REVIEW ARTICLE

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Impact of intra-abdominal drains in emergency gastrointestinal surgery: a scoping review

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Abstract

Introduction: Intra-abdominal drains are often placed in emergency gastrointestinal surgery procedures with the aim to prevent the formation of intra-abdominal collections (IAC) and aid in their early detection. However, the evidence for this is debated. This scoping review aims to evaluate the current evidence for their use in this setting.

Methods: A literature search was performed using MEDLINE via PubMed, Scopus, Web of Science, Cochrane Library, and ClinicalTrials.gov. Primary studies published between January 2000 and September 2023 that assessed intra-abdominal drain placement and post-operative IAC formation in emergency gastrointestinal surgery were included.

Results: A total of 26 articles were identified. There was no strong evidence to suggest that prophylactic intra-abdominal drain placement influences the formation of IAC in emergency gastrointestinal procedures. There was a suggestion that drain placement may increase the rate of surgical site infection and length of hospital stay. However, current studies on the topic are of poor quality and high risk of bias.

Conclusion: The undifferentiated use of drains in emergency gastrointestinal surgery should not be encouraged. Drain placement should be specific to the clinical context. Higher quality research is warranted to better understand the influence drain placement has on post-operative outcomes.

Introduction

Emergency gastrointestinal surgery forms a core part of the general surgeon's workload, often providing a definitive management option for a wide range of acute surgical pathologies, such as perforated peptic ulcer disease, acute appendicitis, or bowel obstruction. Indeed, in the United Kingdom between 30 000 and 50 000 emergency laparotomies[1] and 50 000 appendicectomies[2,3] are performed annually, while in the United States, over 850 000 emergency general surgical procedures are undertaken each year.[4]

Surgical site infections (SSIs) are a common post-operative complication following emergency gastrointestinal surgery, either as a superficial SSI or as an intra-abdominal collection (IAC).[5,6] They result in increased post-operative morbidity, longer hospital stays, higher hospital costs, and increased overall mortality.[7] As a means to reduce IAC formation, the use of intra-abdominal drains during emergency gastrointestinal surgery has long been debated. Advocates argue that their placement may act to prophylactically remove blood, bile, or pus from the abdominal cavity, while also allowing for the earlier detection of haemorrhage or anastomotic leak. However, the overall evidence for their influence on IAC reduction remains conflicting.[8]

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Indeed, there is growing evidence that drains may increase the risk of superficial SSIs, lead to greater analgesic and antibiotic requirements, delay restoration of enteral feeding, and result in prolonged hospital stays.[9,10] As such, the benefits of drain placement need to be weighed against the potential clinical harms. At present, drain placement is often determined by individual surgeon preference, which varies with the seniority of the lead surgeon.[11] A more evidence-based approach to this within emergency gastrointestinal surgery is therefore required.

In this scoping review, we present the current evidence on the use of prophylactic intra-abdominal drains in emergency gastrointestinal surgery, in the context of IAC and their associated morbidity. The aim of this review is to inform evidence-based decision-making for the emergency general surgeon as they consider best surgical practice for their patients.

Methods

Study aims

The primary aim of the study was to assess the efficacy of intra-abdominal drain placement in reducing IAC rates in emergency gastrointestinal surgery. Secondary aims included the impact of intra-abdominal drain placement on morbidity outcomes and length of hospital stay.

Literature search

A literature search was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) guidelines.[12] The study protocol was uploaded and approved on PROSPERO (ID CRD42023407140) prior to commencing the literature search. The search strategy was devised based on searches in similar publications and developed through rounds of expert review (Table S1). We included studies published between January 2000 and September 2023. Any study reporting on non-human data or published in a language other than English was excluded.

A literature search was undertaken using MEDLINE, Scopus, Web of Science, Cochrane Central Register of Controlled Trials (CENTRAL), and ClinicalTrials.gov databases. Any study with primary data that compared drain placement versus no drain placement in emergency gastrointestinal operations, with the primary outcome of intra-abdominal collection formation, was included. All surgical approaches (including open, laparoscopic, and robotic) were included in the search. Studies where drain placement was evaluated as part of a surgical bundle implementation (including enhanced recovery after surgery (ERAS) pathway) were excluded.

The search was performed by two independent reviewers (TH and AH). Each reviewer screened initially by title, then abstract, and finally by full article. Any disagreement in the final list of articles was reviewed by a third independent reviewer (JK). The risk of bias for each study was assessed using the ROBINS-I tool for non-randomized studies[13] and the ROB-2 tool for randomized studies.[14]

Data analysis

Initial review of the literature suggested a large heterogeneity between the studies, precluding any quantifiable analysis. For this reason, data were presented as a scoping review, written in prose. Papers were collated by relevant surgical pathologies; papers were reviewed broadly on the data relevant to either 'Upper Gastrointestinal & Small Bowel Procedures', 'Colorectal Procedures', and 'Open and Laparoscopic Appendicectomy'.

Results

Overall, 4597 articles were identified from the literature search for the scoping review. After screening, 26 articles were included in the final literature review (Fig. 1). The included studies are summarized in Table 1; the overall quality of the included studies was poor, with most studies having a high risk of bias (Table S2 and Table S3).

Upper gastrointestinal and small bowel procedures

For patients undergoing emergency gastrointestinal surgery for gastroduodenal or small bowel perforations, rates of SSI development were equivalent for those with a drain placed and those without.[15–17] While there was a possible lower rate of postoperative interventions associated with the use of a drain in one study (1.9 vs. 5.6%; $P = 0.003$),[16] there was also an increased length of hospital stay with their use noted from another study (6.9 days vs. 5.8 days; $P < 0.001$).[15]

One notable study looked at intra-abdominal drain placement for patients undergoing a laparotomy for typhoid intestinal perforation.[18] Typhoid fever predominantly affects those in low- and middle-income countries, and is often observed in areas with limited access to clean water. Salmonella typhi bacterium will typically affect the ileum and, if left untreated, can result in small bowel perforation. The authors retrospectively reviewed all paediatric cases of typhoid perforation at their institute and concluded that drain placement did not change the rates of superficial SSIs, anastomotic leak detection, or length of hospital stay.[18]

Colorectal procedures

A multi-centre international prospective cohort study recently published observational data on prophylactic intra-abdominal drainage in emergency colorectal surgery.[19] This study collected data on 725 patients across 22 countries, with drains inserted in just over half of cases. After adjustment for confounders, drains were not significantly associated with reduced rates of IACs (OR = 1.6, $P = 0.457$) or the earlier detection of anastomotic leaks (HR = 1.1, $P = 0.805$). Furthermore, drains were not significantly associated with increased length of hospital stay or any other major postoperative complication.[19]

The other studies identified within emergency colorectal surgery were all a retrospective design. While one study identified that drainage was associated with significantly higher risk of IAC formation ($P = 0.002$),[20] this study was at high risk of confounding

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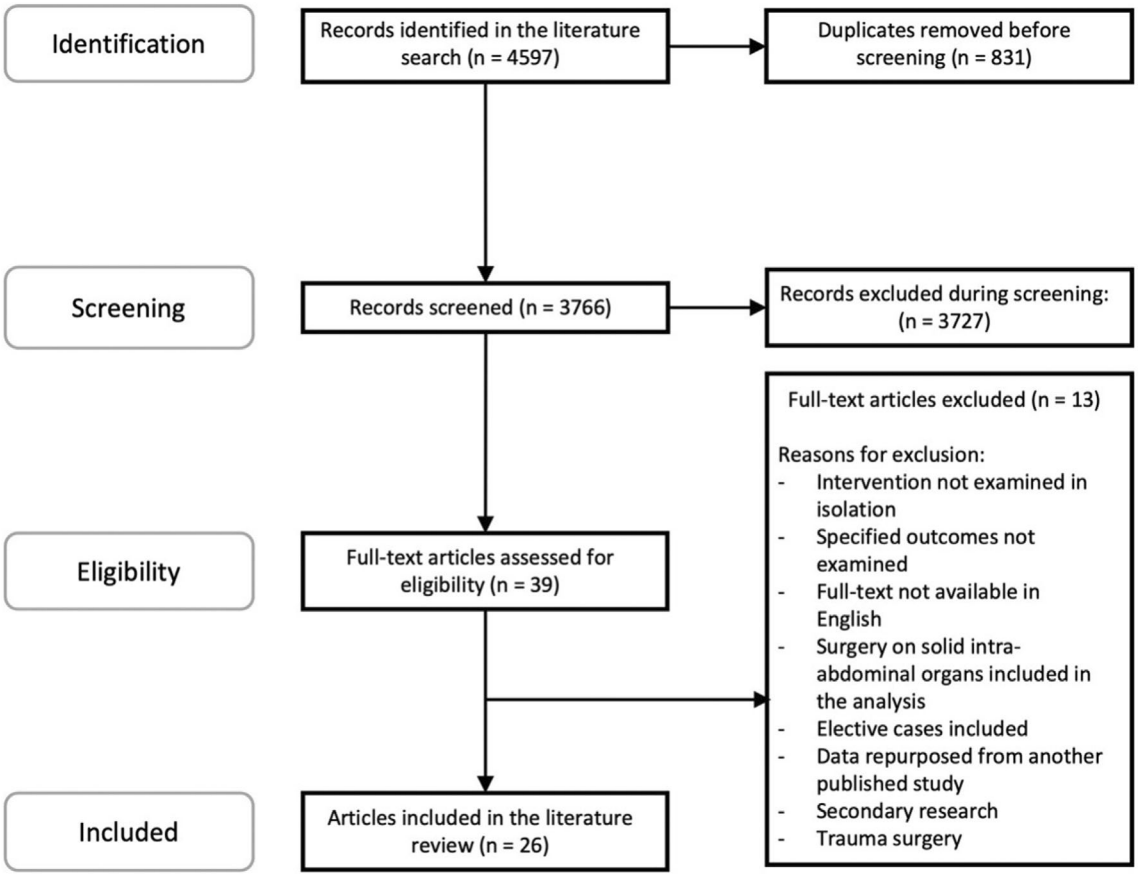

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flowchart.

bias, and a separate retrospective study did not identify any significant difference in risk of IAC with drain placement.[11]

Open and laparoscopic appendicectomy

For patients undergoing laparoscopic appendicectomy, most studies found no influence of intra-abdominal drain placement on the incidence of IAC.[21–29] Indeed, drains were found to increase the risk of post-operative morbidity, including increased rates of superficial SSI[21] and increased length of hospital stay.[22–27,30,31] A randomized controlled trial performed did not find any statistically significant outcomes with intra-abdominal drainage in paediatric patients undergoing laparoscopic appendicectomy for complicated appendicitis, albeit the quality of this study was poor.[28]

In patients undergoing open appendicectomy, the literature on the benefits of prophylactic intra-abdominal drains is conflicting. While some studies identified a potential reduction in IAC formation,[32] others found no such benefit.[33] There was evidence that the placement of an intra-abdominal drain increased the risk of superficial SSI,[33–35] alongside increasing healthcare costs and length of hospital stay.[34,36] Unfortunately, many of these studies were at severe risk of bias and likely underpowered. This includes a randomized controlled trial that was low quality and failed to properly control for confounding factors.[34]

Of note, low-quality evidence suggested the type of intra-abdominal drain used may influence patient outcomes. In two retrospective studies on laparoscopic appendicectomies, negative pressure drains were shown to reduce the risk of IAC formation when compared to passive drainage[37] or no drainage.[37,38] A prospective study on negative pressure drainage after intra-operative peritoneal irrigation also found that this type of drainage was associated with reduced risk of IAC.[39]

Discussion

The use of prophylactic intra-abdominal drains has been a feature of emergency gastrointestinal surgery for over 100 years,[40] however the scenarios in which they confer any true benefit remain unclear. Through our scoping review, we have demonstrated that there remains no strong evidence for the use of prophylactic intra-abdominal drains in preventing intra-abdominal collections, and arguably their use may result in unintended morbidity and delayed patient recovery. If surgeons are to ensure best practice, we cannot remain in the dark about such practice and high-quality prospective randomized trials remain key to better understand the scenarios in which they may be beneficial.

The mechanism by which drains are theorized to reduce the risk of IAC formation revolve around removing excess intra-abdominal

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Table 1 Included studies and key characteristics

Author (year)	Type of study	Type(s) of surgery included	Drain group (n)	Non-drain group (n)	Outcomes measured			
					Detection of leak	Intra-abdominal collection	Superficial SSIs	Length of hospital stay
Upper gastrointestinal and small bowel procedures								
Singh (2022)[15]	Prospective, non-randomized	Gastroduodenal and small bowel perforation peritonitis	50	50	2 days versus 3 days	-	16% versus 16%	6.9 days versus 5.8 days
Okumura *et al.* (2018)[16]	Retrospective	Perforated peptic ulcer repair	467	467	-	-	-	12 days versus 12 days
Lund *et al.* (2021)[17]	Retrospective	Perforated peptic ulcer repair	116	60	3 days versus 4 days	-	-	-
Nasir *et al.* (2012)[18]	Retrospective	Typhoid intestinal perforation (paediatric)	81	66	-	4% versus 9%	63% versus 70%	22 days versus 19 days
Colorectal Procedures								
Rebibo *et al.* (2017)[11]	Retrospective	Lower gastrointestinal tract peritonitis	118	23	-	16% versus 9%	-	14 days versus 9 days
Siembida *et al.* (2022)[20]	Retrospective	Lower gastrointestinal tract peritonitis	50	100	-	30% versus 10%	-	13 days versus 12 days
EuroSurg Collaborative (2023)[19]	Prospective non-randomized	Emergency colorectal surgery (all types)	389	336	Hazard Ratio 1.1	Odds ratio 1.6	-	Hazard Ratio 1.1
Open and Laparoscopic Appendicectomy								
Allemann *et al.* (2011)[21]	Prospective non-randomized	Laparoscopic appendicectomy, acute complicated appendicitis	130	130	-	5% versus 5%	-	-
Pereyaslov *et al.* (2020)[22]	Retrospective	Laparoscopic appendicectomy, acute complicated appendicitis (paediatric)	71	123	-	6% versus 3%	6% versus 2%	-
Schlottman *et al.* (2016)[23]	Retrospective	Laparoscopic appendicectomy, acute complicated appendicitis	56	169	-	14% versus 9%	-	5 days versus 3 days
Aneiros Castro *et al.* (2018)[24]	Retrospective	Laparoscopic appendicectomy, acute complicated appendicitis (paediatric)	117	75	-	29% versus 23%	4% versus 7%	-
Qian *et al.* (2021)[25]	Prospective non-randomized	Laparoscopic appendicectomy, acute complicated appendicitis	159	475	-	7% versus 8%	1% versus 2%	4 days versus 3 days
Ferguson *et al.* (2021)[26]	Prospective non-randomized	Laparoscopic appendicectomy, acute complicated appendicitis (paediatric)	264	115	-	20% versus 23%	0% versus 4%	5 days versus 4 days
Ali Fadl *et al.* (2022)[27]	Prospective non-randomized	Laparoscopic appendicectomy, acute appendicitis	40	40	-	15% versus 13%	3% versus 5%	3 days versus 2 days
Human *et al.* (2022)[28]	Randomized controlled trial	Laparoscopic appendicectomy, acute complicated appendicitis (paediatric)	17	17	-	67% versus 83%	-	5 days versus 6 days
Khirallah *et al.* (2021)[29]	Retrospective	Laparoscopic appendicectomy, acute complicated appendicitis (paediatric)	26	49	-	Odds ratio 1.1	-	7 days versus 3 days
Martínez-Pérez *et al.* (2021)[30]	Retrospective	Laparoscopic appendicectomy, acute complicated appendicitis	96	64	-	-	-	Odds ratio 3.4
Liao *et al.* (2022)[31]	Retrospective	Laparoscopic appendicectomy, acute complicated appendicitis	274	957	-	Odds ratio 1.7	Odds ratio 1.7	5 days versus 3 days
Miranda-Rosales *et al.* (2019)[32]	Retrospective	Open appendicectomy, acute complicated appendicitis	100	50	-	6% versus 0%	29% versus 26%	7 days versus 9 days

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Table 1 Continued

Author (year)	Type of study	Type(s) of surgery included	Drain group (n)	Non-drain group (n)	Outcomes measured			
					Detection of leak	Intra-abdominal collection	Superficial SSIs	Length of hospital stay
Ein *et al.* (2013)[33]	Retrospective	Open appendicectomy, acute complicated appendicitis (paediatric)	105	67	-	11% versus 10%	7% versus 24%	-
Mustafa *et al.* (2016)[34]	Randomized controlled trial	Open appendicectomy, acute complicated appendicitis	34	34	-	-	53% versus 14.7%	6 days versus 4 days
Labricciosa *et al.* (2021)[35]	Prospective non-randomized	Open appendicectomy, acute appendicitis	776	1891	-	-	Odds ratio 2.6	-
Abdulhamid *et al.* (2018)[36]	Retrospective	Open appendicectomy, acute complicated appendicitis	114	113	-	44% versus 47%	37% versus 34%	5 days versus 2 days
Tsai *et al.* (2021)[37]	Retrospective	Laparoscopic appendicectomy, acute complicated appendicitis (paediatric)	19	86	-	21% versus 6%	5% versus 1%	6 days versus 5 days
Pakula *et al.* (2014)[38]	Retrospective	Laparoscopic appendicectomy, acute complicated appendicitis	43	105	-	-	-	4 days versus 4 days
Cho *et al.* (2015)[39]	Retrospective	Laparoscopic appendicectomy, acute appendicitis	592	1225	-	Odds ratio 0.6	-	-

exudative fluid, which may harbour opportunistic pathogens. However, the current evidence does not translate this biological mechanistic theory into any observable patient outcomes. Indeed, it has been proposed that prophylactic drains may exert a negative influence by inducing a pro-inflammatory foreign body reaction, through action as a nadir for infection, or simply by mechanically obstructing the anti-inflammatory actions of the body's routine immune response, such as the migration of the greater omentum.[41,42] While in certain subsets of patients, drain placement may well be beneficial, the current high-quality data to evaluate this is not available.

One of the largest studies identified in our review was a multicentre observational study, performed by the EuroSurg Collaborative.[19] The group concluded that drain placement did not influence the risk of IAC, nor increase the risk of major postoperative complications. This aligns with work on intra-abdominal drainage in elective colorectal surgery, which has identified that drain placement does not improve detection of postoperative collections, but instead prolongs hospital stays and increases the risk of SSIs.[43] Indeed, there have been multiple randomized controlled trials and meta-analyses performed that replicate these outcomes in other elective surgical contexts.[44–46] Current guidelines recommend against the routine use of drains in elective colorectal surgery[47] and we would advocate for similar guidance in the emergency setting. Our study did note a potential advantage with the use of closed-suction intra-abdominal drains, however further work is required to explore this.

Our study does come with limitations. While we performed a wide search strategy, there remained significant heterogeneity within the identified studies, ranging from the population groups studied to the clinical care provided. The studies also used varying terminology and definitions for IAC and SSI, limiting any further quantitative analysis, and as such no meta-analyses were performed to avoid producing misleading or spurious results. Furthermore, the included studies covered a broad range of procedures, limiting any pathology- or procedure-specific assessment. The majority of included studies were of poor study quality, with a serious risk of bias, which is a reflection of the current literature base and we have been careful to not overstate our findings as a result. From this scoping review, it is clear that studies of higher quality, less bias, and greater specificity are required on this topic.

Conclusion

There remains a poor evidence base for the placement of intra-abdominal drains in emergency gastrointestinal surgery. The available evidence, while compromised, does not imply that routine drain placement is clinically beneficial and is potentially associated with increased patient harm and healthcare costs. Presently, we advise that prophylactic drain placement in emergency gastrointestinal surgery should be deployed judiciously and specific to the clinical context. For practice to be influenced, high-quality randomized controlled trials on the matter are paramount.

Author contributions

T. Hubble: Conceptualization; data curation; formal analysis; methodology; writing – original draft. **A. Huseyin:** Conceptualization; data curation; formal analysis; investigation; writing – original draft. **J. Kersey:** Formal analysis; project administration; writing – original draft. **Michael F. Bath:** Conceptualization;

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methodology; supervision; writing – review and editing. **M. Nair:** Conceptualization; supervision; writing – review and editing.

Conflicts of interest

None declared.

References

1. Barrow E, Anderson ID, Varley S *et al*. Current UK practice in emergency laparotomy. *Ann. R. Coll. Surg. Engl.* 2013; **95**: 599–603.
2. Baird DLH, Simillis C, Kontovounisios C, Rasheed S, Tekkis PP. Acute appendicitis. *BMJ* 2017; **357**: j1703.
3. National Institute for Health and Care Excellence. Appendicitis [Internet]. 2021 [Cited 4 Mar 2024.] Available from URL: https://cks.nice.org.uk/topics/appendicitis/
4. Gale SC, Shafi S, Dombrovskiy VY, Arumugam D, Crystal JS. The public health burden of emergency general surgery in the United States: a 10-year analysis of the Nationwide inpatient sample–2001 to 2010. *J. Trauma Acute Care Surg.* 2014; **77**: 202–8.
5. Hopkins S, Shaw K, Simpson L. *English National Point Prevalence Survey on Healthcare Associated Infections and Antimicrobial Use, 2011: Preliminary Data*. London: Health Protection Agency, 2012.
6. Wong J, Ho C, Scott G, Machin JT, Briggs T. Getting it right first time: the national survey of surgical site infection rates in NHS trusts in England. *Ann. R. Coll. Surg. Engl.* 2019; **101**: 463–71.
7. Bath MF, Davies J, Suresh R, Machesney MR. Surgical site infections: a scoping review on current intraoperative prevention measures. *Ann. R. Coll. Surg. Engl.* 2022; **104**: 571–6.
8. David VL, Ciornei B, Popoiu MC, Iacob RE, Boia ES. Is there a role for prophylactic drainage of the abdominal cavity after laparoscopic appendectomy for non-complicated appendicitis in children? *J Pediatr Endosc Surg.* 2019; **1**: 71–4.
9. Reiffel AJ, Barie PS, Spector JA. A multi-disciplinary review of the potential association between closed-suction drains and surgical site infection. *Surg. Infect.* 2013; **14**: 244–69.
10. Mujagic E, Zeindler J, Coslovsky M *et al*. The association of surgical drains with surgical site infections - a prospective observational study. *Am J Surg* 2019; **217**: 5905.
11. Rebibo L, Ebosse I, Iederan C *et al*. Does drainage of the peritoneal cavity have an impact on the postoperative course of community-acquired, secondary, lower gastrointestinal tract peritonitis? *Am. J. Surg.* 2017; **214**: 29–36.
12. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ* 2009; **21**: b2535.
13. Sterne JA, Hernán MA, Reeves BC *et al*. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* 2016; **12**: i4919.
14. Sterne JAC, Savović J, Page MJ *et al*. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019; **28**: l4898.
15. Singh S. A prospective, non-randomized study to determine the role of intra-peritoneal drain placement in perforation peritonitis. *Turk J Trauma Emerg Surg* 2022; **28**: 1397–403.
16. Okumura K, Hida K, Kunisawa S *et al*. Impact of drain insertion after perforated peptic ulcer repair in a Japanese Nationwide database analysis. *World J. Surg.* 2018; **42**: 758–65.
17. Lund S, Chauhan KK, Zietlow J *et al*. Risk factors for gastrointestinal leak after perforated peptic ulcer disease operative repair. *Am. Surg.* 2021; **87**: 1879–85.
18. Nasir AA, Abdur-Rahman LO, Adeniran JO. Is intraabdominal drainage necessary after laparotomy for typhoid intestinal perforation? *J. Pediatr. Surg.* 2012; **47**: 355–8.
19. EuroSurg Collaborative. Safety and efficacy of intraperitoneal drain placement after emergency colorectal surgery: an international, prospective cohort study. *Colorectal Dis* 2023; **25**: 2043–53.
20. Siembida N, Sabbagh C, Chal T *et al*. Absence of abdominal drainage after surgery for secondary lower gastrointestinal tract peritonitis is a valid strategy. *Surg. Endosc.* 2022; **36**: 7219–24.
21. Allemann P, Probst H, Demartines N, Schäfer M. Prevention of infectious complications after laparoscopic appendectomy for complicated acute appendicitis–the role of routine abdominal drainage. *Langenbeck's Arch. Surg.* 2011; **396**: 63–8.
22. Pereyaslov A, Dvorakevych A, Mykyta M, Nykyforuk O, Dats R. Laparoscopic appendectomy In children with complicated appendicitis. Should always drain? *Surg Chron.* 2020; **25**: 23–6.
23. Schlottmann F, Reino R, Sadava EE, Campos Arbulú A, Rotholtz NA. Could an abdominal drainage be avoided in complicated acute appendicitis? Lessons learned after 1300 laparoscopic appendectomies. *Int. J. Surg* 2016; **36**: 40–3.
24. Aneiros Castro B, Cano I, García A, Yuste P, Ferrero E, Gómez A. Abdominal drainage after laparoscopic appendectomy in children: an endless controversy? *Scand. J. Surg.* 2018; **107**: 197–200.
25. Qian S, Vasileiou G, Pust GD *et al*. Prophylactic drainage after appendectomy for perforated appendicitis in adults: a post hoc analysis of an EAST multi-center study. *Surg. Infect.* 2021; **22**: 780–6.
26. Ferguson DM, Anderson KT, Arshad SA *et al*. Prophylactic intra-abdominal drains do not confer benefit in pediatric perforated appendicitis: results from a quality improvement initiative. *J. Pediatr. Surg.* 2021; **56**: 727–32.
27. Ali Fadl EM, F Amer A, S Abdelrahim H. Is abdominal drain necessary after laparoscopic appendectomy for complicated appendicitis? *Surg Gastroenterol. Oncol.* 2022; **27**: 130.
28. Human MJ, Tshifularo N, Mabitsela M. Laparoscopic appendectomy for complicated appendicitis in children: does the post-operative peritoneal drain make any difference? A pilot prospective randomised controlled trial. *Pediatr. Surg. Int.* 2022; **38**: 1291–6.
29. Khirallah MG, Elsossuky NE, Ghazaly M. Predictive factors of post-laparoscopic appendectomy peritoneal collection in children and adolescents with complicated appendicitis. *Afr. J. Paediatr. Surg.* 2021; **18**: 190–4.
30. Martínez-Pérez A, Payá-Llorente C, Santarrufina-Martínez S, Sebastián-Tomás JC, Martínez-López E, de'Angelis N. Predictors for prolonged length of stay after laparoscopic appendectomy for complicated acute appendicitis in adults. *Surg. Endosc.* 2021; **35**: 3628–35.
31. Liao YT, Huang J, Wu CT *et al*. The necessity of abdominal drainage for patients with complicated appendicitis undergoing laparoscopic appendectomy: a retrospective cohort study. *World J. Emerg. Surg.* 2022; **17**: 16.
32. Miranda-Rosales LM, Kcam-Mayorca EJ, Luna-Abanto J, Malpartida-Saavedra H, Flores-Flores C. Use of drains and post-operative complications in secondary peritonitis for complicated acute appendicitis at a national hospital. *Cir Cir* 2019; **87**: 540–4.
33. Ein SH, Nasr A, Ein A. Open appendectomy for pediatric ruptured appendicitis: a historical clinical review of the prophylaxis of wound infection and postoperative intra-abdominal abscess. *Can. J. Surg.* 2013; **56**: E7–E12.
34. Mustafa MIT, Chaudhry SM, Mustafa RIT. Comparison of early outcome between patients of open appendectomy with and without drain for perforated appendicitis. *Pak J Med Health Sci.* 2016; **10**: 890–3.

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35. Labricciosa FM, Sartelli M, Barbadoro P *et al*. Epidemiology and risk factors for superficial surgical site infections after appendectomy for acute appendicitis: a secondary data analysis. *Surg. Infect.* 2021; **22**: 227–33.
36. Abdulhamid AK, Sarker SJ. Is abdominal drainage after open emergency appendectomy for complicated appendicitis beneficial or waste of money? A single centre retrospective cohort study. *Ann. Med. Surg.* 2018; **9**: 168–72.
37. Tsai YW, Lee SY, Jiang JH, Chuang JH. Inappropriate manipulation and drainage exacerbate post-operative pain and prolong the hospital stay after laparoscopic appendectomy for pediatric complicated appendicitis. *BMC Surg.* 2021; **21**: 437.
38. Pakula AM, Skinner R, Jones A, Chung R, Martin M. Role of drains in laparoscopic appendectomy for complicated appendicitis at a busy county hospital. *Am. Surg.* 2014; **80**: 1078–81.
39. Cho J, Park I, Lee D, Sung K, Baek J, Lee J. Risk factors for postoperative intra-abdominal abscess after laparoscopic appendectomy: analysis for consecutive 1817 experiences. *Dig. Surg.* 2015; **32**: 375–81.
40. Billroth T. *Clinical Surgery*. London: The New Sydenham Society, 1881.
41. De Waele JJ, Boelens J, Van De Putte D, Huis In 't Veld D, Coenye T. The role of abdominal drain cultures in managing abdominal infections. *Antibiotics* 2022; **11**: 697.
42. Kawai M, Tani M, Terasawa H *et al*. Early removal of prophylactic drains reduces the risk of intra-abdominal infections in patients with pancreatic head resection: prospective study for 104 consecutive patients. *Ann. Surg.* 2006; **244**: 1–7.
43. EuroSurg Collaborative. Intraperitoneal drain placement and outcomes after elective colorectal surgery: international matched, prospective, cohort study. *Br. J. Surg.* 2022; **109**: 520–9.
44. Denost Q, Rouanet P, Faucheron JL *et al*. To drain or not to drain Infraperitoneal anastomosis after rectal excision for cancer: the GRECCAR 5 randomized trial. *Ann. Surg.* 2017; **265**: 474–80.
45. Karliczek A, Jesus EC, Matos D, Castro AA, Atallah AN, Wiggers T. Drainage or nondrainage in elective colorectal anastomosis: a systematic review and meta-analysis. *Colorectal Dis* 2006; **8**: 259–65.
46. Cavaliere D, Popivanov G, Cassini D *et al*. Is a drain necessary after anterior resection of the rectum? A systematic review and meta-analysis. *Int. J. Color. Dis.* 2019; **34**: 973–81.
47. Gustafsson UO, Scott MJ, Hubner M *et al*. Guidelines for perioperative Care in Elective Colorectal Surgery: enhanced recovery after surgery (ERAS®) society recommendations: 2018. *World J. Surg.* 2019; **43**: 659–95.

Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Supplementary Table S1: Search strategy (MeSH terms or free text words).
Supplementary table S2: ROBINS-I (Risk of Bias in Non-randomized Studies of Interventions) tool.
Supplementary table S3: ROB-2 (Risk of Bias 2) tool.

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