

Closure versus non-closure of fascial defects in laparoscopic ventral and incisional hernia repairs: a review of the literature

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Abstract The laparoscopic technique for repairing ventral and incisional hernias (VIH) is now well established. However, several issues related to laparoscopic VIH repair, such as the high recurrence rate for hernias with large fascial defects and in extremely obese patients, are yet to be resolved. Additional problems include seroma formation, mesh bulging/eventration, and non-restoration of the abdominal wall rigidity/function with only bridging of the hernial orifice using standard laparoscopic intraperitoneal onlay mesh repair (sIPOM). To solve these problems, laparoscopic fascial defect closure with IPOM reinforcement (IPOM-Plus) has been introduced in the past decade, and a few studies have reported satisfactory outcomes. Although detailed techniques for fascial defect closure and handling of the mesh have been published, standardized techniques are yet to be established. We reviewed the literature on IPOM-Plus in the PubMed database and identified 16 reports in which the recurrence rate, incidence of seroma formation, and incidence of mesh bulging were 0–7.7, 0–11.4, and 0 %, respectively. Several comparison studies between sIPOM and IPOM-Plus seem to suggest that IPOM-Plus is associated with more favorable surgical outcomes; however, larger-scale studies are essential.

Keywords Ventral hernia · Incisional hernia · Laparoscopic repair · IPOM-plus · Defect closure

Introduction

The treatment of ventral hernias, either primary or secondary, is a challenge for surgeons. After major abdominal surgery, an incisional hernia develops in 11–20 % of cases [1–3]. In the United States, over 250,000 ventral hernia repairs are performed per year, which have been increasing steadily [4, 5]. In Japan, the number of ventral and incisional hernia (VIH) repair (VIHR) procedures has also been increasing, and the number of cases at institutions that have adopted the fixed payment system for medical expenses based on investigations conducted by the Hospital Intelligence Agency [6] in Japan was reported to be more than 16,000 per year.

As in inguinal hernia repair in adults, VIHR has changed from suture repair to prosthetic repair. The recurrence rate of suture repair and mesh repair for VIHR were reported to be 46–63 and 23–32 %, respectively [7–9]. Since the first introduction by LeBlanc [10] in 1993, laparoscopic VIHR (LVIHR) has gained popularity not only in the United States, but also across the globe. According to recent case series of LVIHR with long-term follow-up, the recurrence rate was as low as 4.4–4.7 % [11–13]. In addition, a Cochrane review proved that LVIHR had advantages in terms of a lower wound infection rate and shorter hospital stay compared to open VIHR (OVIHR) [14]. However, for patients having hernias with a large fascial defect, standard laparoscopic intraperitoneal onlay mesh repair (sIPOM) that simply bridges the hernia orifice is still associated with several problems that need to be solved, including the high recurrence rate, mesh bulging/eventration, seroma formation, and non-restoration of the abdominal wall function [15–17]. In recent years, a fascial closure technique with IPOM reinforcement in LVIHR, named

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Table 1 Relevant literature on IPOM-Plus

| References | No. of patients | BMI (kg/m ²) | Size of defect (cm ²) | Width of defect (cm) |
|------------------------|---|--------------------------|-------------------------------------|----------------------|
| Franklin et al. [19] | 384 | ND | ND | ND |
| Chelala et al. [20] | 400 | 35 (23–48) | ND | 2–14 |
| Palanivelu et al. [21] | 721 | ND | 96 (11–128) | ND |
| Agarwal et al. [22] | 30 | ND | ND | 5.7 |
| Agarwal et al. [23] | 29 | 27 (20–39) | ND | 9.6 |
| Sharma et al. [24] | 17 | ND | Continuous 16.5 Interrupted 16.2 | ND |
| Orenstein et al. [25] | 47 | 31.8 (22–50) | 82 (16–300) | ND |
| Rea et al. [26] | 87 | ND | ND | Major axis <10 cm |
| Banerjee et al. [27] | 193 | 35.6 (20–73.6) | 41.2 ± 74.2* | ND |
| Liang et al. [28] | 22 | 34 (20–51) | 19 (3.1–190.1) | 4 (2–11) |
| Allison et al. [29] | 13 | 31.5 (27–41.65) | 37.39 ± 35.6* | ND |
| Clapp et al. [30] | 36 | 34.25 ± 1.44* | 28.05 ± 6.82* | 4.18 ± 0.42* |
| Zeichen et al. [31] | 35 | 31.7 (21–71) | 43.97 (9–225) | ND |
| Gonzalez et al. [33] | 67 | 34.7 ± 9.0 | ND | ND |
| Lambrecht et al. [34] | 57 (IH:PH = 36:21, prospective study) 17 (IH:PH = 10:7, retrospective study) | ND | ND | ND |

BMI body mass index, ND not described, IH incisional hernia, PH primary ventral hernia

* Mean ± SD

“IPOM-Plus,” has been introduced and appeared in the guidelines for the laparoscopic treatment of ventral and incisional abdominal wall hernias published by the International Endohernia Society (IEHS) in 2014 [18]. Since prospective studies on the quality of IPOM-Plus are not available, the evidence level for the statements in these guidelines remains low.

In this article, we reviewed the literature on IPOM-Plus, including the details of the surgical procedures and outcomes using the PubMed database for papers published between 1993 and April 2015 using the terms laparoscopic AND (ventral or incisional) AND hernia AND (defect closure or augmentation repair) as keywords, and 16 relevant articles [19–34] were reviewed. Out of these articles, four [30, 31, 33, 34] compared sIPOM with IPOM-Plus, and only one report was a randomized controlled study (RCT) [34].

Characteristics of the Hernias (Table 1)

The publication year, number of patients, and the size (surface area and width) of the hernial orifice in the previous literature are shown in Table 1. The largest width and maximum surface area of hernial orifice treated were 14 cm and 300 cm², respectively.

Surgical techniques for IPOM-plus (Table 2)

Closure method

The fascial closure methods can generally be classified into extracorporeal or intracorporeal, and by the use of interrupted or running sutures. The reviewed literature described various unique and informative suture techniques. The simplest closure method is the extracorporeal interrupted suture technique described by Franklin et al. [19] and Liang et al. [27] (Fig. 1). The unique procedures include “Chelala’s reverse U-stitch” [20], “Agarwal’s double-breasted closure” [22, 23], and “Orenstein’s shoelacing technique” [25]. The “double-breasted closure” is a modification of the renowned Mayo technique described as the “vest-over-pant” technique for umbilical hernia repair. The “shoelacing technique,” which consists of “figure-of-eight stitches,” is like tying a shoelace to close the hernial orifice. The details of the peculiar “reverse U-stitch” are shown in Fig. 2 and are based on personal communications with Dr. Chelala, since there has been no schematic explanation in the literature.

In most of the literature reviewed, thick non-absorbable suture threads between 0 and #2 were used to close the fascial defect, and the interval between sutures was recommended to be 1 cm except in the “shoelacing technique,”

Table 2 Literature on the surgical techniques used for IPOM-Plus

| References | Closure method | Suture material | Suture interval (cm) | Type of mesh | Overlap | | Mesh fixation | Additional component separation |
|------------------------|---|-----------------------------|----------------------|--------------------------------------|----------|---------------------------------------|-----------------------------------|---|
| | | | | | OD or CD | cm | | |
| Franklin et al. [19] | Extracorporeal | #2 braided polyester | ND | Polypropylene | OD | 3–5 | Tackers and trans-fascial sutures | – |
| Chelala et al. [20] | Intracorporeal interrupted (Reverse U-stitch) Extracorporeal (defect > 10 cm) | Non-absorbable monofilament | 1 | PCO* | OD | 4–6 cm longitudinally, 5 cm laterally | Sutures | – |
| Palanivelu et al. [21] | Intracorporeal continuous | #1 nylon loop | ND | PCO Dual mesh | CD | 5–6 | Sutures | – |
| Agarwal et al. [22] | Extracorporeal interrupted (double-breasted closure) | #1 polypropylene | 1 | Dual mesh | CD | 5 | Tackers and trans-fascial sutures | – |
| Sharma et al. [24] | Intracorporeal interrupted (far-near-far-near vertical mattress suture) | #1 polypropylene | 1–1.5 | Multilayered tissue-separating mesh | ND | ND | Tackers | – |
| Orenstein et al. [25] | Extracorporeal multiple figure-of-eight (shoelacing technique) | #1 polypropylene | 3 | Polyester, Polypropylene | CD | 5–7 | Tackers and trans-fascial sutures | +(Endoscopic, defect > 10 cm) |
| Rea et al. [26] | Extracorporeal | Slow absorbable suture | 0.8 | Dual mesh | OD | 3–5 | Absorbable sutures | – |
| Liang et al. [28] | Extracorporeal interrupted (TCCD) | 0 polypropylene | 1 | Coated polyester mesh | CD | 6 | Titanium tackers and sutures | – |
| Allison et al. [29] | Intracorporeal continuous (Robotic surgery) | 0 absorbable | ND | Dual mesh, Veritas, Physiomesh, PCO | OD | 5 | Continuous sutures | – |
| Clapp et al. [30] | Extracorporeal interrupted | 0 polypropylene | 1 | ND | OD | 3–6 | Tackers and sutures | – |
| Zeichen et al. [31] | Extracorporeal interrupted | Braided polyester | ND | ND | OD | 3–5 | Tackers and sutures | – |
| Strey et al. [32] | Intracorporeal interrupted | #1 polydioxanone | ND | ND | ND | ND | ND | +(internal release of transversalis fascia) |
| Gonzalez et al. [33] | Intracorporeal (Robotic surgery) | 0 polypropylene | ND | Proceed™, Physiomesh™, Biologic mesh | ND | ND | Tackers and sutures | – |

Table 2 continued

| References | Closure method | Suture material | Suture interval (cm) | Type of mesh | Overlap OD or CD cm | Mesh fixation | Additional component separation |
|-----------------------|---------------------------------|-----------------|----------------------|--|------------------------|---------------|---------------------------------|
| Lambrecht et al. [34] | Intracorporeal, figure-of-eight | #1 Polyglactin | ND | PCO, Compositex and Compositex E/X, Dualmesh, Proceed mesh | OD 5 | Tackers | – |

OD according to original defect, CD according to closed defect, ND not described

* PCO = Parietex™ composite mesh

in which the intervals were 3 cm. For the closure of fascial defects, the IEHS guidelines recommended the use of non-absorbable sutures (Grade B: “recommended,” “surgeon should do it”) [18].

Selection of the mesh size based on the original defect or closed defect size

In the reviewed literatures, a landmark for the overlap of the mesh was divided into two groups: according to the border of the original fascial defect or after closure of the defect by sutures.

The mesh overlap for sIPOM was recommended to be at least 3–4 cm in recent reports, and a minimum of 5 cm is preferable if transfascial sutures are not added [18]. In IPOM-Plus, the fascial defect is closed, and only the newly created suture line is left. Thus, the subject of discussion becomes whether the mesh size has to be selected according to the size of the original defect (OD) or the closed defect (CD). If the mesh size is selected based on the OD, a reduction in the recurrence rate can be expected, as an overlap of more than 5 cm is ensured. On the other hand, surgery becomes difficult because of the need to handle a large mesh in the intraperitoneal cavity. If the mesh is selected based on the CD, the transverse diameter of the mesh can be narrowed, which eases technical difficulty. In the reviewed reports, the overlap can be divided into two groups; those performed with an overlap of 3–6 cm based on the OD and those performed with an overlap of 5–7 cm based on the CD. The recurrence rate for the OD group was 0–7.7 % after a median follow-up period of 23–47.1 months and was 0–0.55 % for the CD group with a follow-up of 16.2–50.4 months.

Additional component separation technique

A strong tension is generated during fascial closure in IPOM-Plus, which is different from sIPOM. The width of the hernial orifice is an important factor related to the size of the VIH, and the closure of defects exceeding 10 cm may be difficult even when the insufflation intraperitoneal pressure is low. Even in the IEHS guidelines [18], IPOM-Plus fascial closure was recommended only for limited-sized hernial orifices, while the use of an additional endoscopic component separation technique has been described as an option for cases with large defects (Grade C: “option,” “surgeon can do it”).

The component separation technique (CST) is a surgical technique reported by Ramirez et al. [35] in 1990. This technique is based on the translation of the muscular layers of the abdominal wall to enlarge its surface area. According to Ramirez’s theory, a longitudinal incision on the aponeurosis of the external oblique muscle and dissection of a

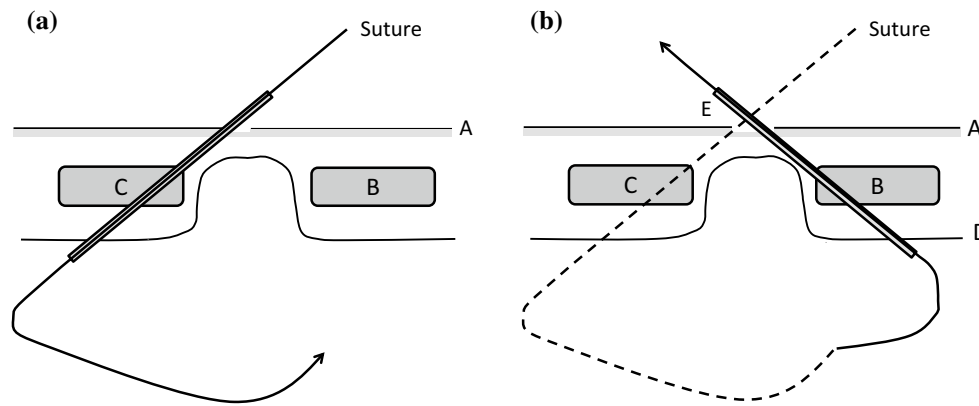


Fig. 1 The extracorporeal interrupted suture technique. A thick monofilament suture is passed through a midline skin incision through the right rectus muscle and fascia (a). Then, the suture is retrieved across the left rectus muscle by an EndoClose™ through the same skin incision (b)

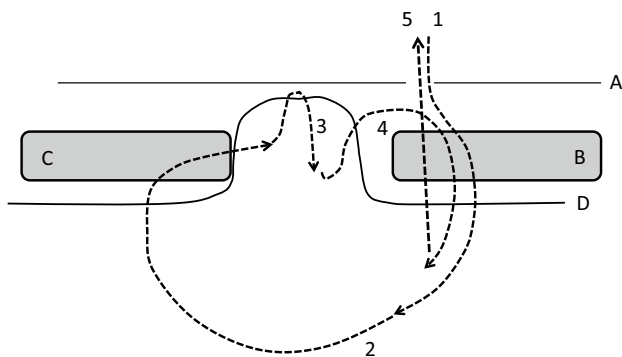


Fig. 2 A schematic explanation of Chelala's reverse U-stitch. A #2 Novafil™ suture is inserted across the left rectus muscle and the parietal wall 1 cm lateral to the left edge of the defect (1). The peritoneum and posterior portion of the right rectus muscle are sutured (2). The top of the hernia sac is sutured and invaginated (or the sac is resected) if possible, especially on the umbilicus, for cosmetic purposes and to reduce dead space (3). The full-thickness of the left rectus muscle is sutured 1 cm lateral to the edge, which is facilitated by pushing the left parietal abdomen laterally (4). The suture is retrieved across the left rectus muscle by an EndoClose™ through the same skin incision (5). The suture is tied subcutaneously after total exsufflation and removal of the dimple of the sac invagination (6). A skin, B left rectus abdominis muscle, C right rectus abdominis muscle, D peritoneum (hernia sac), E EndoClose™

plane between the external and internal oblique muscles allows the anterior sheath of the rectus abdominis muscle to be approximated medially for up to 4 cm at the subxiphoid level, up to 8 cm around the waist level, and up to 3 cm in the suprapubic region on each side. Thus, this technique is an excellent surgical option for closure of a large abdominal wall defect without the use of prosthesis. Endoscopic CST (ECST) is currently being performed to reduce the high-wound complication rates associated with the original CST which is caused by the sacrifice of perforators of the rectus abdominis muscle, with good results [36–41]. In the

previous literature, two reports mentioned different ECST techniques used in combination with IPOM-Plus [25, 32]. One technique was introduced by Rosen et al. [36], in which the external oblique muscle was dissected from the internal oblique muscle through several small skin incisions under endoscopic guidance, and the other was laparoscopic internal release of the transversalis fascia, which was reported by Milburn et al. [42].

Outcomes of IPOM-plus (Table 3)

The major benefit of performing IPOM-Plus is the reduction of the recurrence and complication rates, including mesh bulging/eventration and seroma formation, as well as normalization of the abdominal wall function. A RCT by Lambrecht et al. [34] mainly analyzed the surgical outcomes of primary versus secondary ventral (incisional) hernia repair and also compared IPOM-Plus and sIPOM for these two hernias. This study concluded that IPOM-Plus using absorbable sutures was not effective in reducing the recurrence or complication rates; however, the original data for IPOM-Plus (i.e., recurrence rate, incidence of seroma formation, and mesh bulge) were not mentioned.

Recurrence

The recurrence rate (4.4–29 %) mentioned in the recent reports on sIPOM [12–14, 43–45] has been quite variable, which is attributable to the differences in the size of the hernial orifice and body mass index (BMI) of the patients and the differences in the follow-up periods. A simple comparison of the surgical outcomes of IPOM-Plus with sIPOM is meaningless because of the absence of large prospective randomized studies on the recurrence or complication rates of IPOM-Plus and sIPOM. In the current review, the overall recurrence rate of IPOM-Plus was 0–7.7 % with

Table 3 Surgical outcomes of IPOM-Plus

| References | Length of operation (min) | Hospital stay (days) | Follow-up (months) | Recurrence rate (%) | Overall complication rate (%) | Mesh bulge (%) | Seroma (%) | Chronic pain (%) |
|------------------------|-----------------------------------|----------------------|---------------------------------|---------------------|-------------------------------|----------------|------------|---|
| Franklin et al. [19] | 68 (14–405) | 2.9 (0–36) | 47.1 (1–141) | 2.9 | 10.1 | ND | 3.1 | 1.6 |
| Chelala et al. [20] | 74 (35–150) | 3 (2–30) | 28 (1–57) | 1.5 | 14.0 | ND | 2.0 | 2.5 |
| Palanivelu et al. [21] | 95 (60–115) | 2 (1–6) | 50.4 (3–120) | 0.55 | 15.8 | ND | 7.6 | 5.0 |
| Agarwal et al. [23] | 65 (50–135) | <1 day (0.5–3) | 34 (19–43) | 0 | 62.1 | 0 | 0 | 0 |
| Sharma et al. [24] | Continuous 165 Interrupted 128 | ND | Continuous 22 Interrupted 12 | 0 | ND | 0 | 0 | Continuous 1 Interrupted 1 (>7 days) |
| Orenstein et al. [25] | 134 (40–280) | 2.9 (1–10) | 16.2 (3–36) | 0 | 4.0 | ND | 0 | 0 |
| Rea et al. [26] | ND | 3.1 (3–5) | ND | 0 | ND | ND | ND | ND |
| Banerjee et al. [27] | 91.7 ± 44.1* | 2 ± 2.1* | 10.5 (1–36) | 3 | ND | ND | ND | ND |
| Liang et al. [28] | ND | 1 (0–3) | 21 (10–34) | 0 | 9 | 0 | 0 | ND |
| Allison et al. [29] | 131 ± 57* | 2.4 ± 1.1* | 23 (2–33) | 7.7 | ND | ND | 0 | ND |
| Clapp et al. [30] | ND | 1.3 ± 0.2* | 24 (7–34) | 0 | 33.3 | 0 | 5.6 | 9.4 |
| Zeichen et al. [31] | Mean 89.0 (45–143) | 1.2 (1–3) | 26.6 (0.23–109.5)* | 6.3 | 22.9 | ND | 11.4 | ND |
| Strey et al. [32] | ND | ND | ND | 0 | ND | 0 | 0 | ND |
| Gonzalez et al. [33] | 107.6 ± 33.9 | 2.5 ± 4.1 | 17.1 ± 9.5 | 1.5 | 3.0 | ND | ND | ND |
| Lambrecht et al. [34] | ND | ND | ND | ND | ND | ND | ND | ND |

ND not described

* Mean ± SD

a median follow-up period of 10.5–50.4 months. To date, three reports [27, 30, 31] have indicated that IPOM-Plus was associated with a lower recurrence rate compared with that of sIPOM based on their data: 0 and 16.7, 3.0 and 4.8, and 5.7 and 15.1 %, respectively. However, two studies [32, 33] reported that IPOM-Plus did not contribute to a reduction in the recurrence rate.

Seroma formation

The most common complication after LVIHR is seroma formation, which destroys the esthetic outcome for the patient and causes discomfort, pain and/or infection [46]. In the previous reports on sIPOM, the incidence of clinical seroma has been 0.5–78 % [47, 48]. The reason for this wide range seems to be related to the detection threshold of the imaging

studies, which can detect small asymptomatic seromas [49]. Based on our review of the previous literature, the overall incidence of seroma in IPOM-Plus was 0–11.43 %. The comparisons of IPOM-Plus versus sIPOM in the reports by Clapp et al. [30] and Zeichen et al. [31] showed incidence rates of 5.6 versus 27.8 % and 11.4 versus 4.3 %, respectively, which indicated opposite results. In addition, the RCT by Lambrecht et al. [34] concluded that IPOM-Plus did not reduce seroma formation. Thus, the effectiveness of IPOM-Plus in terms of reducing the incidence of seroma formation remains equivocal from this review.

With regard to seroma prevention in the IEHS guidelines, a low-level recommendation was given to include hernia sac during fascial closure that would eliminate dead space to prevent a seroma [18] (Grade D: no recommendation at all, described options).

Chronic pain

Chronic pain after hernia repair is always an issue of capital importance after either inguinal or ventral hernia repair. IPOM-Plus undoubtedly deviates from the concept of tension-free surgery because of the straight approximation of the edges of fascial defect, and the incidence of postoperative chronic pain among patients who underwent IPOM-Plus may be higher than that of sIPOM. An objective evaluation of chronic pain is difficult, partly because there is no definition of chronic pain for VIHR, which is in contrast to inguinal hernia repair, in which chronic pain is defined as pain lasting over 6 months postoperatively in the International Guidelines of Chronic Pain for Inguinal Hernias [50]. The recent literature [11, 12, 51] using this definition described the incidence of chronic pain after sIPOM to be in the range of 1.3–14.7 %, which was much higher than that after laparoscopic inguinal hernia repair [52, 53]. Therefore, the postoperative pain of IPOM-Plus and sIPOM should be evaluated and compared. In the present review, only Clapp et al. [30] investigated the incidence of chronic pain with IPOM-Plus versus sIPOM and reported that the incidence was not statistically different between the two groups (9.4 and 18.2 %, respectively).

Mesh bulging

Mesh bulging or mesh eventration is a recently reported complication of VIHR [16, 17, 45]. With regard to the mechanism underlying mesh bulging, the central nonfunctioning portion of the abdominal wall will protrude into the hernia sac due to the intraabdominal pressure by Laplace's law, and the patient feels this "bulging." The definition of the recurrence of a ventral hernia is vague, which is in contrast to that of inguinal hernias, in which postoperative ipsilateral groin bulging is diagnosed as a "recurrence" when a swelling (whether or not it is palpable during Valsalva's maneuver) or defect develops in the groin where an inguinal hernia operation has been carried out [54]. On the other hand, after VIHR, an abdominal wall bulge is diagnosed as a "recurrence" only when a definitive gap between the hernia edge and the musculofascial tissues is identified, and other bulges, including mesh bulges, are diagnosed as "pseudo-recurrence," which may contribute to the patient's dissatisfaction.

Kurmann et al. [45] reported that in large VIH, the incidence of mesh bulging after sIPOM was as high as 17.4 % compared with 7.1 % after OVIHR. In this review, Clapp et al. [30] described that IPOM-Plus could control mesh bulging as well as recurrence and concluded that the incidence of mesh bulging after sIPOM was significantly higher than that after IPOM-Plus (69.4 versus 8.3 %). On

the other hand, the reviewed RCT [34] described that the incidence of mesh bulging after IPOM-Plus and sIPOM was similar.

Correction of the abdominal wall rigidity/function

The anterior abdominal wall, which comprises four muscles; the rectus abdominis, the external and internal obliques and the transversus abdominis, is a complex unit providing movement of the trunk, protection of the intra-peritoneal organs and contributions to vital functions, including respiration, micturition, and defecation. The unit of the anterior abdominal wall has been considered to be dysfunctional when a VIH is acquired. An experimental study using animals demonstrated that the fascial separation and loss of midline muscle attachment in large ventral hernias lead to abdominal muscle shortening and relative unloading, particularly of the lateral oblique muscles whose insertions are lost [55, 56].

Although various reports on VIHR describe improvement of vital functions caused by VIH, the evaluation methods and results were not uniform in a recent systematic review [57], and objective functional improvement of the abdomen by appropriate VIHR has yet to be established. In fact, there is no evidence whether IPOM-Plus or sIPOM has superiority over the other technique except for one report by Den Hartog et al. [58], in which higher isokinetic strength of the trunk flexor muscles was acquired by the repair of the gap of the rectus abdominis muscle in two layers compared to sIPOM.

Among the papers reviewed, the abdominal wall functions have been discussed only in the report by Clapp et al. [30], in which the postoperative functional status score of IPOM-Plus using an activities assessment scale was significantly better than that of sIPOM (79.1 ± 1.9 versus 71.3 ± 2.3 , $p = 0.002$).

Discussion

Based on the present review of the literature, the surgical outcomes of IPOM-Plus seem to be favorable, while several comparison studies indicated that IPOM-Plus was not effective in reducing the recurrence rate or incidence of postoperative complications such as seroma formation or mesh bulging. Thus, the relative merits of the two techniques remain unclear. These studies have analyzed the approaches applied under different conditions, such as the techniques used for fascial closure, the size, and site of the hernia and the selection of the mesh. In particular, there are several issues that need to be discussed as follows.

From and up to what size of fascial defect should be closed?

Simple fascial defect closure is not feasible for non-small hernias due to the excessive tension of sutures, which may cut through the tissues, possibly leading to postoperative complications [59]. The major problem is to decide up to what size, or specifically up to what width, of fascial defects can be closed. The largest defect width in the reviewed literature was 14 cm. However, there is no practical method that allows an evaluation of the abdominal compliance and elasticity in the clinical setting, although easily distensible abdominal walls are generally amenable to primary fascial closure. Some reports have described the patient's BMI, gender, and age to be important clinical parameters [60]. The location of the hernia is also a relevant factor that affects closure of the defect, with suprapubic hernias being more difficult to close. In addition, the size for which additional ECST has to be performed or whether there should be a conversion to other surgical procedures, e.g., the Rives-Stoppa technique, is a question to be solved.

Extracorporeal or intracorporeal sutures?

The number of small stab wounds used to introduce into the peritoneal cavity and retrieve the sutures for extracorporeal suture technique may increase the risk of infection, suture granuloma [60], or multiple dimples on the skin, which may affect patient satisfaction for cosmetic reasons. Although Clapp et al. [30] reported the superiority of IPOM-Plus over sIPOM for the cosmetic satisfaction of the patient, the occurrence rate of mesh bulging was significantly higher for sIPOM. This might indicate that the opinion of patients regarding small stab wounds was not included. Alternately, intracorporeal interrupted or running sutures have been shown to be more beneficial in terms of the smaller number of stab wounds, skin dimples, and suture granulomas. However, laparoscopic intracorporeal suturing is technically more demanding, and therefore, surgeons should select the suture technique depending on their skill level for laparoscopic surgery.

What are the landmarks for mesh overlap?

As the landmark for IPOM-Plus, the width of the overlap must be determined based on the original fascial defect or on the suture line. In the former case, handling and fixing the mesh in the abdominal cavity may be difficult. The results of this review showed no significant difference in the recurrence rates between overlap selected based on the OD and CD. The feasibility of mesh size reduction by CD for IPOM-Plus is worth investigating in the future.

Based on the issues mentioned above, large-scale randomized controlled trials using data comparisons between IPOM-Plus and sIPOM seem to be essential.

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Compliance with ethical standards

Conflict of interest None of the authors has any conflict of interest to declare.

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