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REVIEW

Intraperitoneal drains during open appendicectomy for gangrenous and perforated appendicitis

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Abstract

Intra-abdominal drains are still routinely used in the surgical management of gangrenous and perforated appendicitis. A systematic review was performed with the aim of establishing their influence on postoperative complications in such cases. A literature search was conducted using the search engines PubMed and Cochrance Central Register of Controlled Trials. Included were retrospective case-controlled and prospective randomized controlled trials on the use of drain for open appendicectomy in gangrenous and perforated appendicitis. Twelve articles were found that met the inclusion criteria. Intrabdominal abscesses, postoperative ileus, surgical site infections, fecal fistulas and burst abdomen had significant higher incidences in the drain *vs* non drain group (10.3%, 20.3%, 32.5%, 3.4% and 5.7% *vs* 4.7%, 8.5%, 16.2%, 0% and 0%, respectively). In most cases the risk was more than doubled in the drain group compared to the non-drain one. There were no significant differences among groups in terms of mortality while the results were underpowered to effectively evaluate wound dehiscence and adhesions. The use of intra-abdominal drains in the management of gangrenous and perforated appendicitis by open appendicectomy is associated with an increased rate of common postoperative complications.

Key words: Appendix; Appendicectomy; Complications; Infections; Drains

Core tip: The prophylactic use of intraperitoneal drains for the prevention of postoperativeabdominal abscesses in cases of gangrenous or perforated appendicitis remains a contentious issue, particularly considering that recent enhanced recovery programs have frequently excluded their usage in colorectal operations. With regards to open appendicectomy, most studies demonstrate an increase in the incidence of postoperative abscesses, ileus and surgical site infections in patients in whom a drain was used and currently question their routine in cases of gangrenous and perforated appendicitis.

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INTRODUCTION

The use of intraperitoneal drains in abdominal surgery is a long-standing and still highly controversial practice[1]. It was thought that they removed contaminated material

from the abdominal cavity and reduced the risk of forming intra-abdominal abscesses (IAAs)[2,3]. Indications for the insertion of drains were mostly based on personal experiences and preferences rather than on scientific grounds ("When in doubt, drain" - Tait 1905, cited by Yates[2] and Johnson *et al*[3]). Numerous trials and meta-analysis have challenged their routine use, for example in colorectal surgery where they do not decrease mortality, anastomotic dehiscences, surgical site infections (SSIs), re-interventions or extra-abdominal complications[4-6], Conversely, intra-abdominal drains have been shown to contribute to postoperative ileus and increase the length of stay. Based on these findings intraperitoneal drains have been abandoned by most enhanced recovery programs for elective colorectal surgery[6-8] and their role has been limited to therapeutic purposes in cases of postoperative pelvic collections.

The use of intra-abdominal drains as part of the management of gangrenous and perforated appendicitis by open appendicectomy remains an unresolved issue[9]. The indications for the use of drains in this context are not clear and the clinical practice is operator-dependent and not evidence based. Some advocate Penrose drains in which the internal lumen allows the fluid to drain by capillary action (open drain), as opposed to single lumen silicone drains connected to a suction chamber (Hemovac or Redivac) or double lumen drains connected to suction device (Jackson-Pratt drains), both closed suction devices.

The aim of this systematic review was to establish through an analysis of the reported rates of postoperative complications whether or not there is an indication for the use of intra-abdominal drains during the open surgical management of gangrenous and perforated appendicitis.

SEARCH STRATEGY, OUTCOMES AND STATISTICS

Articles were systematically reviewed from the results of the following searches conducted using the PubMed and Cochrane Central Register of Controlled Trials (CENTRAL) search engines: "appendicitis AND drain" (n = 664), "open AND appendicectomy AND drain" (n = 63), "appendicectomy AND drain" (n = 140). Included were retrospective case-controlled studies and prospective randomized controlled trials reporting the postoperative complication rates for patients with gangrenous and perforated appendicitis managed by open appendicectomy who either did or did not receive an intra-abdominal drain during surgery. An acute appendicitis with an already concomitant periappendicitis abscess was considered in the group of perforated appendicitis. Excluded were all studies including cases of endoappendicitis, phlegmonous or catarrhal appendicitis, those that did not report a comparison between the use of drain *vs* non drain, case reports, studies on laparoscopic appendicectomy or those comparing open *vs* laparoscopic appendicectomy, reviews, those regarding the management of appendicular mass, those in which drains were used to treat an abscess *via* a percutaneous drainage, cost analysis studies.

Primary end-point of the study was to examine the influence of intraperitoneal drains in preventing postoperative IAAs following open appendicectomy for gangrenous and perforated appendicitis. Secondary endpoints were the relationships between drains and the occurrence of other postoperative complications such as SSIs, wound dehiscence, adhesions, fecal fistula, burst abdomen and mortality. All studies reporting data on IAAs only, secondary outcomes only, or both were included in the review and data were analysed in the specific chapters. A specifically designed data form was generated in order to capture the demographics and reported rates of postoperative complications considered. Data analysis was performed by two researchers (Gravante G and Sorge R).

Statistical analysis

All data were inserted into an Excel database (Microsoft, Redmond, Washington - United States). Parameters evaluated were categorized either as "present" or "absent" (categorical variables) and descriptive statistics used were frequencies. Analysis of comparison between groups was conducted with the χ^2 test or Fisher's exact test if counts were less than five. The power calculation was verified for each complication and reported. The odds ratio for the use of drains on the occurrence of postoperative complications was also calculated. P values less than 0.05 were considered statistically significant.

LITERATURE AVAILABLE

A total of 871 articles were identified, which were assessed by 2 authors (Gravante G and Overton J) using the PRISMA flow diagram for systematic reviews (Figure 1)[10]. Following the removal of duplicated articles the number of articles screened was 719. Two hundred and forty seven articles were directly excluded from the analysis because their title and abstract made it immediately apparent that they were not relevant to the study question. The titles and abstract of the remaining 472 articles were assessed in more detail and a further 451 articles were excluded for the following reasons: unrelated to the study question of the systematic review (n = 113), case reports (n = 97), laparoscopic appendicectomy (n = 2), open *vs* laparoscopic study (n = 47), review article (n = 43), management of appendicular mass (n = 57), percutaneous appendicular abscess drainage (n = 23), report of experience (n = 20), phlegmonous or catarrhal appendicitis (n =19), single port surgery (n =12), technical note (n = 7), pain study (n = 4), survey (n = 3), natural orifice transluminal endoscopic surgery appendicectomy (n = 2), pilot study (n = 1), cost analysis study (n = 1).

The full texts for the remaining 23 articles were assessed by the authors (Gravante G and Overton J) and nine articles were excluded from the qualitative and quantitative analysis for the following reasons: the study included cases of gangrenous and perforated appendicitis managed with all drain types and did not focus on

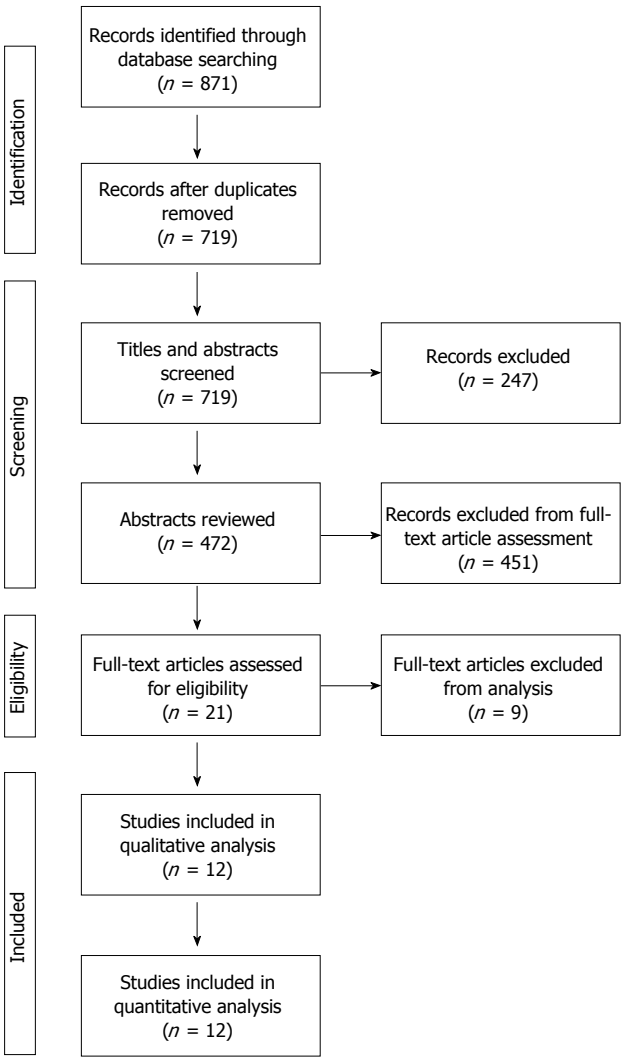

Figure 1 PRISMA figure showing the results of the search strategy.

the use of intra-abdominal drains placed at the time of surgery (n = 3); the outcomes of the respective groups were not presented separately (n = 2); the study included patients with phlegmonous or catarrhal appendicitis (n = 1), did not specify the numbers of patients allocated to the respective groups (n = 1), included patients managed by transperitoneal drainage (n = 1), or presented outcome data relating to groups according to the type of antibiotic used (n = 1).

Twelve articles presented the outcomes for the usage of intra-abdominal drains in the management of gangrenous and perforated appendicitis by open appendicectomy. These were the studies eligible for inclusion in the systematic review and therefore were included in the quantitative analysis: 6/12 were randomized controlled trials, 6/12 were retrospective case-controlled studies (Figure 1).

RATE OF POSTOPERATIVE INTRA-ABDOMINAL ABSCESS FORMATION

Rates of postoperative intra-abdominal abscess formation in open appendicectomy with drainage *vs* non-drainage were presented in 9/12 studies (5/12 were retrospective case-controlled studies and 4/12 were randomised controlled trials) (Table 1)[3,11-18]. The overall rate of intra-abdominal abscess was more than two times higher in the drainage group (10.3%; 39/378) than in the non-drainage group (4.7%; 37/779, χ^2 $P < 0.0001$; Table 1)[3,11-18]. Unfortunately, 2/12 articles span over a long period of time (1978 to 2012)[11,18] and 5/12 of them were retrospective case-controlled studies[3,12,13,16,18]. Studies published before the year 2000 reported an average rate of postoperative intra-abdominal abscess formation of 11.7% in the drainage group (19/163) was compared with a rate of 6.8% in the non-drainage group (30/444; χ^2 test, $P < 0.05$)[3,11-14], Studies published after the year 2000 have an average rate of postoperative intra-abdominal abscess formation of 9.3% in the drainage group (20/215) when compared with 2.1% in the non-drainage group (7/335; χ^2 test, $P < 0.0001$)[16-18].

RATE OF POSTOPERATIVE ILEUS

Only six studies compared the occurrence of postoperative ileus among the drain *vs* non-drain group and all of them showed higher occurrences of postoperative ileus in the drain one[3,11,14,17-19]. Overall, the incidence of postoperative ileus was significant higher (more than 2 times) in patients receiving drains: 20.3% (50/246) for the drain group *vs* 8.5% (33/389) for the non-drain group ($P < 0.0001$; Table 1). Similar to what evidenced for the IAAs, early studies had occurrences significant higher than late studies in both groups: 33.3% (40/120 - before 2000) *vs* 7.9% (10/126 - after 2000; χ^2 test, $P < 0.001$) for the drain group, 20.7% (28/135 - before 2000) *vs* 2.0% (5/254 - after 2000; χ^2 test, $P < 0.001$) for the non-drain group.

RATE OF SSIS

Eleven (6/11 randomised controlled trials and 5/11 retrospective case-controlled studies) reported the rates of SSIs in the drain (149/458; 32.5%) *vs* non-drains group (112/692; 16.2%)[3,11,12,14-21]. The risk was two times greater in the drain group compared to the non-drain one ($P < 0.0001$; Table 1). Early studies had occurrences significant higher than late studies in both groups: 39.0%% (69/177 - before 2000) *vs* 28.5% (80/281- after 2000; χ^2 test, $P = 0.02$) for the drain group, 22.9% (73/319 - before 2000) *vs* 11.2% (46/409 - after 2000; χ^2 test, $P < 0.001$) for the non-drain group.

RATE OF OTHER POSTOPERATIVE COMPLICATIONS

A higher incidence of fecal fistulas[11,14,17,21] and burst abdomen[11,14] was also present in the drain *vs* non drain group, however a formal odds ratio could not be calculated due to the absence of events in the non-drain group (Table 1). No significant differences were found among

Table 1 Comparative studies analyzing the effects of drainage *vs* non drainage in open appendicectomies conducted for perforated and gangrenous appendix

Ref.	Year	Country	Type of study	Type of appendix	Treatment	Patients (*n*)	Antibiotic regimen	Abdominal abscess	Postoperative ileus	Surgical site infections	Wound dehiscence	Adhesions	Fecal fistula	Burst abdomen	Mortality
Everson *et al*[20]	1977	United Kingdom	RCT	PR/GA	D	14	Cephaloridine 1gr QDS - 3 d coverage	-	-	3 (21)	-	-	-	-	-
					ND	16	Cephaloridine 1gr QDS - 3 d coverage	-	-	6 (38)	-	-	-	-	-
Greenall *et al*[11]	1978	United Kingdom	RCT	PR	D	48	(various antibiotics)	7 (15)	18 (38)	34 (71)	-	-	2 (4)	3 (6)	3 (6)
					ND	55	(various antibiotics)	12 (22)	12 (22)	38 (69)	-	-	0 (0)	0 (0)	1 (2)
MacKellar *et al*[12]	1986	Australia	Retros.	PR/GA	D	19	Metronidazole ± Gentamycin and Ampicillin (if suspected peritonitis)	1 (5)	-	3 (16)	-	-	-	-	-
					ND	139	Metronidazole ± Gentamycin and Ampicillin (if suspected peritonitis)	2 (1)	-	2 (1)	-	-	-	-	-
Samelson *et al*[13]	1987	United States	Retros.	PR	D	24	Ampicillin, Gentamycin and Clindamycin if suspected perforation for 7-10 d	3 (13)	-	-	-	-	-	-	-
					ND	170	Ampicillin, Gentamycin and Clindamycin if suspected perforation for 7-10 d	3 (2)	-	-	-	-	-	-	-
Dandapat *et al*[14]	1992	India	RCT	PR	D	40	-	8 (20)	17 (43)	22 (55)	-	-	2 (5)	2 (5)	4 (10)
					ND	46	-	10 (22)	13 (28)	23 (50)	-	-	0 (0)	0 (0)	1 (2)
Johnson *et al*[3]	1993	United States	Retros.	PR	D	32	-	0 (0)	5 (16)	1 (3)	-	-	-	-	-
					ND	34	-	3 (9)	3 (9)	2 (5.9)	-	-	-	-	-
Toki *et al*[15]	1995	Japan	RCT	PR	D	24	Aminoglycoside and Cephem	2 (8)	-	6 (25)	-	0 (0)	-	-	-
					ND	29	Aminoglycoside and Cephem	0 (0)	-	2 (7)	-	0 (0)	-	-	-
Perović *et al*[19]	2000	Croatia	Retros.	PR	D	20	-	-	4 (20)	13 (65)	2 (10)	-	-	-	-
					ND	36	-	-	1 (3)	7 (19)	2 (6)	-	-	-	-
Narci *et al*[16]	2007	Turkey	Retros.	PR	D	109	-	14 (13)	-	31 (28)	-	3 (3)	-	-	-
					ND	117	-	4 (3)	-	19 (16)	-	4 (3)	-	-	-
Jani *et al*[17]	2011	Kenya	RCT	PR	D	45	Cefuroxime and Metronidazole or Penicillin, Gentamicin and Metronidazole or Amoxicillin-Clavulanate and Metronidazole	3 (7)	1 (2)	15 (33)	-	-	2 (4)	-	-
					ND	45	Cefuroxime and Metronidazole or Penicillin, Gentamicin and Metronidazole or Amoxicillin-Clavulanate and Metronidazole	0 (0)	0 (0)	3 (7)	-	-	0 (0)	-	-
Akkoyun *et al*[18]	2012	Turkey	Retros.	PR	D	61	-	3 (5)	5 (8)	3 (5)	1 (2)	1 (2)	-	-	-
					ND	173	-	3 (2)	4 (2)	3 (2)	0 (0)	1 (1)	-	-	-
Al-Shahwany *et al*[21]	2012	Iraq	RCT	PR	D	46	Ceftriaxone and Metronidazole	-	-	18 (39)	-	-	0 (0)	-	0 (0)
					ND	38	Ceftriaxone and Metronidazole	-	-	14 (37)	-	-	0 (0)	-	0 (0)
Total					D	482		39/378 (10.3)	50/246 (20.3)	149/458 (32.5)	3/81 (3.7)	4/194 (2)	6/179 (3.4)	5/88 (5.7)	7/134 (5.2)
					ND	862		37/779 (4.7)	33/389 (8.5)	112/692 (16.2)	2/209 (0.95)	5/319 (1.6)	0/184 (0)	0/101 (0)	2/139 (1.4)
Power calculation								80%	95%	99%	1%	0.02%	99%	99%	99%
odds ratio								2.2	2.4	2	3.9	1.3	-[1]	-[1]	3.7
P value (D *vs* ND)								< 0.0001	< 0.0001	< 0.0001	0.11 (NS)	0.68 (NS)	0.01	0.01	0.08 (NS)

[1]Although the incidence was higher in the drain *vs* non drain group, the odds ratio could not be formally calculated for this complication because of the lack of occurrences in the latter. PR: Perforated appendix; GA: Gangrenous appendix; D: Drainage; ND: Non drainage; RCT: Retrospective randomised trial; Retros.: Retrospective; UTI: Urinary tract infections; QDS: Every 6 h.

groups for the mortality rate (7/134, 5.2% *vs* 2/139, 1.4%; $P = 0.08$)[11,14,21] (Table 1). With regards to the incidence of wound dehiscences[18,19] and bowel obstruction due to adhesions[15,16,18] the data were underpowered to produce reliable result in terms of significant differences among groups (Table 1).

OTHER OUTCOMES

Two retrospective case-controlled studies reported that overall operative times were 8 min longer in the drainage group as compared with the non-drainage group[16,18]. Four articles (2 retrospective case-controlled studies and 2 randomised controlled studies) reported longer length of hospital stay in the drainage group as compared with the non-drainage group[3,15,18,21].

CRITICAL EVALUATION

Appendicectomy is the most common emergency operation performed in abdominal surgery. Generally considered a technically simple procedure, the variability of the intraoperative findings (normal appendix, perforated appendix, presence of IAA or widespread peritonitis, appendicular mass, retrocecal appendix, involvement of the terminal ileum mesentery)[22-24] coupled with the patient's characteristics (*i.e.*, extremes of age, pregnancy, obesity, comorbidities)[25-27] and the approach used (open, laparoscopic, single incision, natural orifice surgery)[28], may increase the technical difficulties and therefore challenge even experienced surgeons. The incidence of postoperative complications differs significantly according to the stage of the disease. Simple appendicitis is when the appendix presents macroscopically normal and the inflammatory infiltrate, if present, is confined mainly to the mucosa (35% of total cases), or when the appendix is macroscopically indurated or purulent and the histological analysis shows mucosal necrosis and transmural inflammation (36% of cases)[29]. In these cases the incidence of postoperative complications is relatively low: SSIs are present in 8.5% of patients (272/3196)[30-40], IAAs in 0.4% (13/3196)[30-40], and bowel obstruction due to adhesions in 0.5% (10/1853)[31,32,34,38,39,41]. Differently, gangrenous and perforated appendicitis is when the appendix presents macroscopically gangrenous with part or whole of the appendix necrotic (9% of cases) or perforated with peritonitis (20% of cases)[29]. In these cases the incidence of complications is higher: SSIs are present in 22.6% of patients (268/1186)[3,11,12,14-21], IAAs in 6.4% (78/1210)[3,11-18], and bowel obstruction due to adhesions in 1.8% (9/513)[15,16,18].

The insertion of intraperitoneal drains during appendicectomies in cases of perforated appendicitis is meant to prevent the formation of IAAs in the early postoperative period. The idea is based on the significant amount of bacterial contamination usually found during the operation that originated from the perforation of the hollow viscus. Following the appendix removal (source of the contamination) and an adequate wash-out of the abdominal cavity (mechanically removal of the contaminated fluid), the insertion of an intraperitoneal drain is meant to continuously aspirate any contaminated pollution leftover that could eventually re-start a local infection. At the same time the patient usually receives an appropriate perioperative course of antibiotic therapy to definitely sterilize the abdominal cavity. If the assumption that drains remove infected fluids and allow the antibiotics a more efficacious action is true, the incidence of postoperative IAAs should be inferior in patients receiving drains *vs* those that do not. Studies available have a significant degree of data heterogeneity with regards to age, co-morbidities, time of presentation to the hospital, type of antibiotic used when considering studies conducted before the year 2000 and those conducted after (including some which are rarely used, *i.e.*, tetracycline, colomycin, streptomycin)[11], the amount of wash-out of the abdominal cavity performed, and the experience of the surgeon. Bearing in mind these limitations some important points can still be made. With the exception of for Greenall *et al*[11] in which the occurrence of abscesses was less in the drainage group than compared to the non-drainage group, 6/12 studies reported higher rates of intra-abdominal abscesses[12,13,15-18] and 2/12 reported comparable rates of intra-abdominal abscesses between the respective groups[3,14]. These reported outcomes demonstrate that the rates of postoperative intra-abdominal abscess formation are lower in the non-drainage group as compared with the drainage group irrespective of the time period during which the study was conducted. Therefore, when considering the rate of intra-abdominal abscess formation reported in early studies (*i.e.*, those published before the year 2000) as compared with those from late studies (*i.e.*, those published after the year 2000) the rate has remained similar in the drainage group among early *vs* late studies (19/163 *vs* 20/215, χ^2 test, P = NS), while it significantly decreased in the non-drainage group (30/444 *vs* 7/335, χ^2 test, $P < 0.001$).

Simple guidelines for the use of drains according to the intraoperative findings cannot be easily drawn and a large role in these cases is actually played by the personal experience and practice. When IAAs are still not formed and the intraoperative findings are those of free pus, a prolonged and abundant irrigation with large amounts of normal saline solution accompanied by a thorough aspiration until the washing liquid is completely clear are frequently sufficient manoeuvres to remove most of the infected material. The abundant wash-out of the abdominal cavity removes the "bulk" of the contamination and facilitates the task for perioperative antibiotics to sterilise the remaining pollution. A careful irrigation is also necessary to remove fecaliths located in remote regions which are not easily accessible by direct exploration (*i.e.*, subphrenic, Douglas, interloop) and in which IAAs are more likely to form[42]. Such areas may require positional changes (*i.e.*, Trendelemburg, anti-Trendelemburg,

right- or left-sided positions) or using the drain shelf to introduce and aspirate the washing liquid in such remote regions. However, it is the authors opinion that when the IAA is completely formed the aspiration of pus leaves an infected cavity that may create an adequate isolated environment for a local recurrence. We believe that if the abscess wall can be adequately removed from the surfaces of the bowel, omentum, and peritoneum then a drain is likely to be superfluous and a thorough irrigation will suffice. However, in cases of incomplete removal, difficult dissection or oozing from raw surfaces a tube drain might be useful to prevent postoperative IAAs. No study has investigated this possibility so far.

The effects of drains manifest also on the occurrence of postoperative ileus and SSIs. Postoperative ileus could be associated to the presence of intraperitoneal drain for a direct irritant effect of the drain on the bowel serosa and consequently the recovery of peristalsis, or for an indirect effect of reduced mobilisation of the patient due to the drain[6]. With regards to SSI, the same considerations of heterogeneity that were observed for the analysis of IAAs can also be applied here. This heterogeneity is reflected in the wide range of reported rates of SSIs (1% to 71%). Rates were 3%-71% in the drainage group and 1%-69% in the non-drainage group (Table 1) but were reportedly lower in the non-drainage group for 9 out of 12 studies presented, suggesting that intra-abdominal drains may represent an independent risk factor for the development of SSIs. A simple explanation to this phenomenon is found in the rare eventuality that drain are exteriorised directly through the main surgical wound, a manoeuvre used to avoid additional wounds in the abdominal wall. In such cases wounds tend to contaminate quickly due to the direct link between the septic intrabdominal focus and the abdominal wall operated by the drain itself. The purulent exudates travel by capillarity not only within the lumen but also on the outer surface of the drain where they easily come into contact with the main wound and start a new infection. For these reasons it is common surgical practice not to drain the infected abdominal cavities through the main wound but to perform a new different one where the drain is exteriorised. When reported, the drainage was operated through a separated wound in most studies[12,15,17], through the same wound in others[20], or the decision was left to the operating surgeon[11]. Therefore, it is still possible that SSIs originate from the direct communication between the intra-abdominal cavity and the external skin surface operated by the outer surface of the drain even when this is exteriorised through separate wounds close to the main one.

CONCLUSION

The prophylactic use of intraperitoneal drains for gangrenous or perforated appendicitis remains a contentious issue, particularly in the context of enhanced recovery programs that frequently exclude their usage. Considering the management of gangrenous or perforated appendicitis by open appendicectomy, all but one study failed to demonstrate any reduction in the rate of postoperative complications and the majority of them found higher incidences associated with the use of drains.

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