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ORIGINAL ARTICLE

Postoperative ileus after laparoscopic primary and incisional abdominal hernia repair with intraperitoneal mesh (DynaMesh®-IPOM versus Parietex™ Composite): a single institution experience

Andreas Domen[1] · Cedric Stabel[1] · Rami Jawad[1] · Nicolas Duchateau[1] · Erik Fransen[2] · Patrick Vanclooster[1] · Charles de Gheldere[1]

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Abstract

Purpose Laparoscopic primary or incisional abdominal hernia repair with intraperitoneal mesh placement is a well-accepted and safe technique. Evidence for complications however remains inconclusive, and little is known about the occurrence of postoperative ileus secondary to postoperative intra-abdominal adhesions with different types of IPOM meshes used. Therefore, we retrospectively compared the occurrence of postoperative ileus between two of the different meshes used in our center.

Methods Three hundred seventy-five patients who underwent ventral hernia repair with intraperitoneal mesh placement, either with a DynaMesh®-IPOM (FEG Textiltechnik mbH, Aachen, Nordrhein-Westfalen, Germany) or a Parietex™ Composite mesh (Medtronic, Minneapolis, MN, USA), at the Heilig-Hart Hospital in Lier (Antwerp, Belgium) between 2012 and 2017 were retrospectively compared with regard to the occurrence of postoperative ileus until 6 weeks postoperatively. Baseline demographics and clinical data up to 6 weeks postoperatively of the patients in the two mesh groups are provided.

Results The DynaMesh®-IPOM mesh group was associated with a significantly higher incidence of postoperative ileus compared with the Parietex™ Composite mesh group with a cutoff limit at postoperative day 1 ($n = 17$, 6.8% vs. $n = 0$, 0.0%; $P = 0.003$) and postoperative day 4 ($n = 13$, 5.2% vs. n = 0, 0.0%, $P = 0.006$), even with a mesh surface area of ≤ 300 cm^2 and when both meshes were fixated with the same method of fixation (Securestrap™) with a cutoff limit for postoperative ileus at postoperative day 1 ($n = 4$, 7.7% vs. $n = 0$, 0.0%; $P = 0.013$) and postoperative day 4 ($n = 3$, 5.8% vs. n = 0, 0.0%, $P = 0.040$). Of the 17 patients with a postoperative ileus, 9 (52.9%) had a suspicion of adhesive small bowel obstruction on CT scan ($P = 0.033$) with definitive confirmation of small bowel adhesions with the DynaMesh®-IPOM mesh at laparoscopy in 2 patients.

Conclusion Our results confirm current literature available regarding postoperative ileus secondary to postoperative intra-abdominal adhesions with the DynaMesh®-IPOM mesh. However, further research with well-designed, multicenter randomized controlled studies to evaluate the use and related complications of these meshes is needed.

Keywords Primary hernia · Incisional hernia · Laparoscopy · Mesh repair · Adhesion · Postoperative ileus

Introduction

Ventral herniation, either primary (i.e., umbilical, epigastric, and Spigelian) or secondary (incisional) after abdominal surgery, is very common [1, 2]. The global overall incidence of primary ventral hernia is estimated to be between 4 and 5% and incisional hernia between 35 to 60% within 5 years after laparotomy and 0.5% after laparoscopy [3, 4]. The fundamental mechanism for hernia formation is loss of the mechanical integrity of abdominal wall structural tissue that results in the inability to offset and contain intra-abdominal forces during

Andreas Domen and Cedric Stabel share first authorship

✉ Charles de Gheldere
charlesdegheldere@me.com

[1] Department of General Surgery, Heilig-Hart Hospital, Mechelsestraat 24, Lier, Belgium

[2] StatUa Center for Statistics, University of Antwerp, Wilrijk, Antwerp, Belgium

Valsalva and loading of the torso [5]. Mostly, this leads to complains like discomfort, pain, or itching, but complications due to incarceration of intestines or omental fat in the defect can also occur. Surgical treatment of symptomatic hernias can either be open or laparoscopic, the latter being widely accepted nowadays with both prosthetic synthetic mesh or primary suture as valuable options as it has been shown to result in lower wound infection rates, less pain, and a shorter hospital stay [6], though with similar hernia recurrence rates compared to open repair [7–9]. However, concerning hernia recurrence a follow-up of at least 3 years is necessary to detect the majority of recurrences [9] and is estimated to be as high as 22% after laparoscopic incisional hernia repair after 3.5 years of follow-up [10]. In herniations with a fascial defect greater than 2 cm, evidence suggests that laparoscopic ventral hernia repair with intraperitoneal onlay mesh (IPOM) is superior to the open onlay technique with fewer overall perioperative complications, decreased length of hospital stay, and decreased mortality [2].

The absorbability of meshes ranges from non- over semi- to fully absorbable, based on a woven or unwoven texture. They can be placed on top of the abdominal muscles (onlay), between the muscles (inlay), beneath the muscles (sublay), or intraperitoneal (IPOM). Although the companies producing meshes designed for intraperitoneal use all claim their mesh is safe, placement of foreign mesh material can be associated with the formation of permanent adhesions formed between the mesh and abdominal viscera due to an inflammatory reaction leading to potential severe complications such as intestinal obstruction, mesh infection, fistulation, chronic pain, and difficulties at reoperation [2, 11–16]. Moreover, since there are different types of commercially available meshes, little is known about complications related to the specific type of mesh, such as postoperative ileus secondary to adhesions. Adhesive small bowel obstruction can cause considerable harm, resulting in 8 days of hospitalization on average and a high risk for reoperation (between 20 and 30% of cases) [17].

The DynaMesh®-IPOM mesh (FEG Textiltechnik mbH, Aachen, Nordrhein-Westfalen, Germany) has a dual-component structure consisting of 88% anti-adhesive polyvinylidene difluoride (PVDF) and 12% polypropylene (PP). Adhesive PP is woven through the mesh structure on the side which is placed parietally to provide a rapid and safe incorporation into the abdominal wall. The anti-adhesive visceral PVDF side acts as a barrier to prevent adhesions of the intestines and/or omental fat with the mesh (https://en.dynamesh.com/ipom-gb/) [18]. As this mesh is thin and translucent and has just enough memory, it is easy to handle, trim, and fix safely, making it to our experience the most easy mesh to handle intended for intraperitoneal use. Because of these properties, we started to use this mesh in our center as the preferred mesh for laparoscopic primary and incisional hernia repair. Before, we often used the Parietex™ Composite mesh (Medtronic, Minneapolis, MN, USA) made from a composite lightweight structure of monofilament polyester textile on one side and a hydrophilic absorbable collagen, polyethylene glycol, and glycerol film on the other side [2, 19–21]. Nonetheless, the final choice of mesh seems to be centered on surgeon's preference due to the lack of guidelines [14].

Because of several cases with postoperative ileus after laparoscopic hernia repair with a DynaMesh®-IPOM mesh over the past years, we retrospectively evaluated our patient population between 2012 and 2017 with regard to postoperative ileus secondary to postoperative intra-abdominal adhesions and the type of mesh that was used (DynaMesh®-IPOM vs. Parietex™ Composite mesh). Moreover, PP, widely used in surgery due to its low cost, nonbiodegradability, and excellent incorporation, is associated with formation of enterocutaneous fistulae and adhesions, despite various materials that have been incorporated into PP (composite meshes) to ameliorate these effects. Therefore, the adhesive potential of modified PP meshes and their usefulness in laparoscopic abdominal hernia repair needs to be re-assessed [12, 13, 22, 23].

Methods

We retrospectively collected a database of 375 patients who underwent laparoscopic primary or incisional abdominal hernia repair with intraperitoneal mesh placement, DynaMesh®-IPOM or Parietex™ Composite, at the Heilig-Hart Hospital in Lier (Antwerp, Belgium) between 2012 and 2017 performed by 2 experienced senior general surgeons. Baseline demographics and clinical data on these patients were collected up to 6 weeks postoperatively. Since there is still no real consensus for a "normal" interval that would distinguish between physiological and pathological postoperative ileus [24, 25], postoperative ileus was defined by the combination of at least one of the following four signs on or after the first/fourth postoperative day, adapted from Vather et al. [26], until 6 weeks postoperatively:

- Nausea or vomiting
- An inability to tolerate solid or semi-liquid diet during the preceding 24 h
- No gas or stool for the preceding 24 h
- Abdominal distension

and radiological confirmation of ileus on an abdominal X-ray and/or CT scan.

Exclusion criteria were an open hernia repair procedure; onlay, inlay, or sublay placement of the mesh; and the use of any type of mesh other than DynaMesh®-IPOM or Parietex™ Composite mesh.

Operative approach

Access to the abdominal cavity was achieved by lateral open or closed laparoscopy via the left abdominal flank with placement of three Yellowport+plus™ (Surgical Innovations, Leeds, UK) trocars, either one 10-mm trocar (left flank) and two 5-mm trocars (left fossa and left subcostal) or three 5-mm trocars (left fossa, flank, and subcostal). The abdominal wall defect was defined with blunt and/or sharp dissection and adhesiolysis. After circumferential deperitonealization of the parietal peritoneum around the abdominal wall defect, the hernia sac was inverted and the abdominal wall defect was routinely approximated or closed, if possible, with an absorbable barbed V-Loc™ (Medtronic, Minneapolis, MN, USA) running suture. Next, an intraperitoneal onlay mesh with a minimum circumferential overlap of 5 cm around the abdominal wall defect was placed and fixated either with Securestrap™ (Ethicon Inc. (Johnson & Johnson), Somerville, NJ, USA) with absorbable securestraps and/or with LiquibandFix8™ (Advanced Medical Solutions, Winsford, Cheshire, UK) using n-butyl-2-cyanoacrylate. The mesh was routinely covered with the peritoneal flap, if possible, by fixation with the residual securestraps or sutured with an absorbable suture. The fascia of the 10-mm trocar port site was closed with a separate absorbable suture. All port sites were superficially closed with absorbable skin sutures and/or skin glue. Patients were discharged on the day of surgery and checked clinically after 1 and 3 weeks by a general surgeon at our center.

Statistical analysis

Statistical analysis was performed using SPSS® (IBM) software version 26. The Mann-Whitney *U* test was used to compare quantitative variables with non-normal distribution. Patient demographics and clinical patient data were compared using the chi-square test and Fisher's exact test. All the quantitative variables are represented in the results as percentages.

P values of less than 0.05 were considered as statistically significant.

Results

A total of 375 patients underwent laparoscopic primary or incisional abdominal hernia repair with intraperitoneal mesh placement, DynaMesh®-IPOM or Parietex™ Composite mesh, at the Heilig-Hart Hospital in Lier (Antwerp) between 2012 and 2017 (Table 1). Of these, 251 patients (66.9%) with a median age of 55 years (range, 19–90 years) received a DynaMesh®-IPOM mesh, and 124 patients (33.1%) with a median age of 56 years (range, 25–90 years) received a Parietex™ Composite mesh. 57,3% of patients were male, and 42,6% were female. The male/female ratio was 1.20:1 in the DynaMesh®-IPOM mesh group and 1.70:1 in the Parietex™ Composite mesh group ($P = 0.125$). Two hundred six patients (54.9%) had a history of abdominal surgery. Of these, 143 patients (38.1%) presented with an incisional hernia, and 28 (7.5%) presented with a recurrent incisional hernia after previous hernia repair. Two hundred four patients (54.4%) presented with a primary hernia. In 316 patients (84.3%), the mesh surface area of the mesh was ≤ 300 cm^2. The DynaMesh®-IPOM mesh was either fixed with Securestrap™ or LiquibandFix8™, or a combination of both. The Parietex™ Composite mesh was solely fixed with Securestrap™. The characteristics of patients in the two mesh groups were similar, except for method of fixation as expected (Table 1). The distribution of mesh surface area and mesh size of the two mesh groups is shown in Table 2.

The DynaMesh®-IPOM mesh group was associated with a significantly higher incidence of postoperative ileus compared with the Parietex™ Composite mesh group with a cutoff limit at postoperative day 1 ($n = 17$, 6.8% vs. $n = 0$, 0.0%; P = 0.003) and postoperative day 4 ($n = 13$, 5.2% vs. $n = 0$, 0.0%, $P = 0.006$), even with a mesh surface area of $\leq$ 300 cm^2 and when both meshes were fixated with the same method of fixation (Securestrap™) with a cutoff limit for postoperative ileus at postoperative day 1 ($n = 4$, 7.7% vs. $n = 0$, 0.0%; $P = 0.013$) and postoperative day 4 ($n = 3$, 5.8% vs. n = 0, 0.0%, $P = 0.040$) (Table 3). Within the DynaMesh®-IPOM mesh group, there was no significant difference between the 3 different methods of fixation with regard to the incidence of postoperative ileus or radiological suspicion of adhesive small bowel obstruction on CT scan (data not shown). Of the 17 patients with postoperative ileus, 14 patients (82.4%) required a prolonged hospitalization (≥ 1 day) or a consultation at the emergency department with re-hospitalization, and 8 patients (47.1%) required intravenous fluid and/or medication, low-residue diet, nil per os, and/or a stomach tube (grade II of the modified Clavien-Dindo classification of surgical complications [28], Table 3). Of the 17 patients with postoperative ileus of the DynaMesh®-IPOM mesh group, 9 (52.9%) had a radiological suspicion of adhesive small bowel obstruction on CT scan vs. 0 patients of the Parietex™ Composite mesh group ($P = 0.033$). Of these 9 patients, 2 required a diagnostic laparoscopy (grade IIIb of the modified Clavien-Dindo classification of surgical complications [28], Table 3). The first patient required a diagnostic laparoscopy 8 days after the initial procedure due to persistent clinical postoperative ileus and a suspicion of adhesive small bowel obstruction on CT scan. At laparoscopy, clear small bowel adhesions with the DynaMesh®-IPOM mesh were seen with one segment of the small bowel attached to the mesh in an obstructive U shape (Fig. 1). All adhesive small bowels were carefully detached from the mesh and checked

Table 1 Characteristics of the two mesh groups

	DynaMesh®-IPOM	Parietex™ Composite	Total (n) (%)	*P value*
Total (n)	251	124	375 (100)	
Median age (years) (range)	55 (19–90)	56 (25–90)		0.556[a]
Sex				0.125[b]
Male	137	78	215 (57.3)	
Female	114	46	160 (42.7)	
History of abdominal surgery				0.492[b]
Yes	141	65	206 (54.9)	
No	110	59	169 (45.1)	
Type of hernia[c]				0.066[b]
Primary hernia	134	70	204 (54.4)	
Midline	132	70	202 (53.9)	
Lateral	2	0	2 (0.5)	
Combined	0	0	0 (0.0)	
Incisional hernia	103	40	143 (38.1)	
Midline	98	36	134 (35.7)	
Lateral	5	1	6 (1.6)	
Combined	0	3	3 (0.8)	
Recurrent incisional hernia	14	14	28 (7.5)	
Midline	12	14	26 (6.9)	
Lateral	1	0	1 (0.3)	
Combined	1	0	1 (0.3)	
Mesh surface area				0.050[b]
≤ 300 cm^2	218	98	316 (84.3)	
> 300 cm^2	33	26	59 (15.7)	
Method of fixation				0.000[b]
LiquibandFix8™	139	0	139 (37.1)	
Securestrap™	64	124	188 (50.1)	
LiquibandFix8™ & Securestrap™	48	0	48 (12.8)	

[a] Mann Whitney U test

[b] Chi-square test

[c] European Hernia Society classification for primary and incisional abdominal wall hernias [27]

for perforation. Except for some minor intra-abdominal fluid, no perforation was observed. The patient recovered uneventful and was discharged 2 days after the diagnostic laparoscopy.

In the second patient, a small bowel herniation at the left flank, near the incision of the 10 mm trocar, with incipient ischemia and accompanying small bowel obstruction and dilatation, was seen on CT scan. At diagnostic laparoscopy 8 days after the initial procedure a Richter hernia, a protrusion and/or strangulation of only a part of the circumference of the intestine's antimesenteric border through a rigid small defect of the abdominal wall [29], at the incision of the 10 mm trocar, was seen. After careful reduction of the hernia, the small bowel recovered and became vital. However, during laparoscopy, also extensive non-obstructive small bowel adhesions with the DynaMesh®-IPOM mesh were seen but were left in place. The patient recovered uneventful and was discharged 2 days after the diagnostic laparoscopy.

The individual characteristics of the 17 patients with a postoperative ileus are shown in Table 4.

According to our definition of postoperative ileus, we did not observe any event in the Parietex™ Composite mesh group. Therefore, a logistic regression model could not be fitted to test whether the difference in postoperative ileus between the two mesh groups, observed in the Chi-square and Fisher's exact test, could be attributable to the effects of age, sex, and a history of abdominal surgery.

Table 2 Distribution of mesh size of the two mesh groups

Mesh size	DynaMesh®-IPOM (*n*) (%)	Mesh size	Parietex™ Composite (*n*) (%)
Mesh surface area ≤ 300 cm^2			
12 cm round	114 (45.4)	15 cm round	66 (53.2)
15 × 15 cm	79 (31.5)	15 × 20 cm	28 (22.6)
15 × 20 cm	25 (10.0)	10 × 15 cm	3 (2.4)
		12 cm round	1 (0.8)
Mesh surface area > 300 cm^2			
20 × 30 cm	14 (5.6)	20 × 25 cm	10 (8.1)
20 × 25 cm	6 (2.4)	20 cm round	9 (7.3)
30 × 30 cm	4 (1.6)	15 cm round & 15 × 20 cm	3 (2.4)
20 × 20 cm	3 (1.2)	20 × 30 cm	1 (0.8)
30 × 45 cm	3 (1.2)	15 cm round & 15 cm round	1 (0.8)
12 cm round & 15 × 15 cm	2 (0.8)	15 cm round & 20 × 25 cm	1 (0.8)
12 cm round & 15 × 20 cm	1 (0.4)	20 × 25 cm & 20 × 25 cm	1 (0.8)

Discussion

Despite laparoscopic primary or incisional abdominal hernia repair with intraperitoneal mesh placement is a well-accepted technique with benefits over the open procedure in terms of overall complications [2, 19], little is known about the occurrence of postoperative ileus secondary to postoperative intra-abdominal adhesions with different types of IPOM meshes used. Our results confirm the findings of Tandon et al., which reported a significantly higher incidence of postoperative

Table 3 Outcome of the two mesh groups

Postoperative ileus (independent of method of fixation, *n* = 375)			
	DynaMesh®-IPOM (*n* = 251) (*n*) (%)	Parietex™ Composite (*n* = 124) (*n*) (%)	*P* value
≥ Postoperative day 1	17 (6.8)	0 (0.0)	0.003[a]
≥ Postoperative day 4	13 (5.2)	0 (0.0)	0.006[b]
Suspicion of adhesive small bowel obstruction on CT scan	9 (3.6)	0 (0.0)	0.033[b]
Postoperative ileus (mesh surface area ≤ 300 cm^2 and fixation with Securestrap™, *n* = 150)			
	DynaMesh®-IPOM (*n* = 52) (*n*) (%)	Parietex™ Composite (*n* = 98) (*n*) (%)	*P* value
≥ Postoperative day 1	4 (7.7)	0 (0.0)	0.013[b]
≥ Postoperative day 4	3 (5.8)	0 (0.0)	0.040[b]
Suspicion of adhesive small bowel obstruction on CT scan	1 (1.9)	0 (0.0)	0.347[b]
Grade of complications[c] (independent of method of fixation, *n* = 375)			
	DynaMesh®-IPOM (*n* = 251) (*n*) (%)	Parietex™ Composite (*n* = 124) (*n*) (%)	
I	7 (2.8)	0 (0.0)	
II	8 (3.2)	0 (0.0)	
IIIb	2 (0.4)	0 (0.0)	

[a] Chi-square test

[b] Fisher's exact test

[c] Modified Clavien-Dindo classification of surgical complications [28]

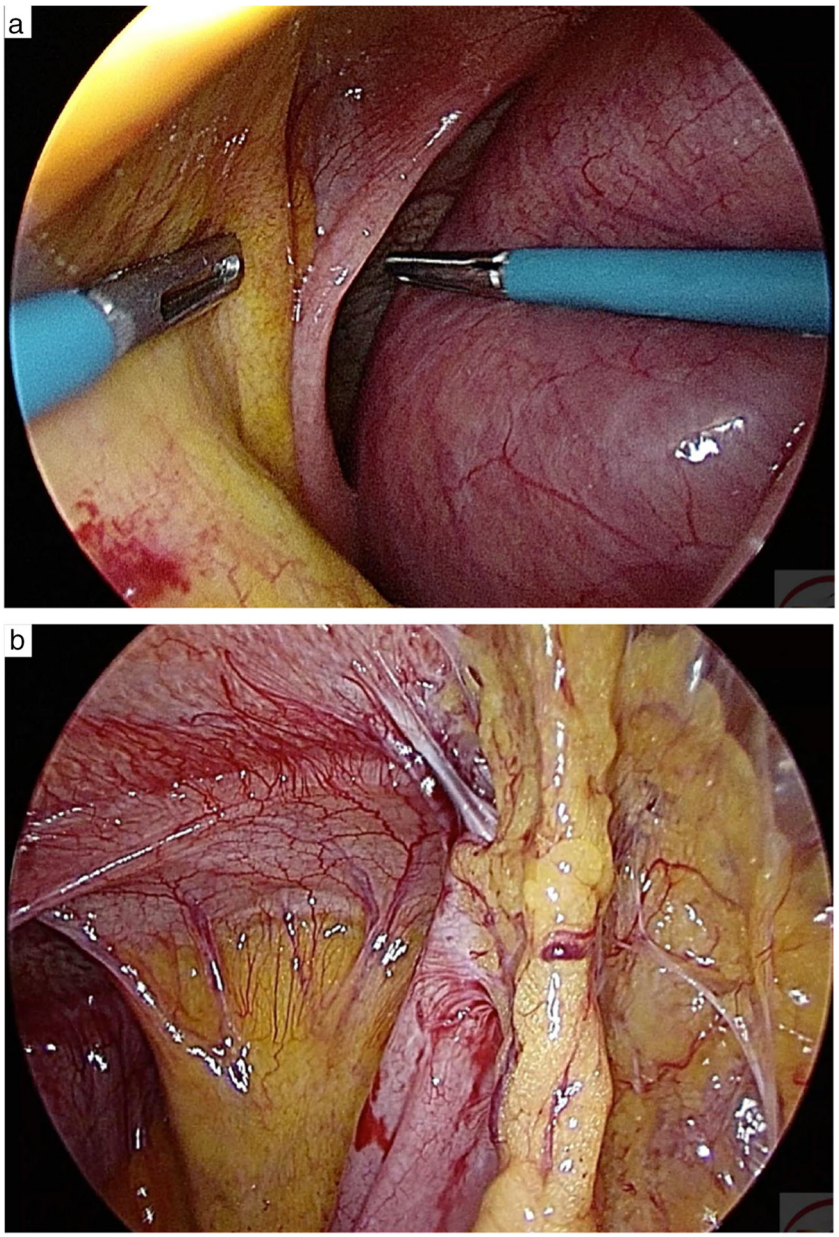

Fig. 1 Laparoscopic evidence of a small bowel obstruction with a collapsed (left) and dilated (right) small bowel loop (**a**) due to small bowel and omental adhesions with the DynaMesh®-IPOM mesh (**b**)

intestinal obstruction secondary to adhesions with the DynaMesh®-IPOM group compared with the Parietex™ Composite group (11.5%, vs. 0.0%; $P = 0.006$) [19]. Also, in a prospective trial of 181 patients investigating mesh-related complications using DynaMesh®-IPOM, 3 patients (1.7%) developed intestinal obstruction requiring removal of the mesh, and in at least 8 patients (4.4%) requiring reoperation for mesh-related complications, extensive mesh-related adhesions to the bowel were observed [15]. Despite the theoretical properties of the DynaMesh®-IPOM mesh with a good anti-adhesive visceral side and a fast integration of the parietal side into the abdominal wall, a rationale for this phenomenon was already provided by Fortelny and colleagues. Due to rapid reperitonealization (resulting from dissection of the hernia sac) secondary to mechanical stress and a foreign material on the parietal abdominal wall, bowel movements and the saw-tooth profile on the visceral side of the DynaMesh®-IPOM mesh unidirectional irritation of the visceral peritoneum occur with subsequent protrusion of the adhesions through the pores of the whole mesh surface and attachment to the abdominal wall, despite the anti-adhesive visceral PVDF [18]. This rationale is supported by the in vivo findings of others who evaluated the adhesion formation of the DynaMesh®-IPOM mesh in pigs, rabbits, and rats, respectively [13, 14, 22]. Jamry et al. demonstrated that the DynaMesh®-IPOM mesh does not prevent adhesion formation. Instead, adhesion formation occurred in 83.3% with an adhesion surface area of 37.7% and a mean hardness of 1.46

Table 4 Characteristics of patients with postoperative ileus ($n = 17$)

Age	Sex	History of abdominal surgery	Type of hernia[a]	Mesh	Method of fixation	Radiological confirmation	Grade of complications[b]
36	Male	No	Primary: midline umbilical, N/A	DynaMesh®-IPOM, 12 cm round	LiquibandFix8™	CT	I
43	Female	Yes	Primary: midline umbilical, 1.5 cm ∅	DynaMesh®-IPOM, 12 cm round	Securestrap™	CT	IIIb
44	Male	No	Primary: midline umbilical, 1.5 cm ∅	DynaMesh®-IPOM, 12 cm round	LiquibandFix8™	CT	I
47	Male	No	Primary: midline epigastric, N/A	DynaMesh®-IPOM, 15 × 20 cm	LiquibandFix8™	CT	II
49	Male	No	Primary: midline umbilical, 1.5 cm ∅	DynaMesh®-IPOM, 15 × 15 cm	LiquibandFix8™ & Securestrap™	X-ray	I
50	Male	Yes	Primary: midline NOS, N/A	DynaMesh®-IPOM, 12 cm round	Securestrap™	X-ray	I
53	Male	Yes	Incisional: M3, 1 cm ∅	DynaMesh®-IPOM, 15 × 15 cm	LiquibandFix8™	CT	II
56	Male	Yes	Primary: midline umbilical, 1 cm ∅	DynaMesh®-IPOM, 15 × 15 cm	LiquibandFix8™	CT	II
57	Male	Yes	Incisional: L3, 2 cm ∅	DynaMesh®-IPOM, 12 cm round	Securestrap™	X-ray	I
61	Male	Yes	Incisional (recurrent): M3, 2 cm ∅	DynaMesh®-IPOM, 15 × 15 cm	Securestrap™	CT	II
64	Female	Yes	Incisional: M3, 4 cm ∅ & multiple small hernias	DynaMesh®-IPOM, 20 × 30 cm	LiquibandFix8™	X-ray	I
64	Male	Yes	Incisional: M3, 1 cm ∅	DynaMesh®-IPOM, 15 × 15 cm	LiquibandFix8™	CT	I
65	Female	Yes	Primary: midline umbilical, N/A	DynaMesh®-IPOM, 12 cm round	LiquibandFix8™	CT	II
70	Male	Yes	Incisional: M2 & M3, N/A	DynaMesh®-IPOM, 12 cm round & 15 × 15 cm	LiquibandFix8™	CT	II
70	Male	No	Primary: midline umbilical, N/A	DynaMesh®-IPOM, 12 cm round	LiquibandFix8™	CT	IIIb
78	Male	Yes	Incisional: M3, 1 cm ∅	DynaMesh®-IPOM, 15 × 15 cm	LiquibandFix8™ & Securestrap™	CT	II
82	Female	Yes	Incisional: M4, 3 cm ∅	DynaMesh®-IPOM, 15 × 15 cm	LiquibandFix8™ & Securestrap™	CT	II

[a] European Hernia Society classification for primary and incisional abdominal wall hernias [27]

[b] Modified Clavien-Dindo classification of surgical complications [28]

∅, diameter of facial defect; N/A, not available; NOS, not otherwise specified

according to the Zhulke scale, a scale for adhesion hardness [22, 30]. Gomez-Gil et al. concluded, in line with previous findings of D'Amore et al. [14] and Bellon et al. [31, 32], that the reticular structure of the DynaMesh®-IPOM mesh limits the formation of a continuous mesothelial monolayer, regardless of its composition (anti-adhesive PVDF interwoven with PP), thus inducing adhesions [13]. Indeed, the DynaMesh®-IPOM mesh did not prevent adhesions in vivo [13, 14]. In contrast, in a single institution's systematic retrospective review of 1326 laparoscopic incisional and ventral hernia repairs with the Parietex composite mesh, only 9 patients (0,67 %) experienced a postoperative ileus and all of them were treated conservatively. Moreover, only 12.7% of mild serosal bowel adhesions to the mesh were reported in patients who were reoperated for several reasons after a mean period of 78 months, after an initial laparoscopic primary or incisional abdominal hernia repair with a Parietex™ Composite mesh. 42.1% of the patients showed simple adhesions of the omentum, and 45.2% were found to be adhesion-free [33]. After 1 year from surgery, the overall rate of adhesions with the Parietex™ Composite mesh was only 14% detected with ultrasound [34]. Based on in vivo findings, D'Amore et al. conclude that composite meshes, such as the Parietex™ Composite mesh, should be considered safer and preferable for clinical intraperitoneal use, as the surface is smooth and does not provide any physical anchor points to adhesive tissue [14].

Concerning hernia recurrence, seroma, and hematoma formation, Tandon et al. demonstrated a lower incidence with the DynaMesh®-IPOM mesh as compared with Parietex™

Composite mesh [19]. However, to our knowledge, to date, there are no other results available or an ongoing well-designed, multicenter randomized controlled study that investigates the complications of these specific meshes in patients. As such, the optimal mesh type for laparoscopic primary or incisional abdominal hernia repair has yet to be determined [12, 19].

A recent review of Baylon et al. summarized the advantages and disadvantages of the DynaMesh®-IPOM mesh and the Parietex™ Composite mesh as minimal foreign body reaction, though risk for adhesions versus short-term benefit for anti-adhesion property, though with a greater infection rate (57%), respectively [35].

Our results of postoperative ileus within 6 weeks after surgery are in line with the results of Fortelny et al., which too saw early formation of adhesions with the DynaMesh®-IPOM mesh which led to clinical symptoms of ileus within 1 week after surgery [18]. Indeed, there is general agreement that most adhesions occur in the immediate postoperative period until a new mesothelial layer covers the mesh [12, 14, 36]. In our study, at least 9 out of 17 patients of the DynaMesh®-IPOM mesh group with postoperative ileus had a radiological suspicion of adhesive postoperative small bowel obstruction on CT scan, of which 2 patients required operative treatment with definitive confirmation of small bowel adhesions with the mesh. The remaining 7 patients could be managed conservatively. However, CT scans do not automatically provide any sensitive or conclusive data regarding the rate of intra-abdominal adhesions with the mesh in contrast to ultrasound and MRI [34, 37]. According to the Bologna guidelines for diagnosis and management of adhesive small bowel obstruction, definitive confirmation of the adhesive etiology of bowel obstruction is made during operative treatment. Methods to confirm the adhesive etiology of bowel obstruction noninvasively include a history of previous episodes of bowel obstruction by adhesions or exclusion of other causes of bowel obstruction by imaging, often by CT scan [17]. Moreover, as suggested by Sommer et al. concerning the DynaMesh®-IPOM mesh, some patients may have substantial but asymptomatic adhesions, whereas few adhesions in others may cause intestinal obstruction [15]. Nonetheless, the presence of adhesions, symptomatic or asymptomatic, can cause considerable difficulties at reoperation [12, 14].

As we did not observe any postoperative ileus according to our definition in the Parietex™ Composite mesh group, we were not able to statistically identify significant risk factors for developing postoperative ileus after laparoscopic primary or incisional abdominal hernia repair with intraperitoneal mesh placement. However, of the 17 patients with postoperative ileus, 13 (76.5%) were male, and 12 (70.1%) had a history of abdominal surgery. Indeed, male gender has been repeatedly identified by various authors as a risk factor [25] next to advanced age, American Society of Anesthesiologists (ASA) scores 3 to 4, open approach, operative difficulty, operative duration more than 3 h, significant blood loss, bowel handling, delayed mobilization, and use of opioids [25, 38]. A history of prior laparotomy, the length of abdominal incision, and emergency surgery has been anecdotally identified as a risk factor [25], and in general, adhesions causing small bowel obstructions are typically the footprints of previous abdominal surgical procedures or disease [17].

In general, factors involved in the formation of postsurgical adhesions include trauma, peritoneal thermal injury (lower in bipolar electrocautery and ultrasonic devices as compared to monopolar electrocautery), infection, ischemia, and foreign bodies [17, 39]. In laparoscopic primary or incisional abdominal hernia repair with intraperitoneal mesh placement, visceral adhesion formation is influenced by various factors such as textile parameters of the mesh (type of material, pore size, and surface area), laparoscopic handling of the mesh, the type of fixation, and surgical trauma to the bowel or the peritoneal surface of the anterior peritoneal wall during the process of adhesiolysis [34, 40, 41].

Except for the 2 patients which required a diagnostic laparoscopy, in our study, we cannot provide conclusive evidence regarding the exact etiology of the postoperative ileus. However, literature states that adhesions are the leading cause of small bowel obstructions, accounting for 60% of cases [17].

Our study has the following limitations. Our study design is retrospective, and therefore, we were not able to provide additional data of our patient population such as BMI, ASA score, operative duration, and the postoperative use of opioids since this data was not always available for all patients. Therefore, our results need to be interpreted with caution as we were not able to correct our statistical analyzes for these parameters. Also, patients presenting with a postoperative ileus in a different hospital after the initial follow-up at 1 and 3 weeks postoperatively were not included in our study and could influence our results.

Conclusion

In our study, the DynaMesh®-IPOM mesh was associated with a significantly higher incidence of postoperative ileus compared to the Parietex™ Composite mesh. As half of the patients with a postoperative ileus had a suspicion of adhesive small bowel obstruction on CT scan with definitive confirmation of small bowel adhesions with the DynaMesh®-IPOM mesh at laparoscopy in 2 patients, our results confirm current literature available regarding postoperative ileus secondary to postoperative intra-abdominal adhesions with the DynaMesh®-IPOM mesh. However, further research with well-designed, multicenter randomized controlled studies to evaluate the use and related complications of these meshes is needed.

Authors' contributions Andreas Domen, Cedric Stabel, and Charles de Gheldere contributed to the study conception and design. Material preparation and data collection were performed by Andreas Domen, Cedric Stabel, Rami Jawad, Nicolas Duchateau, Patrick Vanclooster, and Charles de Gheldere. Analysis was performed by Andreas Domen, Cedric Stabel, and Erik Fransen. The first draft of the manuscript was written by Andreas Domen and Cedric Stabel, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest to declare.

Ethical approval This study was approved by the local ethical committee.

Informed consent As this was a retrospective study, no informed consent could be obtained.

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