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REVIEW ARTICLE

Internal hernia after laparoscopic colorectal surgery: an under-reported potentially severe complication. A systematic review and meta-analysis

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Abstract

Background Internal hernia following laparoscopic colorectal surgery is often under-reported. The aim of this review was to evaluate the occurrence rate of internal hernia following laparoscopic colorectal surgery, and to describe clinical presentation and management strategies.

Methods A comprehensive literature review was conducted including MEDLINE/Pubmed, EMBASE, SCOPUS, clinicaltrials.gov, and the Cochrane Database of Systematic Reviews through April 2018. The review was conducted according to MOOSE guidelines. Quality was appraised with the Methodological Index for Non-Randomized Studies (MINORS) tool. Meta-analysis was performed using a random effects model. Studies reporting data on internal hernia after laparoscopic colorectal surgery were included.

Results Ten observational studies with a total of 8453 patients were included. All included articles were non-comparative prospective or retrospective cohort studies with an average MINORS score of 8.3 (range 6–11). Summary estimate of proportion of patients developing internal hernia after laparoscopic colorectal resection was 0.5% (95% CI 0.3–0.8%). Heterogeneity was moderate (I^2 46%, $p=0.03$) and study size (> 1000 vs. <1000 patients) was found to have a significant contribution to heterogeneity ($p=0.002$). Thirty patients (90.9%) required surgery, with 5 non-fatal and 3 fatal postoperative complications. Quality of some studies was limited; some patients were followed up for less than 1 year; primary surgical procedures included different laparoscopic approaches.

Conclusions Occurrence rate of internal hernia after laparoscopic colorectal resection is around 5 per 1000 patients. Small-sized studies are likely to overestimate the occurrence of internal hernia. Need for reoperation is high with a substantial risk of mortality.

Keywords Systematic review · Internal hernia · Laparoscopy · Colorectal surgery · Morbidity · Mortality

Internal hernia is the protrusion of viscera, usually small bowel, through a congenital or acquired mesenteric defect within the peritoneal cavity, found during surgical reoperation [1]. Overall, its incidence is less than 1%, causing 5–8% of all small bowel obstructions [2]. Over the past two decades, this incidence has been increasing because of growing number of gastric by-pass surgery performed for bariatric treatment. In these patients, internal hernias represent nearly half of the cases of small bowel obstruction [3, 4]. This situation has heightened awareness and allowed better understanding of these hernias following other surgical procedures [1].

Internal hernia is an infrequent complication following laparoscopic colorectal resection but the real incidence is difficult to ascertain [5]. Large clinical trials (such as CLASICC, COST, and COLOR) did not report any specific data on this complication, thus the only sources of information from literature include a limited number of surgical series,

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mostly retrospective, and few case reports [6–8]. The laparoscopic approach for colorectal surgery, either for benign or malignant disease, has gained widespread acceptance due to its undisputed advantages (reduced postoperative pain, better and faster recovery, etc) along with comparable oncological results for cancer patients [9–11]. It is noteworthy that some advantages of laparoscopic approach (i.e., early mobilization and reduced adhesions) can contribute to explain the occurrence of internal hernia in colorectal surgery.

This systematic review aimed to provide a quantitative and qualitative summary of occurrence of internal hernia following laparoscopic colorectal resections, also reporting clinical presentation and management strategy.

Materials and methods

Study design

This is a systematic review of observational studies investigating the occurrence of internal hernia during follow-up after laparoscopic colorectal resection. The Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guidelines were used in this review [12].

Search strategy

To identify relevant studies, we systematically searched MEDLINE/Pubmed, EMBASE, SCOPUS, clinicaltrials.gov, and the Cochrane Database of Systematic Review between January 1995 and May 2018. Two researchers (GP and MP) independently reviewed search results and screened titles/abstracts. A third researcher (FC) resolved any inconsistency. We obtained the full texts of all potentially eligible studies. In PubMed, the following search strategy was used: 'internal hernia' AND ('laparoscopic surgery' OR 'colorectal surgery' OR 'laparoscopic colectomy'). This search strategy was adapted to suit the other electronic sources. Only clinical studies in English were considered. Case reports were excluded. Data from meeting abstracts were not included, as details were not enough to allow for data extraction. The reference lists of included articles were hand-searched to identify additional studies of interest.

Criteria for considering studies for this review

Observational studies investigating internal hernia after laparoscopic colorectal resection were considered eligible for this review. Only the most recent and complete data were included when duplicate publications reporting on similar patients were found. Studies not including humans were excluded.

Data collection extraction

Two researchers (GP and OP) independently extracted key data from the included studies. A third researcher (FC) checked the extracted data. For each study, we extracted relevant data (occurrence and timing of internal hernia, need for surgery, type of surgery, morbidity, and mortality) and the following data: title, first author, journal, year of publication, study design, disease, sample size, primary surgical intervention, and length of follow-up. When queries arose, or additional data were required, we contacted study authors.

Quality assessment

Two researchers (GP, FC) completed the quality appraisal with the Methodological Index for Non-Randomized Studies (MINORS) tool [13]. The MINORS tool includes eight items for non-comparative studies and four additional items for comparative studies. Items are scored as 0 (not reported), 1 (reported but inadequate), and 2 (reported and adequate), with a total score of 16 for non-comparative studies and 24 for comparative studies. Our systematic review included only observational non-comparative studies, thus the 8-item section was used. A third researcher (MP) resolved any inconsistency.

Data synthesis and statistical analysis

Statistical analysis was performed using 'metafor' package for R 3.3 (R Foundation for Statistical Computing, Vienna, Austria) [14, 15]. Meta-analysis was performed using a random effects model. Heterogeneity was assessed using the I^2 value and meta-regression was used to explore potential sources of heterogeneity [16]. The risk of publication bias was assessed with funnel plot and trim-and-fill method as proposed by Duval and Tweedie [17]. According to literature, this method was not used to provide adjusted estimates by performing a meta-analysis including the filled studies, but it was only used to suggest possible missing studies. A p-value less than 0.05 was considered statistically significant [18].

IRB approval and informed consent were not needed for this study.

Results

Search results

Overall, the searches yielded 475 non-duplicated articles; 463 articles were excluded based on title and/or abstract

(which were not appropriate for the topic of this review, such as surgical approach not minimally invasive, internal hernia after bariatric or gastric surgery, inguinal hernia), while 12 articles were retrieved for full text review. Three case reports and one study on radiologic imaging were excluded. Two additional studies were found via hand search. Ultimately, 10 observational studies were included in the qualitative and quantitative synthesis (Fig. 1) [2, 19–27].

Study and patient characteristics

Ten observational studies (2 prospective and 8 retrospective) including 8453 patients met the inclusion criteria. Characteristics of included studies are reported in Table 1. Individual study size ranged from 118 to 4069 (median 473). The primary surgical procedure was either right or left colectomy or rectal resection or a combination of colonic and rectal procedures in 6 studies, while the information was not reported in 4 studies. Four studies included both malignant and benign patients, 3 studies only malignant (4753 patients with 14 reported internal hernias, 0.29%), and the nature of the disease was not clear in 3 studies. In addition, no data were available on surgeon's or center's experience in laparoscopic colorectal surgery (Table 1). Closure of mesenteric defect was routinely not performed at primary surgical intervention in most studies. Follow-up ranged from 0.1 to 10 years.

Quality assessment

The MINORS scores for the methodological quality appraisal of included articles are shown in Table 2 [13]. The item about unbiased assessment of study endpoint studies (blind evaluation of objective endpoints) was not applicable in our studies. All included articles were non-comparative prospective or retrospective cohort studies with an average MINORS score of 8.3 (range 6–11).

Patients developing internal hernia during follow-up

Overall, 33 out of 8453 patients (0.39%) developed internal hernia during the follow-up period. Occurrence, timing, and management of internal hernia are reported in Table 3. Individual study proportion ranged from 0.2 to 1.1%, with a time interval between primary surgical intervention and occurrence of internal hernia ranging from 8 h to 7 years. Data on closure/not closure of the mesenteric defect were available in 6938 patients: 6157 did not have closure of the mesenteric

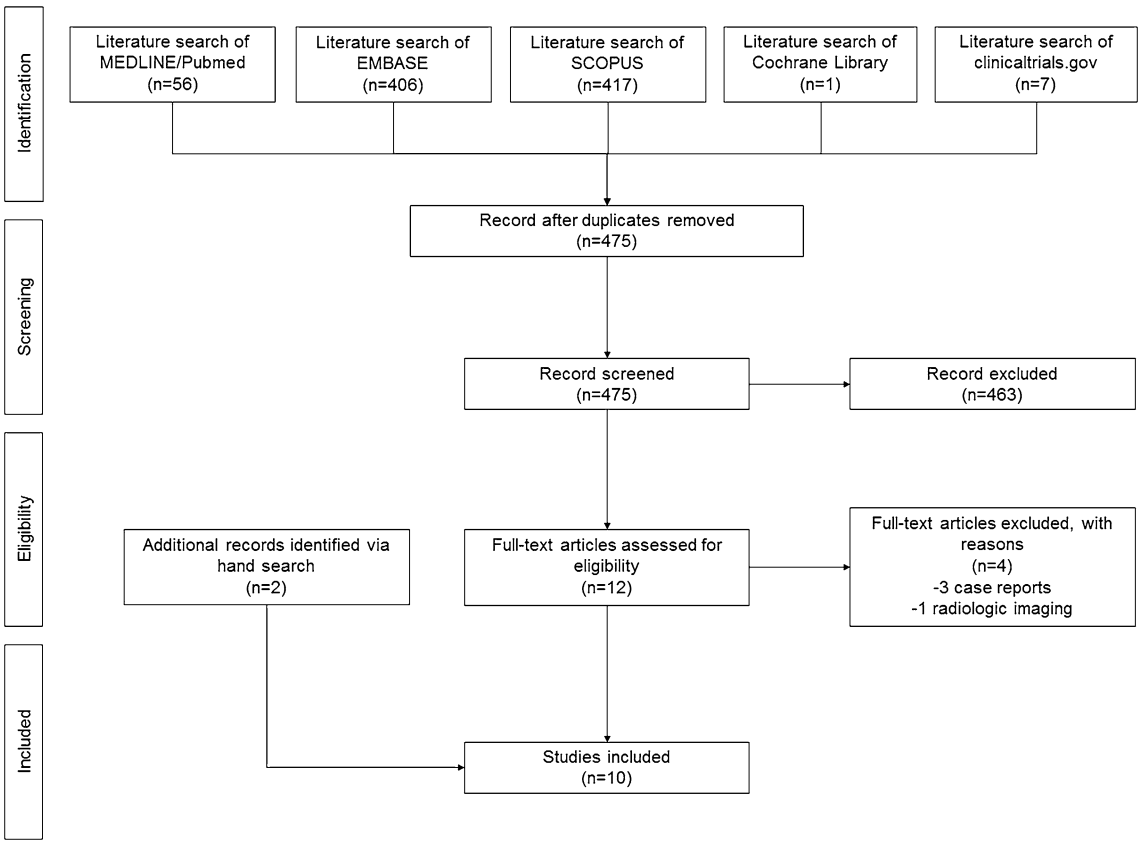

Fig. 1 Meta-analysis Of Observational Studies in Epidemiology (MOOSE) flow chart

Table 1 Study description

Study	Country, year	Design	Disease (benign and/or malignant)	Patients, no.	Primary surgical procedure	Closure of mesenteric defect at surgery	Range of follow-up (years)
Svraka et al. [19]	Denmark, 2017	Retrospective	Both	1093	Unclear	No	1–7
Angelini et al. [20]	Italy, 2017	Retrospective	Both	1079	LLC and LARR	298 No 781 yes	1.5–11
Lee et al. [21]	Korea, 2017	Retrospective	Malignant	4069[a]	Unclear	No	0.3–9
Ansari et al. [22]	Australia, 2013	Retrospective	Unclear	297	LAR	n.r.	0.5–6.5
O'Riordan et al. [23]	Ireland, 2013	Retrospective	Malignant	154[b]	Unclear	n.r.	0.1–1.8
Saklani et al. [24]	United Kingdom, 2012	Retrospective	Unclear	167	Unclear	No	0.1–10
Cabot et al. [25]	United States, 2010	Retrospective	Malignant	530	LRC	No	n.r.
Rotholtz et al. [26]	Argentina, 2009	Retrospective	Both	510	[c]	n.r.	1.2–8.5
Sereno Trabaldo et al. [2]	France, 2009	Retrospective	Unclear	436	LLC	In some patients	2.3–8.8
Lacy et al. [27]	Spain, 1997	Prospective	Both	118	Laparoscopic assisted colectomies	n.r.	0.3–3.5

LLC laparoscopic left colectomy, *LARR* laparoscopic anterior resection of the rectum, *LAR* laparoscopic anterior resection, *LRC* laparoscopic right colectomy, *n.r.* not reported

[a]The original study included 4589 patients; 4069 patients underwent laparoscopic approach and were included in this systematic review

[b]The original study included 203 patients; 154 patients underwent laparoscopic surgery and were included in this systematic review

[c]Primary surgical intervention included segmental resection, anterior resection, proctocolectomy, subtotal colectomy, protectomy, Hartmann's reversal, Hartmann's, and other procedures

defect at first operation (22 had internal hernia, 0.35%) while 781 had closure of the mesenteric defect (none had internal hernia). Thirty patients (90.9%) required surgery, including reduction of internal hernia with or without closure of the meso defect (17 patients), small bowel resection (nine patients), or other surgical procedures (three patients; not reported in one patient). After surgery for internal hernia, postoperative complications occurred in 11 out of 31 patients (35.5%), while the information was not reported in two patients. These complications included mostly postoperative ileus or wound infections, but also severe complications such as renal failure, pulmonary edema, or multi-organ failure, leading to death in three patients (Table 3).

Synthesis of research findings

Summary estimate of proportion of patients developing internal hernia after laparoscopic colorectal resection was 0.005 (95% CI 0.003 to 0.008) (Fig. 2). Heterogeneity was moderate (I^2 46%, $p=0.03$) and study size (>1000 vs. <1000 patients) was found to have a significant contribution to heterogeneity ($p=0.002$). Summary estimates of proportion of patients developing internal hernia were 0.003 (95% CI 0.002 to 0.004; I^2 0%, $p=0.11$) in studies including more than 1000 patients and 0.008 (95% CI 0.005 to 0.012%; I^2 0%, $p=0.62$) in studies including less than 1000 patients. The trim-and-fill method by Duval and Tweedie (Fig. 3) suggested two missing studies (with sample sizes of 510 and 1079 patients, and proportions of internal hernia of 0.02 and 0.04, respectively) in the right area of the plot. According to literature, results from trim-and-fill method were not used to adjust estimates.

Discussion

Several complications following laparoscopic colorectal surgery have been extensively reported, such as intestinal obstruction, anastomotic leak, abdominal and pelvic abscess, bleeding, stenosis, wound infection, or dehiscence. Small bowel obstruction (SBO) is probably the most commonly reported cause of morbidity following this type of surgery, ranging between 1 and 3% [27–29]. The most common causes of SBO include adhesions (explaining over 50% of the cases) and incarcerated hernia at trocar site. Internal hernia is a well-known complication of other laparoscopic procedures such as Roux-en-Y gastric by-pass, colecystectomy, Nissen fundoplication, although it is considered a rare occurrence [3, 30]. In laparoscopic colorectal resection,

Table 2 Quality assessment of included studies using MINORS tool [13] (for non-comparative studies)

Study	Clearly stated aim	Inclusion of consecutive patients	Prospective data collection	Endpoints appropriate to study aim	Unbiased assessment of study endpoint	Follow-up period appropriate to study aim	< 5% lost to follow-up	Prospective calculation of study size	Total score
Svraka et al. [19]	2	2	1	0	NA	2	2	0	9/14
Angelini et al. [20]	1	2	1	2	NA	2	2	0	10/14
Lee et al. [21]	2	2	1	2	NA	1	2	0	10/14
Ansari et al. [22]	1	2	1	0	NA	1	2	0	7/14
O'Riordan et al. [23]	1	2	1	0	NA	1	2	0	7/14
Saklani et al. [24]	0	2	1	0	NA	1	2	0	6/14
Cabot et al. [25]	0	2	1	2	NA	0	2	0	7/14
Rotholtz et al. [26]	1	2	1	0	NA	2	2	0	8/14
Sereno Trabaldo et al. [2]	2	2	1	2	NA	2	2	0	11/14
Lacy et al. [27]	1	2	2	0	NA	1	2	0	8/14

Items are scored as 0 (not reported), 1 (reported but inadequate), and 2 (reported and adequate), with a total score of 16 for non-comparative studies

NA not applicable

internal hernia is an infrequent complication, but the real incidence is difficult to ascertain [5].

This study used a systematic literature search and meta-analysis to provide an estimate of the occurrence of internal hernia after laparoscopic colorectal resection. Our meta-analysis estimated a proportion less than 1% of patients developing internal hernia after laparoscopic colorectal resection. This estimate could be considered as a lower bound for the real proportion because of the limited quality of included studies, which was penalized by (i) the retrospective nature of all studies but one, (ii) the absence of a prospective calculation of study size (which is rarely undertaken in observational and/or retrospective studies), and (iii) the limited duration of follow-up period (since internal hernia has been found to occur even at several years after surgery). Study size was found to have a significant contribution to heterogeneity, resulting in smaller proportion of internal hernia when pooling large studies and greater proportion of internal hernia when pooling small studies. Such finding was due to the small proportion being estimated, because studies including less than 1000 patients were likely to overestimate the occurrence of internal hernia. Funnel plot and trim-and-fill method suggested two possible missing studies with high proportion of internal hernia in moderate to large sample sizes [17]. According to literature, this method was not used to provide adjusted estimates by performing a meta-analysis including the filled studies, but it was only used to suggest possible missing studies [18]. While this method usually suggests publication bias in meta-analyses of clinical trials, it has a different meaning in meta-analyses of proportion studies [31]. In our study, the results from the trim-and-fill method indicated the absence of moderate/large studies reporting high proportion of internal hernia, thus suggesting the tendency to overestimation in small studies.

Several mechanisms have been proposed to explain the development of internal hernia after laparoscopic colorectal resection. Minimally invasive surgery minimizes postoperative adhesions, thus reducing the chance for mechanical obstructions from adhesive bands, but also increases the risk of SBO by promoting free movement of ileal loops in the abdominal cavity—even below the mesentery—if the defect created with colonic resection is not closed [10]. Further, laparoscopy, with reduced postoperative pain, compared to open procedures, especially with recent widespread diffusion of Enhanced Recovery After Surgery (ERAS) principles, promotes early mobilization. This prevents the adherence of the neo-descending colon to the Gerota's fascia [32].

It is noteworthy that many reported cases occurred after left-sided resections. The defect that is created after colorectal resections allows for an easy passage of the small

Table 3 Occurrence, timing, and management of internal hernia following laparoscopic colorectal resection

Study	Patients with internal hernia, no. (%)	Timing of complication from primary surgical intervention	Patients requiring reoperation, no. (%)	Type of surgery	Laparoscopic approach	Morbidity, no. (%)[a]	Mortality, no. (%)[a]
Svraka et al. [19]	6 (0.55)	3, 5, 6, 7 days; 5,7 years	6/6 (100)	Reduction of IH and closure meso defect (4 pts); RH and closure meso defect (2 pts, with stoma in 1)	No	1/6 (16.7)	1/6 (16.7)
Angelini et al. [20]	1 (0.09)	3 days	1/1 (100)	Reduction of IH and closure meso defect, small bowel decompression via enterotomy	Yes (+ small laparotomy for enterotomy with small bowel decompression)	0	0
Lee et al. [21]	9 (0.2)	5, 13, 20 days; 3, 4, 5, 7, 19, 27 months	6/9 (66.7)	SB segmental resection (3 pts, +Hartmann in 1 of these); reduction of IH (3 pts)	No	6/6 (100)	0
Ansari et al. [22]	3 (1)	17, 97, 115 days	3/3 (100)	Reduction of IH	Yes (2 patients)	1/3 (33.3)	0
O'Riordan et al. [23]	1 (0.65)	1 day	1/1 (100)	Reduction of IH	Yes	0	0
Saklani et al. [24]	2 (1.2)	2 days; 2 months	2/2 (100)	SB segmental resection (1 pt); reduction of IH (1 pt)	No	0	0
Cabot et al. [25]	4 (0.75)	10, 10, 10 days; 8 months	4/4 (100)	SB segmental resection	Unclear	1/4 (25)	1/4 (25)
Rotholtz et al. [26]	1 (0.2)	n.r.	1/1 (100)	Reduction of IH	Yes	n.r.	n.r.
Sereno Trabaldo et al. [2]	5 (1.1)	8, 8, 18, 24 h; 5 days	5/5 (100)	Reduction of IH+ closure of meso defect with suture (3 pts); SB segmental resection with ileostomy (1 pt); reduction of IH+ Hartmann (1 pt)	n.r.	2/5 (40)	1/5 (20)
Lacy et al. [27]	1 (0.8)	1 month	1/1 (100)	n.r.	n.r.	n.r.	0

SB small bowel, *SBO* small bowel obstruction, *IH* internal hernia

[a]Only operated patients were considered for morbidity and mortality rates calculation

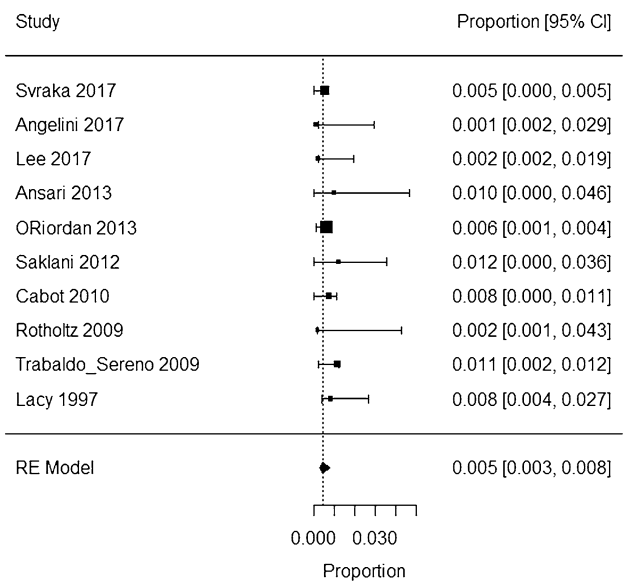

Fig. 2 Pooled proportion of patients developing internal hernia after laparoscopic colorectal resection

bowel. In fact, the small bowel mesentery, which is normally anchored to the posterior abdominal wall from posterior to anterior and from left to right, has a natural tendency to lie in the left iliac fossa and therefore can slide below the left mesocolon [2]. On the other hand, the process for internal hernias following right hemicolectomy is not completely clear. Furthermore, the Treitz ligament could also play a role, as a 'pivotal' point for the proximal jejunum to pass below the neo mesenteric defect [2]. The mobilization of the splenic flexure can contribute to preventing internal hernia, but also to developing severe complications. If mobilization is incomplete (as often reported for non-malignant resection, such as sigmoidectomy for diverticular disease), the descending or transverse colon is pulled towards the pelvis and the meso has a greater tension compared to cases with full mobilization of the splenic flexure and therefore the chances for a passage of ileum below the defect are reduced. However, if the small bowel somehow passes below the mesentery, the risk of it remaining trapped is high with consequent intestinal ischemia and life-threatening complications if not recognized [2]. It is interesting to note that nearly all the patients with symptomatic internal hernia after laparoscopic colorectal resection, included in this systematic review, had been operated on for cancer. Trabaldo et al. suggested that the defect created—and left open—can be larger for oncological cases where the dissection goes to the root of the mesentery, compared to resection for benign disease [2].

The evaluation of the role of some additional aspects (i.e., type of surgery, malignant or benign aetiology, surgeon's or center's experience in laparoscopic colorectal surgery) on the development of internal hernia could have been interesting, but unfortunately the available data did not allow any meaningful subgroup analysis.

Currently, the mesenteric defect created during laparoscopic colorectal surgery is either left open or closed, according to surgeon's preference and laparoscopic skills, while there is no strong evidence to support routine closure. Several techniques have been described to seal the defect

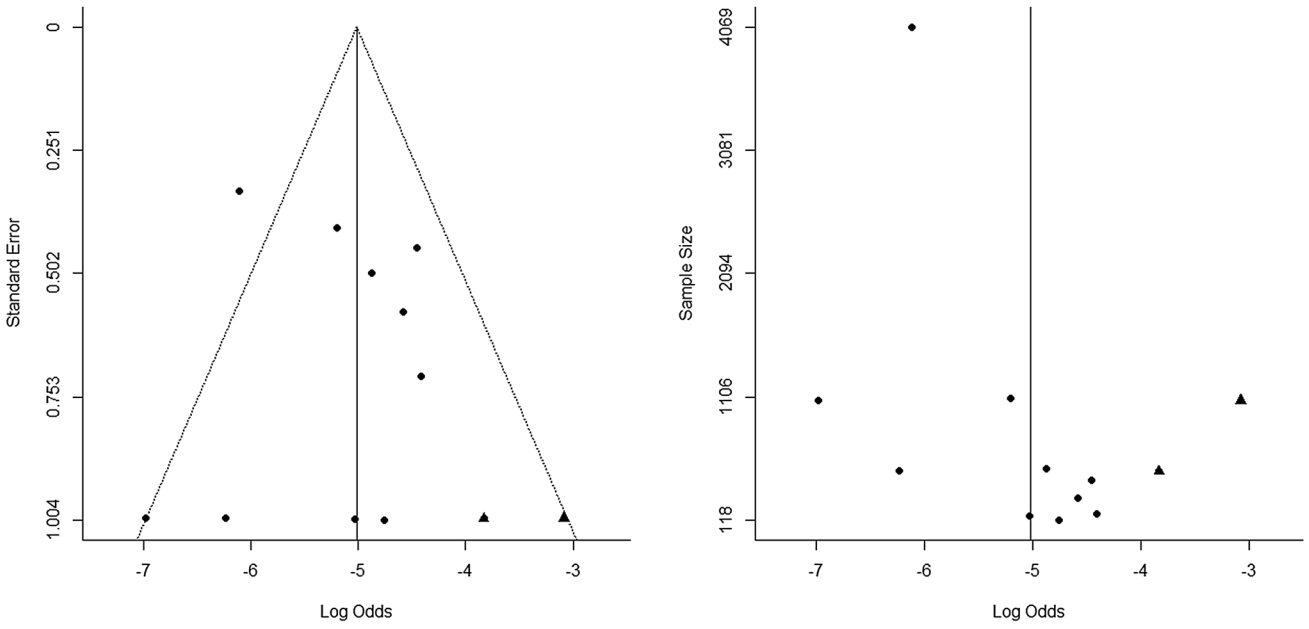

Fig. 3 Funnel plots of log odds vs. standard error (left) or sample size (right); the circles represent the study which were included in the meta-analysis; the triangles represent two missing studies as estimated by trim-and-fill method (Duval and Tweedie)

and prevent the risk of internal hernia, with running suture (preferably non-reabsorbable), clips, or fibrin glue being the most common [2, 5, 20]. However, there are several issues regarding the laparoscopic closure of the mesenteric defect. It is a time-consuming and technically challenging step of the procedure (usually coming after several hours of operation) and increases the risk of damaging the retroperitoneal structures (including the left ureter) and the marginal arcade with suture or clips [33]. Jeopardizing the vascularization of the anastomosis exposes the patient to the risk of 'iatrogenic' ischemia following the defect closure. Some authors suggest a simple repositioning of the small bowel to the right of the mesocolon for left colorectal resection (vice versa for right colonic resections) [33]. This can be performed at the end of the procedure, after dividing the ligament of Treitz at the duodeno-jejunal passage, with or without omental interposition medial to the mobilized colon [33]. The defect should be either closed completely with suture, clips, or fibrin glue (to overcome the technical difficulties of this step of the operation) or left wide open to avoid entrapment of ileal loops, in case of passage [5]. Some authors suggested a 'selective' closure of the meso in thin patients, in which a slim mesentery can readily pass beneath the mesenteric defect [34]. Thin patients may also provide a more favorable anatomical situation compared to patients with excessive body weight and allow for an easier suture of the defect.

It is noteworthy that internal hernia may occur during a large time span, ranging from few hours to several years after surgery [2, 19]. Data from the literature suggest that high alert is mandatory on the first postoperative year, but patients remain at risk also during the following years [5]. Timely recognition and prompt treatment are important in these patients because 90% require surgery with 10% postoperative mortality. An internal hernia can be asymptomatic or present with a cohort of aspecific symptoms, including mild discomfort, vague to diffuse abdominal pain, nausea, and vomiting [1, 2]. It is not easy for the clinicians to immediately recognize the possibility of internal hernia, but persistent abnormal colicky pain after colorectal resection should prompt further investigations, including abdominal X-ray or CT scan. Although several typical CT findings have been described (including 'U'- or 'C'-shaped small bowel loops postero-lateral to the left neo-descending colon after left-sided resections), their absence does not warrant the exclusion of internal hernia [1, 2]. In addition, other radiological findings may be non-specific for internal hernia (such as twisting and/or stretching of mesenteric vessels) but still call for attention and prompt immediate therapeutic decision. Bowel ischemia is the most severe complication of internal hernia, with a mortality rate up to 20% [2]. Internal hernia after left-sided colonic resections usually involves the first jejunal loops, which means that most ileal loops are empty, thus allowing a laparoscopic approach in the treatment of the complication which maintains the benefits of the original laparoscopic surgery. This represents an 'unicum' when compared to all other small bowel obstructions usually involving distal jejunal loops and reducing the working space for laparoscopic repair [35]. When the diagnosis is delayed, severe complications may occur, including perforation and/or ischemia, which limit the likelihood of a laparoscopic approach and increase the risk of mortality as in every small bowel obstruction [22, 36].

The findings of our study should be interpreted within its limitations. First, the topic of interest allowed the inclusion of only observational studies, which can be prone to different types of bias, thus such limitations should be taken into account when reading the results. Second, the quality of most studies in this systematic review was limited: the estimated proportion of internal hernia could be considered as a lower bound for the real proportion. Third, some studies included patients who were followed up for less than 1 year, while internal hernia may occur beyond such time point [19, 21]. Fourth, primary surgical procedures in the whole series included different laparoscopic approaches and was unclear in some studies. Fifth, only clinical studies in English were considered, thus potential studies in other languages were not included.

Conclusions

The rate of internal hernia after laparoscopic colorectal resection is around 5 per 1000 patients. Small-sized studies are likely to overestimate this complication. Need for reoperation is high with a significant risk of mortality. Internal hernia may occur during a large time span, thus high alert is mandatory on the early postoperative period, but patients remain at risk also at long term.

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Compliance with ethical standards

Disclosures Drs. Giuseppe Portale, George Octavian Popescu, Matteo Parotto, and Francesco Cavallin have no conflict of interests or financial ties to disclose.

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