Hernia (2019) 23:915–925
https://doi.org/10.1007/s10029-019-02031-6

ORIGINAL ARTICLE

Primary non-complicated midline ventral hernia: is laparoscopic IPOM still a reasonable approach?

S. Van Hoef[1] · T. Tollens[1]

Received: 10 July 2019 / Accepted: 7 August 2019 / Published online: 27 August 2019

Abstract

Purpose Ventral hernia repair has become a common procedure, but the way in which it is performed still depends on surgeon's skill, experience, and habit. The initial open approach is faced with extensive dissection and a high risk of infection and prolonged hospital stay. To tackle these problems, minimally invasive procedures are gaining interest. Several new techniques are emerging, but laparoscopic intra-peritoneal onlay mesh (IPOM) is still the mainstay for many surgeons. We will discuss why laparoscopic IPOM is still a valuable approach in the treatment of primary non-complicated midline hernias and review the current literature.

Methods We performed a literature search across PubMed and MEDLINE using the following search terms: "Laparoscopic hernia repair", "Ventral hernia repair" and "Primary ventral hernia". Articles corresponding to these search terms were individually reviewed by the primary author and selected on relevance.

Conclusion Laparoscopic IPOM still is a good approach for the efficient treatment of primary non-complicated midline hernias. Several techniques are emerging, but are faced with increased costs, technical difficulties, and low study patient volume. Further research is warranted to show superiority and applicability of these new techniques over laparoscopic IPOM, but until then laparoscopic IPOM should remain the go-to technique.

Keywords Laparoscopic · IPOM · Ventral hernia · Primary

Ventral hernia: definition and epidemiology

A ventral hernia is a protrusion of fat with or without abdominal content through the anterior abdominal wall. Classification by the European Hernia Society divides ventral hernias into primary or congenital and incisional. The first group comprises midline (epigastric and umbilical) and lateral hernias (lumbar and spigelian) [1]. Incisional hernias are categorized by their localisation on the abdomen. Finally, various hernias are subdivided based on the size.

✉ S. Van Hoef
stijnvanhoef@gmail.com

T. Tollens
tollenstim@hotmail.com

[1] Department of Abdominal Surgery, Imelda Hospital, Bonheiden, Belgium

Primary hernias

Umbilical hernias occur quite often in childhood as it affects between 10 and 25% of all newborns, with a higher frequency in females. Due to a failed closure of the umbilical ring, a central defect in the linea alba remains, allowing protrusion of abdominal contents through the umbilical canal. This canal is lined posteriorly by the umbilical fascia, anteriorly by the linea alba, and laterally by both rectus sheaths [2, 3]. Most umbilical hernias at birth are less than 1 cm and usually close spontaneously by 4 years of age. In adulthood, 9 out of 10 umbilical hernias are not congenital and have no tendency to close. Females or patients with increased intra-abdominal pressure (f.e. pregnancy, obesity) are at risk and most hernias occur around the age of 35.

Umbilical hernias tend to have a narrow neck, as the linea alba above and below shows increased resistance to strain. Consequently, the actual hernia orifice remains often small, despite the possibility of developing a large hernia sac.

Epigastric hernias originate between the xiphoid and the umbilicus and are all acquired defects. They are due to

excessive strain on the midline aponeurosis, where fibres from both sides cross and form the linea alba [4]. Their pathophysiology is still not fully understood, but a combination of chronic strain on diaphragmatic fibres, vessels perforating the abdominal wall, defective collagen turnover, and specific patient characteristics (such as obesity and smoking) have been proposed. We differentiate between a true and a false hernia, with the first containing both a peritoneal pouch and extra-peritoneal fat, while the latter only contains extra-peritoneal fat [5]. An epigastric hernia is a common condition, affecting up to 10% of the general population, although not always being symptomatic. They occur more frequently between 20 and 50 years of age and a male predominance has been described, though recent studies indicate no marked difference in gender [5].

Incisional hernias

An incisional hernia is always an acquired lesion. Up to 20% of patients develop an incisional hernia after major abdominal surgery. Chronic cough, prostate hypertrophy, steroid use, obesity, and smoking are all the risk factors predisposing a patient for an incisional hernia [6]. In contrast with primary midline hernias, incisional hernias tend to grow rapidly and often involve the whole length of the incision if not repaired on time. Around 50% of incisional hernias manifest within the first 12 months after surgery [7]. An incisional hernia is correlated with intra-abdominal adhesions, which might complicate its repair [8].

Ventral hernia repair has become a common surgical procedure. Over 350,000 cases are treated every year in the US, by both laparoscopic and open approaches [9, 10].

Approximately 75% of these repairs are performed on primary ventral hernias. However, the best way of repair is still up for debate, where this commonly depends on the experience, training, and preference of the surgeon. In this article, we want to evaluate the literature if there is still room for laparoscopic intra-peritoneal onlay mesh (IPOM) in the treatment of primary midline ventral hernias.

Primary suturing is not an option

In general, a tension-free mesh repair is considered the golden standard, as it reduces the recurrence risk even with smaller hernias [11–13]. Several papers and surgeons still advocate primary ventral herniorrhaphy for small (< 2 cm width) hernias, as placement of mesh in small hernias often leads to iatrogenic enlargement of the hernia defect and carries the risk of mesh-related complications (such as adhesion formation and mesh erosion) [11]. Ventral herniorrhaphy, like the technique of 'vest-over-pants' suturing, as developed by William Mayo in 1895 (Fig. 1), is in our experience

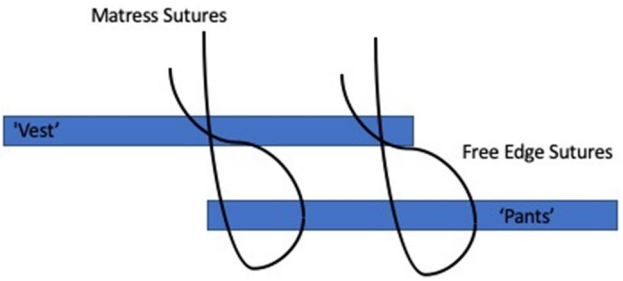

Fig. 1 'Vest-over-pants' technique

insufficient as a repair and should only be used as an escape in selected cases. It is associated with high recurrence rates of up to 50%. Mesh reinforcement lowers this recurrence rate by three or even more [11, 14–17]. Furthermore, iatrogenic fascial enlargement does not influence recurrence rate as recently shown by Ponten et al. [18]. Reluctance against mesh reinforcement has also been fuelled by initial reports showing an increased risk for surgical site infections and chronic pain with mesh placement. However, these results might not be straight forward, as several systematic reviews were unable to detect a significant difference in postoperative complication rate or chronic pain [13–15, 19]. Moreover, a recent systematic review by Holihan et al. showed that the absolute risk for a surgical site infection (SSI) is small compared to the impact on recurrence rate (NNT for recurrence is 7.93, whereas NNH for SSI is 27.82) [16]. Increased costs associated with mesh reinforcement might also be a 'relative' concept, when compared with the increased costs brought on by recurrence repair [14]. Specific mesh-related risks should only be considered when placing the mesh intra-peritoneally, as we will discuss later.

Taken all the above into account, it is our opinion that mesh reinforcement is the way to go, both in small and large midline primary hernias.

Mesh yes, but where?

As ventral hernia repair requires mesh reinforcement, we are faced with the next hurdle. Where do we place the mesh to allow minimal recurrence and complication rate and optimal abdominal wall reconstruction?

Looking at the abdominal wall, four different positioning layers can be identified, commonly depicted as onlay, inlay, sublay or retromuscular, and underlay.

During onlay repair (Fig. 2a), the mesh is sutured to the exposed anterior fascia. This is an easily applicable approach when considering an open repair. It involves creating large skin flaps and is often used for large complex hernias, where additional myofascial release is necessary for primary facial closure [20]. As a large subcutaneous dissection is involved,

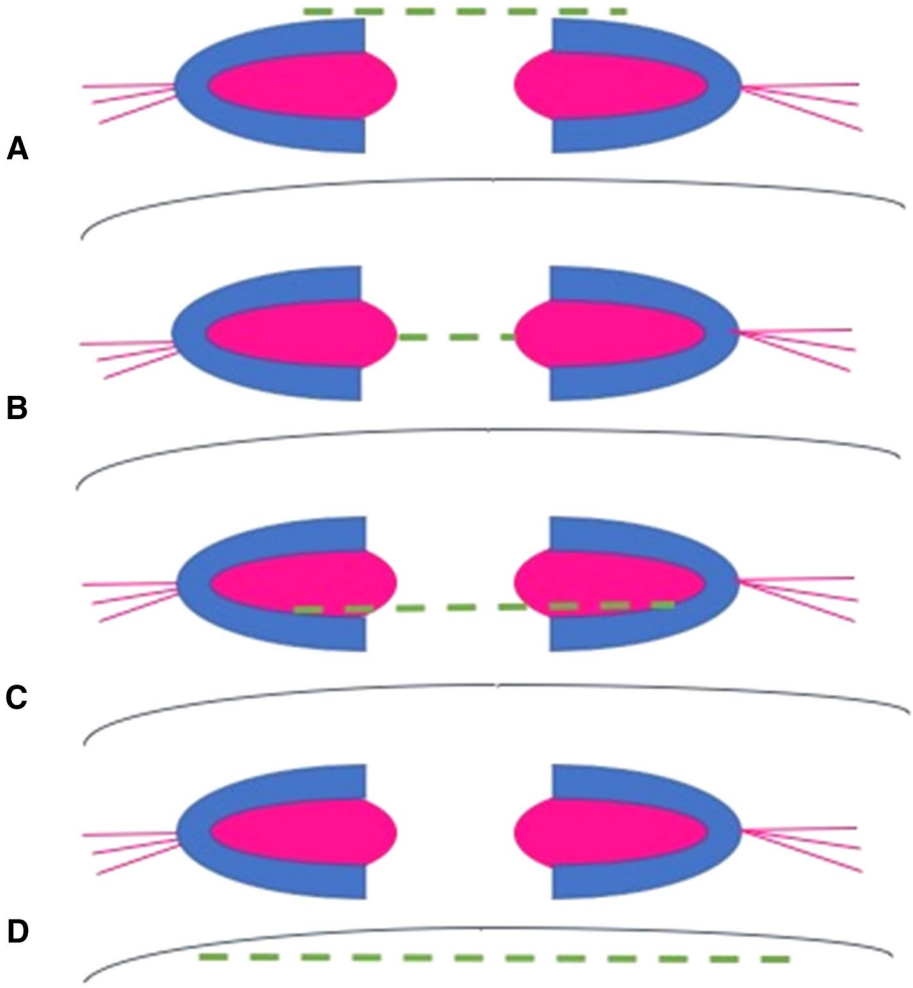

Fig. 2 Mesh locations. **a** Onlay repair, **b** inlay repair, **c** sublay/retromuscular repair, **d** underlay repair; key: green, mesh; red, muscle; blue, fascia; grey, hernia sac/peritoneum (color figure online)

the onlay technique is accompanied with a high risk for wound complications and is prone to mesh infection, due to its superficial position [13]. Moreover, studies show a higher recurrence rate compared to the sublay and underlay position [17, 20].

With an inlay repair (Fig. 2b), the mesh is placed within a defect and secured circumferentially to the edges of the fascia without primary suturing the defect [20]. It is sometimes also called an interposition repair or bridged repair. This type of repair is associated with the worst outcome regarding recurrence and mesh infection rate. Being uncovered, the mesh is often in contact with the intra-peritoneal content, allowing possible erosion and it is susceptible for infiltration of superficial SSI [17, 20]. Due to low tissue–mesh contact, mesh integration is decreased, contributing to a long-term recurrence of more than 50%. As no anatomical reconstruction of the abdominal wall is performed, this type of repair is prone to mesh bulging, also called pseudo-recurrence, decreasing patient satisfaction. Considering all the above, inlay repair only has a limited place in primary ventral hernia repair [16, 17, 20, 21].

Sublay repair (Fig. 2c) is considered the golden standard in open ventral hernia repair [22]. The mesh is placed in the retromuscular or pre-peritoneal plane, also known as the Rives–Stoppa plane. Dissection of the retromuscular plane poses a risk for damaging the muscle itself and more importantly the blood supply, as well as the innervation to the rectus abdominus. Overall, sublay positioning has shown to be the best choice, when considering recurrence rates and postoperative complications [17, 20]. However, due to its technical difficulties, its widespread usage has been limited.

During underlay repair (Fig. 2d) the mesh is placed intraperitoneally and secured to the anterior abdominal wall. It is the most common position when performing a laparoscopic repair, as in the laparoscopic IPOM. It is easy to perform and allows the placement of a larger mesh with minimal need for dissection.

Placing the mesh intra-peritoneally or retromuscular is biomechanically speaking the most advantageous position (Fig. 3). As stated by Pascal's law, an increase in abdominal pressure is exerted in every direction, keeping the mesh firmly in place. Contrary to onlay or inlay meshes, where

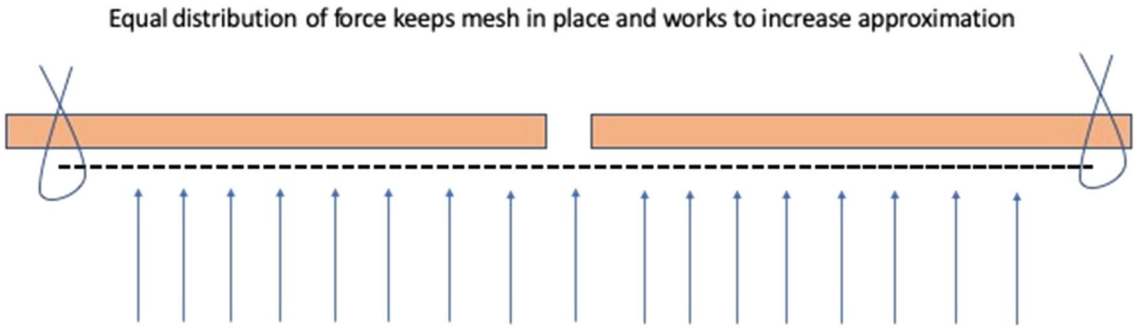

Fig. 3 Pascal's Law illustrating benefit of mesh positioning in hernia repair

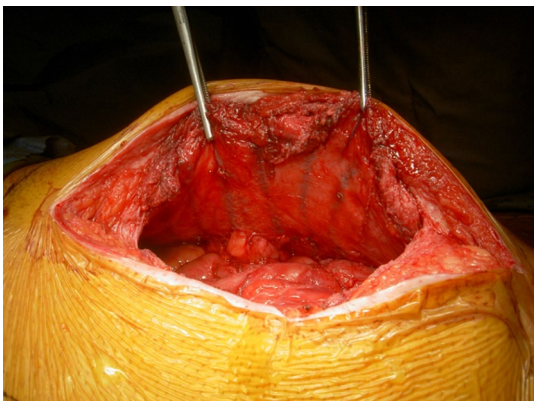

Fig. 4 Postoperative view showing complete integration of IPOM mesh without adhesions

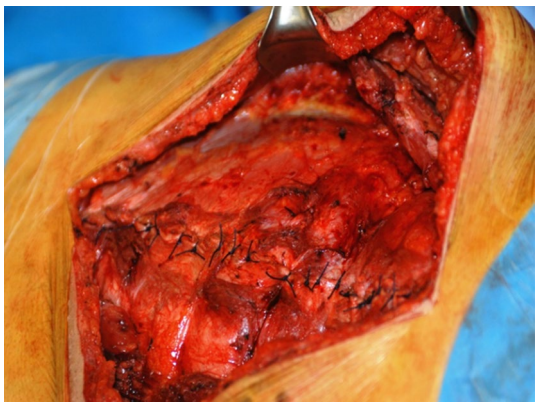

Fig. 5 Open retromuscular approach showing large dissection plane

an increase in pressure exerts a lifting force onto the mesh [23, 24]. However, placing the mesh intra-peritoneally has its risk which needs to be considered. Fixating the mesh to the abdominal wall, commonly done with tacks and/or transfascial sutures, has been linked to increased postoperative pain [12, 25, 26] and haematoma. Furthermore, the mesh is exposed to intra-peritoneal contents. This poses a risk for development of intra-peritoneal adhesions and fistulas due to excessive inflammatory reaction, as seen in the initial laparoscopic case reports [27, 28]. Pharmaceutical innovations and mesh development have been able to diminish this issue by changing the pore size and creating multi-layered meshes [29], but it is not yet fully resolved (Fig. 4).

How do we get the mesh there?

Laparoscopic vs. open

As sublay and underlay techniques are both preferred, there are different means of getting it there.

Both planes can be reached open and laparoscopically. Initially, the open approach was preferred, as it is the easiest way to reach both planes (e.g. open retromuscular or open IPOM). However, reaching this plane is often accompanied by an extensive dissection (Fig. 5). This carries a higher risk for postoperative complications, such as haematoma, seroma, surgical site infections, and prolonged drainage, especially with patients at risk (Cfr. obesity, diabetes, and steroid use) [30]. As postoperative complications lead to longer hospital stay and higher recurrence [31, 32], other approaches have been put forward in an attempt to reduce these complications. In 1993, Leblanc and Booth were the first to propose a laparoscopic approach, placing the mesh in the underlay position allowing for larger mesh placement with minimal cutaneous damage [33]. However, their initial approach had several flaws leading to early failure. Aside from the mesh-associated problems as mentioned before, they did not close the fascial gap. This leads to early true- and pseudo-recurrence (Fig. 6). Some studies also indicate an increase in seroma formation as the hernia sac remained untouched [17, 34, 35]. Fascial closure has a marked impact on pseudo-recurrence and mesh bulging [9, 36–39]. As closure also eliminates the dead space, a reduction in seroma

Fig. 6 CT-scan showing early pseudo-recurrence

formation is expected. However, several studies show conflicting results [9, 17, 34, 36, 39, 40].

When using new types of meshes and an adapted technique, several studies comparing open vs. laparoscopic IPOM have shown that the laparoscopic approach is a safe and feasible alternative. As expected, a laparoscopic approach results in diminished amount of SSI, wound dehiscence, and shorter length of hospital stay [4, 23, 30, 41–49]. No difference in recurrence rate has been reported between both the approaches, moreover some studies indicate an even lower recurrence rate after laparoscopic repair, due to concomitant identification of satellite defects [43, 48]. Despite being minimally invasive, there has been no marked difference reported in postoperative pain between open and laparoscopic repairs. The latter might be due to the need for mesh fixation to the abdominal wall (e.g. tacks), which has been correlated with prolonged pain [44].

Although the overall complication rate is lower with a laparoscopic approach, intra-peritoneal bowel lesions are a feared complication. Studies showed similar rates of iatrogenic bowel lesions between open and laparoscopic procedures, however enterotomy in open surgery is easily recognized and repaired, whereas in a laparoscopic approach the intestine might retract out of the field of vision and is left untreated [8, 41, 44, 50]. A recognised enterotomy is associated with a mortality rate of 1.7–2.8%, but an unrecognized enterotomy had a mortality rate of 7.7%, thus illustrating its risk [8, 31].

As the laparoscopic approach is preferred in non-complicated cases, several techniques have been described to reach both preferred planes.

Laparoscopic sublay repair

Laparoscopic sublay repairs are an emerging practice, showing promising short-term results. Several different techniques such as the transabdominal sublay technique [51], (robotic) transabdominal retromuscular umbilical prosthetic hernia repair (TARUP) [52], and the extended totally extra-peritoneal repair (eTEP) [53] have been described.

eTEP was originally first described as a means to repair an inguinal hernia, but is now finding its way to ventral hernia repair. Compared to 'conventional' IPOM, it has the advantage of avoiding intra-peritoneal foreign body, sublay mesh position without the need for further fixation, faster recovery, and restoration of the abdominal wall anatomy and no need to access the abdominal cavity, eliminating the risk of iatrogenic bowel injury. However, this minimal invasive laparoscopic or robotic approach is complex and very time consuming.

In the transabdominal sublay technique, first described by Schroeder et al., the retromuscular plane is approached transabdominally. Through an incision of the lateral border of the posterior rectus sheath, the retromuscular plane is developed.

After fascial closure of the defect and mesh placement, the incised rectus sheath is closed by non-absorbable sutures. This technique allows sublay mesh positioning without the need for massive cutaneous dissection. Initial reports show promising results [51].

TARUP is a novel technique first coined by Muysoms et al. [52]. It is an adaptation of the technique by Schroeder, to repair umbilical hernias, using the robot to decrease operating time.

Broad adaptation of all the above techniques has been limited due to increased technical difficulty, increased costs and operative time, low study patient volume, and the absence of long-term results. The robotic approach might provide an answer to the increased technical difficulty, but is correlated with excessive costs, both in purchase and maintenance of the robot, as in increased operative time.

A novel hybrid technique is the (e) MILOS [(endoscopic) minimal/less open sublay] technique published by Reinpold et al. [54]. By minimal incision over the hernia sac, the posterior rectus sheath is reached and dissected to create a retromuscular plane. For extensive dissection, an endoscopic video tower is utilized to dissect from the Retzius space up to the fatty triangle, away from the initial incision. Their initial report shows promising results, but further research is warranted.

Pre-peritoneal placement of the mesh, named transabdominal pre-peritoneal (TAPP) or pre-peritoneal onlay mesh (PPOM), avoids intra-peritoneal mesh placement and its potential risk. Furthermore, as pre-peritoneal placement deletes the need for fixation, lowered postoperative pain is expected [45, 55]. However, broad adaptation of this technique has been halted due to its technically demanding nature when dissecting the flaccid peritoneum.

Laparoscopic underlay repair

Laparoscopic IPOM is considered the most widespread adopted technique, as it is easy to perform and shows good short- and long-term results. However, as indicated above, due to the intra-peritoneal placement of the mesh, it has its own disadvantages, such as adhesion formation, possible risk of mesh erosion, and increased costs due to specific mesh usage. To tackle these problems, there have been adaptions, both at the level of mesh development [29, 45] and pre-peritoneal positioning of the mesh.

Laparoscopic IPOM itself has evolved as well in recent years to correct some frequently occuring complications. Nguyen et al. [12] were the first to describe primary fascial closure in combination with mesh reinforcement, to bridge the gap between interposition and underlay placement, as well as to reduce the amount of pseudo-recurrence, as the hernia sac was untouched in conventional IPOM surgery. This technique, described as IPOM-plus, has been shown to be superior to standard IPOM, in regard to recurrence rate and mesh bulging/pseudo-recurrence [34–36, 56], thus making the IPOM-plus the go-to technique for many surgeons (Fig. 7).

The BONHEIDEN algorithm: when to choose laparoscopic IPOM?

When faced with a primary non-complicated ventral hernia in our centre (AZ, Imelda, Bonheiden, Belgium), we follow a specific protocol to guide the patient to, what is in our experience, the best type of repair.

Hernia size

The main defining characteristic is hernia size, that is the width of the orifice. Smaller midline hernia (< 2–3 cm) are repaired with an open herniorrhaphy, augmented with a small mesh reinforcement, with sufficient mesh overlap accounting for shrinkage. Mesh type depends on surgeon's preference, but should be appropriate for intra-peritoneal placement. Several studies have compared different meshes (PP vs PTFE, biological vs non-biological), where none have been proven superior in terms of adhesions or complication ratio [29, 57–59]. We reported on the use of Ventralex ST Mesh, with good results [60], as did other centres [61, 62]. When faced with larger hernias (> 3 cm), we prefer placing a larger mesh using the laparoscopic IPOM technique (Fig. 8).

Irrespective of hernia size, patients with multiple hernias on clinical preoperative evaluation (Swiss cheese hernias), or patients facing higher abdominal strain due to their profession (builders, etc.) are always treated with a laparoscopic IPOM.

Additionally, some comorbidities such as obesity, diabetes, steroid use, and other factors influencing tissue healing and early recurrence will also guide us to an IPOM approach. Let us elaborate on this.

Obesity

Obese patients pose risks every step of the way. During preoperative screening, additional hernias might be missed and left untreated [63]. Peri-operatively, obesity is associated with a higher anaesthesiologic risk, both on pulmonary and cardiovascular level [64]. Furthermore, obese patients are often more difficult to operate on than normal weight patients. In an open approach this might interfere with proper suturing of the defect and need for larger incisional width. In laparoscopic approach, intra-abdominal obesity might interfere with proper visualisation of essential landmarks, as illustrated by Mercoli et al., where a significant haematoma was caused due to inability to identify the epigastric artery [32]. Postoperatively, obesity (BMI > 30) is an independent risk factor for SSI, due to compromised tissue healing, [65] and creates a higher intra-abdominal pressure. Both are factors linked to early recurrence [7, 19, 31, 32]. If

Fig. 7 Fascial closure during lap IPOM to reduce remaining death space

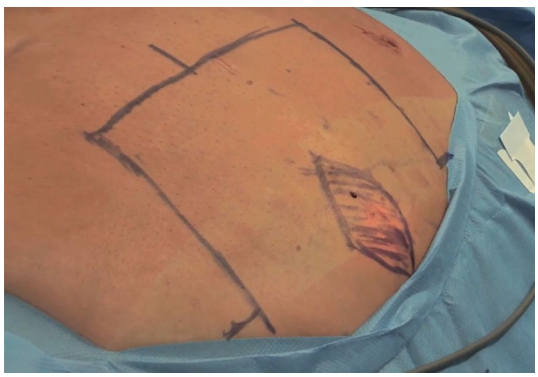

Fig. 8 Lap IPOM allows large mesh placement to allow shrinkage

possible, weight loss is achieved before elective surgery, as watchful waiting is a safe alternative [11]. When considering weight-loss surgery, a staged hernia repair (preceded by bariatric surgery) [66], or combined procedure might be considered [67], but should be based on case-by-case assessment.

Diabetes mellitus

Diabetes interferes with microvascular circulation, thus interfering with proper tissue healing. This increases the risk of an SSI as well as early recurrence. A glycosylated haemoglobin > 6.0–7.0% increases the risk of postoperative complications by odds of 1.69–5.8 [11, 19, 32, 65]. This effect on postoperative complications is higher with insulin dependent diabetes mellitus, compared to non-insulin dependent diabetes mellitus [68]. A minimal invasive approach minimises tissue disruption and thus decreases the chance of surgery related postoperative complications. Preoperative counselling and optimisation of therapy is advised.

Smoking

The detrimental effect of smoking on tissue healing and on postoperative complications across a variety of surgical procedures is well known. In elective ventral hernia repair, smoking increases the risk of postoperative SSI as well as serious postoperative pulmonary complications [31, 69]. Moreover, demographic data from a recent study by Delancey et al. show smokers to have a higher risk of comorbid diabetes, COPD, and peripheral vascular disease compared to non-smokers, all of which increase the risk for early recurrence and impaired tissue healing [69]. Smoking cessation for at least 4 weeks before elective ventral hernia repair has been advised [11].

Steroid use

Steroids interfere with tissue healing and increase the risk of SSI drastically. The same can be commented about immunosuppressants. However, unlike the factors mentioned above, steroids in themselves are not a risk factor for early recurrence [70].

Discussion

How does laparoscopic IPOM compared to other techniques in primary midline hernia repair?

As already discussed above, the laparoscopic approach for ventral repair has been proven to be safe, feasible, and comparable in recurrence rate to open approaches. SSI is diminished due to minimal tissue disruption. However, these results might differ when selecting primary hernias only. Most systematic reviews pool data from both incisional and primary hernias to analyse the results. However, as Subramanian et al. showed, primary and incisional hernias behave differently after laparoscopic repair and showed an increase in long-term recurrence rate and chronic pain after incisional hernia repair [71]. Lambrecht et al. showed the same increase in recurrence rate, however not statistically significant [40].

When selecting primary ventral hernias only, Hajibandeh et al. compared laparoscopic IPOM and open repair and confirmed the results of the other 'combined' reviews, showing a lower risk of wound infection, wound dehiscence, and recurrence rate, shorter length of stay, but longer operative time with laparoscopic repair. These results were confirmed by Nguyen et al., but they raised the issue of port site hernias, especially at the 10 mm trocar ports [12]. However a recent study by Liot et al. showed that when properly closing the fascial defect, the risk for port site hernias is very low [72].

When comparing laparoscopic IPOM to other laparoscopic techniques, the amount of relevant studies is small (Table 1).

Schroeder et al. compared their transabdominal approach to an open approach for both types of hernias. Their initial report showed no difference in complication or recurrence rate compared to an open approach. The length of stay was reduced compared to an open approach. Schroeder also indicated the advantages of their techniques against IPOM technique, but was unable to perform a direct comparison. When comparing to the available literature, they were unable to discern any significant difference between both techniques, due to low patient volume [51].

Reinpold et al. compared the new eMILOS technique against laparoscopic IPOM. They showed a lower complication rate, lower recurrence rate, and lower postoperative pain rate, in favour of the eMILOS approach [54]. However, we should note that this comparison was made for incisional hernia repair and might differ significantly when applied to primary hernia repair. Furthermore, eMILOS has a longer operating time [103 min (range 40–332 min) vs 82 min] and is technically challenging. This will interfere with the optimistic cost analysis made by Reinpold et al. in favour of the eMILOS technique [54]. Further studies will need to evaluate its applicability.

Prassad et al. compared laparoscopic IPOM to TAPP. They used pooled data from both incisional and primary hernia repair. They found no statistically significant difference between both techniques when considering minor complication rate, recurrence rate or hospital stay. Statistical differences were noted in operating time (In favour of IPOM), hospital costs (in favour of TAPP due to the lower mesh-costs), and seroma formation (in favour of TAPP).

Table 1 Overview of comparative studies comparing IPOM to other approaches

		Patients	Recurrence (%)	*p* value	Seroma formation (%)	*p* value	LOS (days)	*p* value	Operation time (mins)	*p* value
Prassad et al.	Lap IPOM	211	2.90	NS	8.5	0.05	1.4	0.35	87.4	0.001
(Pooled data)	Lap TAPP	68	3.30		5.8		1.5		96.7	
Schroeder et al.	Open retromuscular	50	0	1	2.20	1	4	0.295	115	0.13
(Pooled data)	Lap sublay	43	0		0		3.4		125	
Kockerling et al.	Open sublay	5797	4.2	0.783	5.12	0.0001	6.14	0.001	NR	
(Incisional hernia)	Lap IPOM	4110	4.1		1.94		4.35		NR	
Liang et al.	Open (pre-peritoneal)	79	13.90	0.8	8.9	0.1	0	0.001	NR	
(Primary hernia)	Lap IPOM	79	11.40		20.3		1		NR	
Lomanto et al.	Open sublay	50	10		6		4.7	0.044	93.3	0.796
(Pooled data)	Lap IPOM	50	2		10		2.47		90.6	
Penchev et al.	eTEP	27	0	NS	14.80	NS	2.9	NS	186	S
(Pooled data)	Lap IPOM	27	3.70		11		3.4		90	
Reinpold et al.	eMILOS	615	2.16	0.0001	0.55	0.001	NR		103	
(Incisional hernia)	Lap IPOM	5865	7.34		3.33		NR		82	

S significant, *NS* non-significant, *NR* not recorded

However, it should be noted that seroma formation and pseudo-recurrence are known issues with laparoscopic IPOM, if the hernia sac remains untouched. Recent studies show a marked decline in reported bulging and recurrence rate when the hernia sac is resected and the fascia is closed [34–37, 56]. A similar effect was expected on seroma formation, however studies show conflicting results.

Yang et al. were able to describe differences between the pre-peritoneal and intra-peritoneal technique, pros and cons, but was unable to present a comparative result between both techniques [45].

Penchev et al. were able to compare laparoscopic IPOM to eTEP. They showed comparable results regarding complication rate and recurrence rate between both techniques. However, eTEP significantly reduces post-operative pain, but also had a significantly longer operating time. This reduction in pain might be due to the absence of mesh fixation, as it is placed in the retromuscular position. Penchev et al. are aware of the limitations of their techniques, as eTEP might not be applicable for several small concomitant hernias and large complex hernias. Moreover, they do recognise the issues of longer operating time and poor ergonomic position [73]. Belyansky showed superiority of eTEP compared to open repair, in regard to length of stay, surgical site infections, and early postoperative pain. No direct comparison was made with other conventional laparoscopic approaches [74].

A recent systematic review by Henriksen et al., evaluating the possibilities of a robotic approach, showed comparable results regarding recurrence and complication rate between laparoscopic and robotic IPOM. The robotic IPOM was associated with longer operating time, more seroma formation, and higher costs. As indicated by Henriksen et al., the robotic platform should be considered an additional tool for the surgeon, proving its worth in complex ventral hernia cases and might not necessarily outperform the conventional laparoscopic approach in easy non-complicated hernia cases [75].

Conclusion

Is laparoscopic IPOM still a reasonable approach for primary non-complicated ventral hernia repair? In our opinion, laparoscopic IPOM is not only a robust method of repair but should be considered as the go-to treatment for this type of hernias, especially when comorbidities such as obesity, diabetes, and steroid use are present. Several new techniques are emerging but are lagging in widespread implementation due to technical difficulties. Moreover, no study has shown absolute superiority over laparoscopic IPOM. Laparoscopic IPOM has shown its merit since its introduction in 1993 and in combination with ever evolving mesh development, it shows good results when looking at recurrence and complication rate. It is easy to perform and does not require specialised equipment. Following this review, we will present our experience with laparoscopic IPOM, discussing our technique and its short- and long-term results.

Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest with regard to this paper.

Ethical approval This study did not require approval from the local ethical committee.

Human and animal rights This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Formal consent was not required for this study.

References

1. Muysoms FE, Miserez M, Berrevoet F et al (2009) Classification of primary and incisional abdominal wall hernias. Hernia 13:407–414. https://doi.org/10.1007/s10029-009-0518-x
2. Coste AHPJ (2019) Umbilical hernia. In: StatPearls. https://www.ncbi.nlm.nih.gov/books/NBK459312/. Accessed 19 Aug 2019
3. Zens T, Nichol PF, Cartmill R, Kohler JE (2017) Management of asymptomatic pediatric umbilical hernias: a systematic review. J Pediatr Surg 52:1723–1731. https://doi.org/10.1016/j.jpedsurg.2017.07.016
4. Ponten JEH, Thomassen I, Nienhuijs SW (2014) A collective review on mesh-based repair of umbilical and epigastric hernias. Indian J Surg 76:371–377. https://doi.org/10.1007/s12262-013-0920-6
5. Ponten JEH, Somers KYA, Nienhuijs SW (2012) Pathogenesis of the epigastric hernia. Hernia 16:627–633. https://doi.org/10.1007/s10029-012-0964-8
6. Faylona JM (2017) Evolution of ventral hernia repair. Asian J Endosc Surg 10:252–258. https://doi.org/10.1111/ases.12392
7. Lindmark M, Strigård K, Löwenmark T et al (2018) Risk factors for surgical complications in ventral hernia repair. World J Surg 42:3528–3536. https://doi.org/10.1007/s00268-018-4642-6
8. Sharma A, Khullar R, Soni V et al (2013) Iatrogenic enterotomy in laparoscopic ventral/incisional hernia repair: a single center experience of 2,346 patients over 17 years. Hernia 17:581–587. https://doi.org/10.1007/s10029-013-1122-7
9. Suwa K, Okamoto T, Yanaga K (2016) Closure versus non-closure of fascial defects in laparoscopic ventral and incisional hernia repairs: a review of the literature. Surg Today 46:764–773. https://doi.org/10.1007/s00595-015-1219-y
10. Kroese LF, Gillion JF, Jeekel J et al (2018) Identification of risk factors for 30-day postoperative complications in patients undergoing primary ventral hernia repair: a prospective cohort study of 2,374 patients. Surg (US) 163:1160–1164. https://doi.org/10.1016/j.surg.2017.12.019
11. Liang MK, Holihan JL, Itani K et al (2016) Ventral hernia management. Ann Surg 265:80–89. https://doi.org/10.1097/sla.0000000000001701
12. Nguyen MT, Berger RL, Hicks SC et al (2014) Comparison of outcomes of synthetic mesh vs suture repair of elective primary ventral herniorrhaphy: a systematic review and meta-analysis. JAMA Surg 149:415–421. https://doi.org/10.1001/jamasurg.2013.5014
13. Mathes T, Walgenbach M, Siegel R (2016) Suture versus mesh repair in primary and incisional ventral hernias: a systematic review and meta-analysis. World J Surg 40:826–835. https://doi.org/10.1007/s00268-015-3311-2
14. Aslani N, Brown CJ (2010) Does mesh offer an advantage over tissue in the open repair of umbilical hernias? A systematic review and meta-analysis. Hernia 14:455–462. https://doi.org/10.1007/s10029-010-0705-9
15. Christoffersen MW, Helgstrand F, Rosenberg J et al (2015) Long-term recurrence and chronic pain after repair for small umbilical or epigastric hernias: a regional cohort study. Am J Surg 209:725–732. https://doi.org/10.1016/j.amjsurg.2014.05.021
16. Holihan JL, Hannon C, Goodenough C et al (2017) Ventral hernia repair: a meta-analysis of randomized controlled trials. Surg Infect (Larchmt) 18:647–658. https://doi.org/10.1089/sur.2017.029
17. Sosin M, Nahabedian MY, Bhanot P (2018) The perfect plane: a systematic review of mesh location and outcomes, update 2018. Plast Reconstr Surg 142:107S–116S. https://doi.org/10.1097/PRS.0000000000004864
18. Ponten JEH, Leclercq WKG, Lettinga T et al (2018) Mesh OR patch for hernia on epigastric and umbilical sites (MORPHEUS-Trial). Ann Surg. https://doi.org/10.1097/sla.0000000000003086
19. Shankar DA, Itani KMF, O'Brien WJ, Sanchez VM (2017) Factors associated with long-term outcomes of umbilical hernia repair. JAMA Surg 152:461–466. https://doi.org/10.1001/jamasurg.2016.5052
20. Holihan JL, Nguyen DH, Nguyen MT et al (2016) Mesh location in open ventral hernia repair: a systematic review and network meta-analysis. World J Surg 40:89–99. https://doi.org/10.1007/s00268-015-3252-9
21. Albino FP, Patel KM, Nahabedian MY et al (2013) Does mesh location matter in abdominal wall reconstruction? A systematic review of the literature and a summary of recommendations. Plast Reconstr Surg 132:1295–1304. https://doi.org/10.1097/PRS.0b013e3182a4c393
22. Holihan JL, Bondre I, Askenasy EP et al (2016) Sublay versus underlay in open ventral hernia repair. J Surg Res 202:26–32. https://doi.org/10.1016/j.jss.2015.12.014
23. Misiakos EP, Patapis P, Zavras N et al (2015) Current trends in laparoscopic ventral hernia repair. JSLS J Soc Laparoendosc Surg 19(e2015):00048. https://doi.org/10.4293/jsls.2015.00048
24. Rajkumar J, Chopra P, Chintamani (2015) Basic physics revisited for a surgeon. Indian J Surg 77:169–175. https://doi.org/10.1007/s12262-015-1308-6
25. Ahmed MA, Tawfic QA, Schlachta CM, Alkhamesi NA (2018) Pain and surgical outcomes reporting after laparoscopic ventral hernia repair in relation to mesh fixation technique: a systematic review and meta-analysis of randomized clinical trials. J Laparoendosc Adv Surg Tech 28:1298–1315. https://doi.org/10.1089/lap.2017.0609
26. Reynvoet E, Deschepper E, Rogiers X et al (2014) Laparoscopic ventral hernia repair: is there an optimal mesh fixation technique? A systematic review. Langenbeck's Arch Surg 399:55–63. https://doi.org/10.1007/s00423-013-1126-x
27. Leber GE, Garb JL, Alexander AI, Reed WP (1998) Long-term complications associated with prosthetic repair of incisional hernias. Arch Surg 133:378–382. https://doi.org/10.1001/archsurg.133.4.378
28. Matthews BD, Pratt BL, Pollinger HS et al (2003) Assessment of adhesion formation to intra-abdominal polypropylene mesh and polytetrafluoroethylene mesh. J Surg Res 114:126–132. https://doi.org/10.1016/S0022-4804(03)00158-6
29. D'Amore L, Ceci F, Mattia S et al (2017) Adhesion prevention in ventral hernia repair: an experimental study comparing three lightweight porous meshes recommended for intraperitoneal use. Hernia 21:115–123. https://doi.org/10.1007/s10029-016-1541-3
30. Köckerling F, Simon T, Adolf D et al (2019) Laparoscopic IPOM versus open sublay technique for elective incisional hernia repair: a registry-based, propensity score-matched comparison of 9907 patients. Surg Endosc. https://doi.org/10.1007/s00464-018-06629-2

31. Bittner R, Bingener-Casey J, Dietz U et al (2014) Guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias (International Endohernia Society [IEHS])—Part 2. Surg Endosc 28:353–379. https://doi.org/10.1007/s00464-013-3171-5
32. Mercoli H, Tzedakis S, D'Urso A et al (2017) Postoperative complications as an independent risk factor for recurrence after laparoscopic ventral hernia repair: a prospective study of 417 patients with long-term follow-up. Surg Endosc 31:1469–1477. https://doi.org/10.1007/s00464-016-5140-2
33. LeBlanc KA, Booth WV (1993) Laparoscopic repair of incisional abdominal hernias using expanded polytetrafluoroethylene: preliminary findings. Surg Laparosc Endosc 3:39–41
34. Tandon A, Pathak S, Lyons NJR et al (2016) Meta-analysis of closure of the fascial defect during laparoscopic incisional and ventral hernia repair. Br J Surg 103:1598–1607. https://doi.org/10.1002/bjs.10268
35. Martin-del-Campo LA, Miller HJ, Elliott HL, Novitsky YW (2018) Laparoscopic ventral hernia repair with and without defect closure: comparative analysis of a single-institution experience with 783 patients. Hernia 22:1061–1065. https://doi.org/10.1007/s10029-018-1812-2
36. Wiessner R, Vorwerk T, Tolla-Jensen C, Gehring A (2017) Continuous laparoscopic closure of the linea alba with barbed sutures combined with laparoscopic mesh implantation (IPOM plus repair) as a new technique for treatment of abdominal hernias. Front Surg 4:1–6. https://doi.org/10.3389/fsurg.2017.00062
37. Ahonen-Siirtola M, Nevala T, Vironen J et al (2019) Laparoscopic versus hybrid approach for treatment of incisional ventral hernia: a prospective randomised multicentre study, 1-year results. Surg Endosc. https://doi.org/10.1007/s00464-019-06735-9
38. Moreno-Egea A, Campillo-Soto Á, Morales-Cuenca G (2015) Which should be the gold standard laparoscopic technique for handling Spigelian hernias? Surg Endosc 29:856–862. https://doi.org/10.1007/s00464-014-3738-9
39. Clapp ML, Hicks SC, Awad SS, Liang MK (2013) Trans-cutaneous closure of central defects (TCCD) in laparoscopic ventral hernia repairs (LVHR). World J Surg 37:42–51. https://doi.org/10.1007/s00268-012-1810-y
40. Lambrecht JR, Vaktskjold A, Trondsen E et al (2015) Laparoscopic ventral hernia repair: outcomes in primary versus incisional hernias: no effect of defect closure. Hernia 19:479–486. https://doi.org/10.1007/s10029-015-1345-x
41. Pham CT, Perera CL, Scott Watkin D, Maddern GJ (2009) Laparoscopic ventral hernia repair: a systematic review. Surg Endosc Other Interv Tech 23:4–15. https://doi.org/10.1007/s00464-008-0182-8
42. Castro PMV, Rabelato JT, Monteiro GGR et al (2014) Laparoscopy versus Laparotomy in the repair of ventral hernias: systematic review and meta-analysis. Arq Gastroenterol 51:205–211. https://doi.org/10.1590/s0004-2803201400030008
43. Liang MK, Berger RL, Li LT et al (2013) Outcomes of laparoscopic vs open repair of primary ventral hernias. JAMA Surg 148:1043–1048. https://doi.org/10.1001/jamasurg.2013.3587
44. Sauerland S, Walgenbach M, Habermalz B et al (2011) Laparoscopic versus open surgical techniques for ventral or incisional hernia repair. Cochrane Database Syst Rev. https://doi.org/10.1002/14651858.CD007781.pub2
45. Yang GPC (2017) From intraperitoneal onlay mesh repair to preperitoneal onlay mesh repair. Asian J Endosc Surg 10:119–127. https://doi.org/10.1111/ases.12388
46. Jin J, Rosen MJ (2008) Laparoscopic versus open ventral hernia repair. Surg Clin N Am 88:1083–1100. https://doi.org/10.1016/j.suc.2008.05.015
47. Al Chalabi H, Larkin J, Mehigan B, McCormick P (2015) A systematic review of laparoscopic versus open abdominal incisional hernia repair, with meta-analysis of randomized controlled trials. Int J Surg 20:65–74. https://doi.org/10.1016/j.ijsu.2015.05.050
48. Hajibandeh S, Hajibandeh S, Sreh A et al (2017) Laparoscopic versus open umbilical or paraumbilical hernia repair: a systematic review and meta-analysis. Hernia 21:905–916. https://doi.org/10.1007/s10029-017-1683-y
49. Lomanto D, Iyer SG, Shabbir A, Cheah WK (2006) Laparoscopic versus open ventral hernia mesh repair: a prospective study. Surg Endosc Other Interv Tech 20:1030–1035. https://doi.org/10.1007/s00464-005-0554-2
50. Zhang Y, Zhou H, Chai Y et al (2014) Laparoscopic versus open incisional and ventral hernia repair: a systematic review and meta-analysis. World J Surg 38:2233–2240. https://doi.org/10.1007/s00268-014-2578-z
51. Schroeder AD, Debus ES, Schroeder M, Reinpold WMJ (2013) Laparoscopic transperitoneal sublay mesh repair: a new technique for the cure of ventral and incisional hernias. Surg Endosc 27:648–654. https://doi.org/10.1007/s00464-012-2508-9
52. Muysoms F, Van Cleven S, Pletinckx P et al (2018) Robotic transabdominal retromuscular umbilical prosthetic hernia repair (TARUP): observational study on the operative time during the learning curve. Hernia 22:1101–1111. https://doi.org/10.1007/s10029-018-1825-x
53. Baig SJ, Priya P (2018) Extended totally extraperitoneal repair (eTEP) for ventral hernias: short-term results from a single centre. J Minim Access Surg. https://doi.org/10.4103/jmas.JMAS_29_18
54. Reinpold W, Schröder M, Berger C et al (2018) Mini- or less-open sublay operation (MILOS). Ann Surg 269:748–755. https://doi.org/10.1097/sla.0000000000002661
55. Luque JAB, Luque JAB (2014) Advances in laparoscopy of the abdominal wall hernia, pp 1–211. https://doi.org/10.1007/978-1-4471-4700-8
56. Nguyen DH, Nguyen MT, Askenasy EP et al (2014) Primary fascial closure with laparoscopic ventral hernia repair: systematic review. World J Surg 38:3097–3104. https://doi.org/10.1007/s00268-014-2722-9
57. Ramakrishna HK, Lakshman K (2013) Intra peritoneal polypropylene mesh and newer meshes in ventral hernia repair: what EBM says? Indian J Surg 75:346–351. https://doi.org/10.1007/s12262-012-0743-x
58. Darehzereshki A, Goldfarb M, Zehetner J et al (2014) Biologic versus nonbiologic mesh in ventral hernia repair: a systematic review and meta-analysis. World J Surg 38:40–50. https://doi.org/10.1007/s00268-013-2232-1
59. de Biondo-Simões MLP, de Pessini VCA, Porto PHC, Robes RR (2018) Aderências em telas de polipropileno versus telas Sepramesh®: estudo experimental em ratos. Rev Col Bras Cir 45:1–11. https://doi.org/10.1590/0100-6991e-20182040
60. Tollens T, Den Hondt M, Devroe K et al (2011) Retrospective analysis of umbilical, epigastric, and small incisional hernia repair using the Ventralex™ hernia patch. Hernia 15:531–540. https://doi.org/10.1007/s10029-011-0816-y
61. Nicolau AE, Vasile R, Haiducu C (2019) Laparoscopic repair of small ventral hernias using the "Ventralex Hernia Patch". Chirurgia (Bucur) 114:95. https://doi.org/10.21614/chirurgia.114.1.95
62. Martin DF, Williams RF, Mulrooney T, Voeller GR (2008) Ventralex mesh in umbilical/epigastric hernia repairs: clinical outcomes and complications. Hernia 12:379–383. https://doi.org/10.1007/s10029-008-0351-7
63. Alizai PH, Andert A, Lelaona E et al (2017) Impact of obesity on postoperative complications after laparoscopic and open incisional hernia repair—a prospective cohort study. Int J Surg 48:220–224. https://doi.org/10.1016/j.ijsu.2017.11.006
64. De Jong A, Verzilli D, Geniez M et al (2018) Why is the morbidly obese patient at high risk of anesthetic complications? Press Medicale 47:453–463. https://doi.org/10.1016/j.lpm.2018.01.016

65. Brahmbhatt R, Carter SA, Hicks SC et al (2014) Identifying risk factors for surgical site complications after laparoscopic ventral hernia repair: evaluation of the ventral hernia working group grading system. Surg Infect (Larchmt) 15:187–193. https://doi.org/10.1089/sur.2012.179
66. Newcomb WL, Polhill JL, Chen AY et al (2008) Staged hernia repair preceded by gastric bypass for the treatment of morbidly obese patients with complex ventral hernias. Hernia 12:465–469. https://doi.org/10.1007/s10029-008-0381-1
67. Eid GM, Wikiel KJ, Entabi F, Saleem M (2013) Ventral hernias in morbidly obese patients: a suggested algorithm for operative repair. Obes Surg 23:703–709. https://doi.org/10.1007/s11695-013-0883-5
68. Tobler WD, Itani KMF (2016) Current status and challenges of laparoscopy in ventral hernia repair. J Laparoendosc Adv Surg Tech 26:281–289. https://doi.org/10.1089/lap.2016.0095
69. DeLancey JO, Blay E, Hewitt DB et al (2018) The effect of smoking on 30-day outcomes in elective hernia repair. Am J Surg 216:471–474. https://doi.org/10.1016/j.amjsurg.2018.03.004
70. Weiss S, Weissenbacher A, Sucher R et al (2015) Outcome analysis of laparoscopic incisional hernia repair and risk factors for hernia recurrence in liver transplant patients. Clin Transplant 29:866–871. https://doi.org/10.1111/ctr.12558
71. Subramanian A, Clapp ML, Hicks SC et al (2013) Laparoscopic ventral hernia repair: primary versus secondary hernias. J Surg Res 181:e1–e5. https://doi.org/10.1016/j.jss.2012.06.028
72. Liot E, Bréguet R, Piguet V et al (2017) Evaluation of port site hernias, chronic pain and recurrence rates after laparoscopic ventral hernia repair: a monocentric long-term study. Hernia 21:917–923. https://doi.org/10.1007/s10029-017-1663-2
73. Penchev D, Kotashev G, Mutafchiyski V (2019) Endoscopic enhanced-view totally extraperitoneal retromuscular approach for ventral hernia repair. Surg Endosc. https://doi.org/10.1007/s00464-019-06669-2
74. Belyansky I, Daes J, Radu VG et al (2018) A novel approach using the enhanced-view totally extraperitoneal (eTEP) technique for laparoscopic retromuscular hernia repair. Surg Endosc 32:1525–1532. https://doi.org/10.1007/s00464-017-5840-2
75. Henriksen NA, Jensen KK, Muysoms F (2019) Robot-assisted abdominal wall surgery: a systematic review of the literature and meta-analysis. Hernia 23:17–27. https://doi.org/10.1007/s10029-018-1872-3