rectus muscle may be advantages for paramedian incisions. In a review, the IH rate following colorectal surgery performed via transverse (4.5%) or paramedian incisions (3.6%) was lower than for midline wounds (9.9%) (62).

Avoiding the midline whenever possible has been endorsed by the European Hernia Society (13). Where appropriate, laparoscopic techniques may reduce IH risk.

Of all abdominal approaches, the suprapubic Pfannenstiel incision is notable for its low IH rate (42). However, lateral extension, excessive traction, or careless suturing may damage the ilioinguinal nerves, causing chronic pain.

When dividing the rectus and lateral muscles, the risk of denervation and chronic wound pain can be reduced by avoiding nerves and blood vessels. In the case of flank incisions and based on cadaver labs, it is recommended to steer clear of the intercostal space between the 11th and 12th ribs, minimise the incision length, not cross dermatomes, and to follow the intercostal nerves medial (41).

#### Collaboration with the anaesthesiology team

During major abdominal surgery, the patient is usually paralysed, affording the surgeon a relaxed operative field. Inadequately relaxed patients at the end of the operation may make abdominal closure an awkward procedure. Surgeons and anaesthetists must work together to conclude a successful procedure (63).

#### Organisational and attitudinal factors

Pressure to 'get the list done', a desire to save on PMA costs, and lack of surgeon reimbursement may predispose to IH formation (64). Some surgeons view this complication as a secondary problem that can easily be solved later. Others may be unconvinced of new techniques' benefits, citing weaknesses discussed in recent publications (65). Finally, inexperienced junior staff may be left to close the wound without supervision (15). Inadequate auditing of outcomes may prevent the problem being recognised and corrected.

### Appropriate suture technique

Poor operative technique (e.g. suturing under tension) may increase IH risk. Employing 'large bites' (LBs) to close abdominal wounds had previously been favoured because of work showing that sutures inserted at least 10mm from the defect edge resulted in a stronger wound (66).

Much has been written about the SB technique's recommendation for the closure of midline laparotomy wounds. Key components are the use of a continuous slowly absorbable monofilament suture inserted 5–8mm from the wound edge. Placement should be 4–5mm apart with a suture-to-wound-length ratio of at least 4:1 (Fig. 1)(67).

Two RCTs have provided support for SBs over LBs.(68, 69) Both RCTs found significantly fewer wound complications and IHs in the SB group. Despite a limited follow-up of one year, both research groups recommend using SBs over LBs for midline laparotomy. The European Hernia Society supports a single-layer aponeurotic SB technique using a slowly absorbable monofilament suture without separate closure of the peritoneum. Surgeons should employ a suture-to-wound-length ratio of at least 4:1(13). An SB approach has also been shown to halve the wound dehiscence rate following an emergency midline laparotomy(70).

### Prophylactic mesh augmentation in patients at increased risk

Over the last 20 years, there have been many publications advocating the use of mesh to prevent IH after abdominal surgery. Most refer to midline wounds in high-risk patients.

Three depths of mesh placement have been proposed to reinforce fascial closure of midline wounds (Fig. 2): 1) the onlay approach, with mesh fixed to the anterior rectus aponeurosis; 2) the sublay technique, performed between the posterior rectus sheath and rectus muscle; and 3) intraperitoneal reinforcement, with mesh being fixed to the peritoneum in direct contact with abdominal content.(5)

Available evidence indicates that the 3 approaches are effective in reducing IH incidence, but intraperitoneal mesh presents a marginally increased risk of chronic wound pain and less trunk extension compared with primary suture techniques (26, 71) Adhesions, small bowel obstructions, and fistulae do not appear to be short-term reasons for avoiding intraperitoneal reinforcement.(72) Onlay reinforcement is at increased risk of seroma formation, though this is not usually a significant clinical problem and the technique is probably the easiest to perform (27).

A recent systematic review concluded that mesh reinforcement is safe and effective at early-to-midterm assessment (73).

But what about the longer term? San Miguel et al. reported that 13/144 (9.0%) patients with a midline wound reinforced with onlay mesh were found to have an IH after a mean of 5 years ( $\pm 1.6$ ). (74) Two meshes required early removal due to chronic infection. Five IHs were repaired without mesh-related difficulties. In a similar study, Caro-Tarrago et al. reported that 5 years after surgery, 4/80 (5.1%) in the mesh group suffered an IH, compared with 37/80 (46.8%) in the suture-only group.(29) With regards to finances, Fischer et al. suggest that adding mesh is likely to be less expensive when the costs of managing IH complications are taken into account.(12)

PMA is not the universal answer to preventing IHs and requires careful discussion with the patient. Glauser et al., for example, reported 26% IH occurrence in high-risk patients following

intraperitoneal mesh at a median follow-up of 5.3 years (vs 52% for simple suture;  $p < 0.001$ ).<sup>(28)</sup> While Kohler et al. supported the addition of intraperitoneal PMA, the patients reported more pain at 6 weeks, and had slow-to-heal surgical-site infections and a significant reduction in trunk extension compared with the control group.<sup>(26)</sup>

What about employing mesh at other sites to prevent IHs? There is good evidence to support its use to reduce the risk of parastomal hernias, notably when placed retromuscularly.<sup>(75, 76)</sup> PMA has also been successfully utilised following bilateral subcostal incisions.<sup>(38)</sup> By comparison, there is little evidence to support a widespread role for mesh in flank incisions.<sup>(10)</sup>

#### Unanswered questions

Can the risks of an IH after a midline incision be mitigated by an enhanced closure technique, making advice to use an alternative approach redundant? Is the SB technique equivalent to PMA? Further, does a combined approach bring added value? These questions are being investigated in the HULC trial.<sup>(77)</sup>

The value of PMA is generally accepted in high-risk patients, but who does this apply to? Although treatment algorithms have been proposed and a risk calculator has been implemented, these remain rather crude.<sup>(78)</sup> Should PMA be used universally after all laparotomies? For many, implantation will be an unnecessary cost and unwanted by the patient, with the risks outweighing benefits.

Once the decision has been made to incorporate PMA, what is the best type of mesh to use—synthetic, biologic, or bioabsorbable<sup>(5)</sup>—and where should it be placed in different circumstances (e.g. elective or emergency surgery)?

Information on the choice of incision at other sites and optimum means of closure is generally lacking across disciplines. Similarly, it is unknown whether the use of wound closure teams or financial incentives are practical or effective in preventing IHs.

#### Discussion

IHs are not just an issue for digestive surgeons but for all working within the abdomen, pelvis, and retroperitoneum. Our impression is that patients undergoing abdominal surgery are often underinformed of the risks and potential implications of developing an IH. Data from large databases have shown that the repair of incisional hernia repair is a risky procedure (7, 9). Patients who undergo a surgical repair have a significant probability of complications, recurrences and dangerous reoperations for these recurrences.

Why is there such complacency? Do some senior surgeons consider abdominal closure not worthy of their skill and experience, something to be left for the ‘juniors’?<sup>(15)</sup> Alternatively, are some surgeons unaware of their high IH rates or unconvinced by the many published reports advocating enhanced wound closure techniques? Our conclusion is that current literature is sufficient to guide practice, and where evidence is incomplete, this should not be used as an excuse for doing nothing.

It all starts with planning and preparation (e.g. having a fit patient, sufficient time, an experienced operator, and surgeon-anaesthetist harmony). It should be considered whether a minimally invasive technique would be more appropriate. Where open access is required, our main recommendations include avoiding the midline wherever this does not compromise the

procedure, using the SB suture technique with a >4:1 suture-to-wound length, and adding PMA wherever the patient may be more likely to suffer herniation. It is not just cancer, inflammatory bowel disease, or aortic aneurysm that affect the risk, as morbidity increases with age and expanding waistlines. Therefore, the list of those likely to benefit will grow. There is no evidence that the location or mesh type make a big difference. Basic prosthetic costs are relatively small and the extra few minutes of operating time insignificant. By considering at the outset how best to close the wound and discussing options and complications, surgeons will be doing their patients, care providers, and the health system a good service.

We will never prevent IHs altogether, but surely more can be done. Now is the time to push for benchmarking and greater research into all aspects of IH prevention. Let us together aim to achieve a goal of <10%. This does not seem unreasonable in these days of increasing surgical sophistication. 'Closing time' should no longer be 'coffee time'.

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Table 1: Measures that may contribute to reduction in the risk of hernia following abdominal wall surgery

Aim for patient optimisation: diet/nutrition, prehabilitation/exercise, smoking cessation, morbidity reduction (e.g. diabetic control, chest physiotherapy, steroid reduction)

Consider a minimally invasive approach

Choose an incision providing adequate access with a low risk of herniation

Reduce surgical site infection

Have a cooperative relationship between surgeon and anaesthesiologist

Use small bites with a  $\geq 4:1$  rule for midline abdominal wound closure

Use PMA in high-risk patients

Have an experienced surgeon or supervised trainee

Ensure absence of time pressure

Audit results comprehensively

Promote the message among international scientific societies representing all surgical disciplines that measures to prevent incisional hernias are important

#### FIGURE LEGENDS

Figure 1. The small-bite aponeurotic closure technique used in midline wounds

Figure 2. A. Prophylactic mesh augmentation in midline laparotomies illustrating placement in the onlay position. B. Prophylactic mesh augmentation in midline laparotomies illustrating placement in the sublay position. C. Prophylactic mesh augmentation in midline laparotomies illustrating placement in the inlay (IPOM) position.