Background

Post-appendectomy intra-abdominal abscesses (IAA) are estimated to complicate up to 4.2% of acute non-perforated appendicitis cases and 6.7% to 28% of acute perforated appendicitis cases [1]. Laparoscopic appendectomy (LA) has been demonstrated to be safe and effective for acute appendicitis but, compared to open appendectomy (OA), an increased rate of IAAs has been reported [2, 3]. IAA is a significant cause of morbidity that increases the length of the hospital stay and needs to be treated by prolonged antibiotic therapy, percutaneous drainage or even reoperation.

The etiology of this complication remains unclear. On the one hand, some authors speculate that the occurrence of postoperative IAA might be influenced by several factors, such as advanced appendicular disease, appendicular perforation, the type of technique used for the removal of the appendix and the lack of an adequate perioperative antibiotics’ regimen [4]. On the other hand, there are suggestions that a large-volume intraoperative peritoneal lavage might increase the rate of post-appendectomy IAA [5–8]. Unfortunately, most of the studies investigating the risk factors...
for IAA are relatively small-sized, retrospective, and often report conflicting results. The aim of the present study was to discover what factors might contribute to the onset of IAA in patients undergoing LA.

Methods

Data collection

We reviewed the data of a prospectively collected database of patients who underwent laparoscopic appendectomy for acute appendicitis during the period 2001–2017 at the Department of Emergency Surgery of Pisa University Hospital. The diagnosis of acute appendicitis was based on clinical presentation, laboratory parameters, and imaging studies. Patients treated with laparotomy and those requiring a conversion to open were excluded. An ultrasound scan was performed for all patients with suspected acute appendicitis. Computed tomography was required in those cases for which a discordance was noted between the clinical presentation and the ultrasound. For all patients, antibiotics were administered about 30 min before the surgical operation or at the moment of the diagnosis in case that surgery would have been delayed after more than six hours, according to the international guidelines on antibiotic prophylaxis in general surgery. The surgical operations were directly performed by experienced surgeons or by a senior resident in co-presence with the consultant. This study is compliant with the STROCSS criteria [9] and is in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The informed consent for this study was waived because of the retrospective nature.

Surgery

We adopted the policy of performing a laparoscopy for all comers. Laparoscopic surgery was accomplished with the patient supine in the Trendelenburg position, and the table rotated 10°-15° to the left. Pneumoperitoneum was established with CO2 at 12 to 14 mmHg by placing a Veress needle in the umbilical area or by using a Hasson open technique in case of previous surgical operations. A 5-mm trocar was inserted in the periumbilical region for the introduction of a 5-mm—30° laparoscope. Then, another 5-mm trocar was inserted in the suprapubic area, and a 12-mm trocar was inserted in the left iliac fossa for the removal of the appendix. A complete exploration of the whole abdominal cavity, including the identification of signs of acute appendicitis, was firstly performed. The mesoappendix was transected with electrocautery or using clips (HEM-O-LOK® Ligation System, Teleflex, Inc., Morrisville, NC, USA). The base of the appendix was ligated with endoloops and divided or sectioned with a 45-mm laparoscopic articulating stapler in the case of a large or gangrenous/perforated appendicular base. The appendix was then removed with a bag. After the complete evacuation of abdominal collections, a peritoneal lavage with warm saline solution, followed by suctioning, was performed in all patients until a satisfactory peritoneal clearance was achieved. One or two drains were placed in the pelvis and/or in the right paracolic gutter at discretion of the operating surgeon. Drains were removed maximum 48 h after surgery.

Post-operative management

Postoperative antibiotic treatment (amoxicillin/clavulanic acid or ciprofloxacin) was considered “prolonged” in case it was continued up to five days after surgery. In cases of severe and diffuse contamination of the peritoneal cavity, a pipercillin/tazobactam regimen of antibiotic therapy was given.

Follow-up and IAA diagnosis

After discharge, a follow-up program was accorded with patients in case of appearance of fever or abdominal pain, referring to outpatient clinic or emergency department. IAA was suspected in the presence of fever, leukocytosis, and abdominal pain, and an abdominal imaging investigation confirmed the diagnosis (US and CT scan). Treatment consisted of broad-spectrum antibiotics for small-sized abscesses (< 3 cm) and percutaneous drainage for larger abscesses (>3 cm). Abscesses not amenable to percutaneous drainage or associated with peritonitis were best managed by surgical exploration.

Data analysis and statistics

The following parameters were the target of the analysis: gender, age, American Society of Anesthesiologists (ASA) score, BMI, time interval between symptoms onset and surgery, intraoperative findings (abscess, gangrenous appendicitis, perforated appendix, pelvic peritonitis), method of management of the mesoappendix, type of technique adopted for the division of the inflamed appendix, use of peritoneal drains, postoperative use of antibiotics, and postoperative use of pipercillin/tazobactam. Pelvic peritonitis was defined as the presence of suppurative fluid with fibrin and local contamination in the pelvis at the moment of the operation. The Lilliefors test was used to assess the normality of the distributions. A Mann–Whitney test was carried out to analyze quantitative variables. In addition, the Chi-squared test was performed to study categorical variables. Furthermore, multivariate logistic regression was used, and
the Hosmer–Lemeshow test was carried out to evaluate the goodness of fit of the multivariate model. A p value < 0.05 was considered statistically significant. The statistical analysis was performed using the R software package (The R Foundation for Statistical Computing, Vienna, Austria), version 3.5.0.

Results

From 2001 to 2017, 2076 patients underwent laparoscopic appendectomy for acute appendicitis. The mean age was 29.5 years (SD ± 18.47). There were 1,110 (53.5%) male and 966 (46.5%) female patients. The ASA score was ≥ 2 in 497 patients (23.9%). Mean BMI was 23.2 (SD ± 2.53) kg/m². Mean time interval between symptoms onset and surgery was 31.18 (SD ± 15.07) h. Table 1 summarizes the patients’ demographics and preoperative variables.

At surgical exploration, 269 (12.9%) patients turned out to have an intraoperative abscess, 274 (13.2%) had gangrenous appendicitis, 180 (8.7%) had a perforated appendix, and 374 (18%) had pelvic peritonitis.

In 1,438 cases (69.3%), the mesoappendix was coagulated and dissected by bipolar current forceps. In the remaining 638 patients (30.7%), the mesoappendix vessel was clipped and divided via scissors.

Endostapling was the preferred method of dealing with the basis of the inflamed appendix in 467 (22.5%) patients, whereas division of the basis of the appendix between endoloop ligatures was the most used method. Peritoneal drains were placed in 1533 cases (73.8%).

Overall, the mean operative time was 59.3 min (SD ± 29.96), and the mean postoperative hospital stay was 2.6 days (SD ± 2.13). Postoperative antibiotic treatment was given to 1,083 patients (52.2%). In particular, a piperacillin/tazobactam regimen was administered to 318 patients (15.3%).

Thirty-seven patients (1.8%) developed a postoperative intra-abdominal abscess. The average elapsed time from surgery to the diagnosis of IAA was 13.5 days (range 3–163 days). Management included antibiotics only in 19 cases (51%), percutaneous drainage with antibiotics in 13 (35%), and redo surgery (laparoscopic drainage) in the remaining 5 cases (14%). Median follow up was 123 months (range 213–212).

Using univariate analysis, male gender (p = 0.04), ASA score ≥ 2 (p = 0.04), intraoperative abscess, gangrenous appendix, signs of appendicular perforation, pelvic peritonitis (p < 0.0001), clipping of the mesoappendix (p < 0.0001), and the use of the endostapler (p = 0.02) were associated with a higher occurrence of postoperative IAA (Table 2).

Prolonged postoperative antibiotic treatment was significantly more frequent in the group with postoperative IAA (52.1% vs. 73%; p = 0.01) (Table 2). The same was for the postoperative use of piperacillin/tazobactam (14.7% vs. 45.9%; p < 0.0001).

Using multivariate analysis, a perforated appendix (OR 6.4; 95% CI 2.4–17.6; p < 0.0002), pelvic peritonitis (OR 3; 95% CI 1.3–6.9; p = 0.010), and the clipping of the mesoappendix (OR 3.8; 95% CI 1.8–7.8; p = 0.0002) were identified as predictive factors for postoperative IAA (Table 3). The Hosmer–Lemeshow test showed a p value of 0.27 with an appropriate level of goodness of fit.

Discussion

The present study shows that pelvic peritonitis, perforated appendicitis, and clipping the mesoappendix represent independent predictive factors for postoperative IAA following laparoscopic appendectomy. As a matter of facts, these results not only confirm data reported in the literature but also highlight the use of clips for the mesoappendix as a further potential risk factor for postoperative IAA. So far, they should be avoided for the closure of the appendicular artery.

The severity of the appendix inflammation is believed to be the main risk factor associated with IAA. The IAA rate after laparoscopic appendectomy reported in non-perforated appendicitis is 1–4%, but the incidence of postoperative IAA increases by up to 26% in patients with gangrenous perforated appendicitis [10–13]. We found perforated

Table 1 Patients’ general and perioperative characteristics

| Demographics and preoperative variables | Value |  
|----------------------------------------|-------|
| Age (mean ± SD) (years) | 29.5 ± 18.47 |
| Male gender (n, %) | 1110 (53.5) |
| ASA score ≥ 2 (n, %) | 497 (23.9) |
| BMI (mean ± SD) | 23.2 ± 2.53 |
| Time interval between symptoms onset and surgery (mean ± SD) (hours) | 31.18 ± 15.07 |

| Intraoperative findings | Value |
|-------------------------|-------|
| Complicated acute appendicitis (n, %) | 449 (21.6) |
| Intraoperative abscess | 269 (12.9) |
| Gangrenous appendicitis | 274 (13.2) |
| Perforated appendix | 180 (8.7) |
| Pelvic peritonitis | 374 (18) |
| Endostapler for appendix transection (n, %) | 467 (22.5) |
| Coagulation of mesoappendix (n, %) | 1438 (69.3) |
| Peritoneal drainage (n, %) | 1533 (73.8) |
| Duration of operative time (mean ± SD) (min) | 59.3 ± 29.96 |

| Postoperative outcomes | Value |
|-----------------------|-------|
| Prolonged antibiotic treatment (n, %) | 1083 (52.2) |
| Piperacillin/tazobactam (n, %) | 318 (15.3) |
| Postoperative hospital stay (mean ± SD) (days) | 2.6 ± 2.13 |
| Postoperative IAA (n, %) | 37 (1.8) |
appendicitis in 45.9% of patients who developed a postoperative IAA, while only 8% of the patients who did not suffer this complication presented this finding (Table 2). According to Schlottmann et al. the higher is the grade of intraperitoneal bacterial contamination, the higher is the risk of postoperative IAA [14], and few doubts exist about the fact that perforation increases the grade of contamination of the peritoneum surrounding the appendix. Indeed, this study strongly supports the hypothesis that a perforated appendix should be regarded as a predictive factor for postoperative IAA (OR 6.4; \( p = 0.0002 \)) (Table 3). In addition, pelvic peritonitis was significantly more frequent in patients who developed postoperative IAA (17.5% vs. 43.2%; \( p < 0.0001 \)) (Table 2) and was recognized as a predictive factor for postoperative IAA via multivariate analysis (OR 3; \( p = 0.010 \)) (Table 3).

According to the WISS study, acute appendicitis is still the most frequent cause of intra-abdominal sepsis [15]. A delayed diagnosis, mostly occurring in patients who are unreliable or have an atypical clinical onset, may lead to severe, life-threatening complications such as gangrene, perforation, appendiceal mass, and peritonitis [16]. Overall, 18% of patients enrolled had a peritonitis localized in the pelvis or in the paracolic gutter. This result is in line with the rate reported in the literature (17.3%) [13].

The clipping of the mesoappendix is associated with a higher incidence of postoperative IAA. In this study, the use of clips was left to the operating surgeon’s discretion, but such use was always limited to the management of the mesoappendix. Compared to bipolar coagulation, we recorded a significantly higher occurrence of IAA when the mesoappendix was secured with polymeric clips (29.7% vs. 62.1%; \( p < 0.0001 \)). Polymeric clips have been increasingly used for the closure of the appendiceal stump [17, 18], but the correlation between the use of polymeric clips and the increased rate of IAA, if it exists, remains unexplained. Some studies have indeed investigated the possible correlation between the method of mesoappendix dissection and the onset of IAA, with no significant conclusion. Wright et al., in a review of 565 patients undergoing laparoscopic appendectomy for uncomplicated appendicitis, analyzed 149 patients (26%) who had a transection of the mesoappendix and appendix with a single staple line, 259 (46%) who had multiple staple lines, and 157 (28%) who had their mesoappendix dissected with the aid of ultrasonic shears and their appendix divided by a single staple line. They found that the incidence of

### Table 2 Univariate analysis

|                          | NO Post-op IAA | Post-op IAA | \( p \) |
|--------------------------|----------------|-------------|--------|
| Age (mean ± SD)          | 25 ± 18.3      | 28 ± 22.5   | 0.30   |
| M: F (n)                 | 1084:955       | 26:11       | 0.04   |
| ASA score ≥ 2 (n, %)      | 483 (23.7)     | 14 (37.8)   | 0.04   |
| BMI (mean ± SD)          | 23.19 ± 2.46   | 23.9 ± 4.8  | 0.88   |
| Time interval between symptoms onset and surgery (mean ± SD) | 31.04 ± 14.86 | 38.91 ± 22.56 | 0.21 |
| Intraoperative abscess (n, %) | 256 (12.5)   | 13 (35.1)  | <0.0001 |
| Gangrenous appendicitis (n, %) | 261 (12.8)    | 13 (35.1)  | <0.0001 |
| Perforated appendix (n, %) | 163 (8)       | 17 (45.9)  | <0.0001 |
| Pelvic peritonitis (n, %) | 358 (17.5)    | 16 (43.2)  | <0.0001 |
| Endostapler for appendicular transaction (n, %) | 453 (22.2)    | 14 (37.8)  | 0.02   |
| Clipping of mesoappendix (n, %) | 606 (29.7)  | 23 (62.1)  | <0.0001 |
| Peritoneal drainage (n, %) | 1502 (73.6)  | 31 (83.7)  | 0.168   |
| Prolonged antibiotic therapy (n, %) | 1062 (52.1)  | 27 (73)    | 0.01    |
| Piperacillin/tazobactam (n, %) | 301 (14.7)  | 17 (45.9)  | <0.0001 |

\( p \) values inferior to significance level are in bold

### Table 3 Multivariate analysis

| Multivariate analysis                  | Odds ratio | 95% CI        | \( p \) |
|---------------------------------------|------------|---------------|--------|
| ASA score (<2 vs. ≥2)                 | 0.7        | 0.3–1.7       | 0.53   |
| Gender (M vs. F)                      | 1.7        | 0.8–3.5       | 0.15   |
| Endostapler vs. endoloop for appendicular transaction | 1 | 0.5–2.2 | 0.86 |
| Intraoperative abscess                | 1.4        | 0.5–3.5       | 0.42   |
| Gangrenous appendicitis               | 1          | 0.4–2.5       | 0.97   |
| Perforated appendix                   | 6.4        | 2.4–17.6      | 0.0002 |
| Pelvic peritonitis                    | 3          | 1.3–6.9       | 0.010  |
| Clipping vs coagulation of mesoappendix | 3.8 | 1.8–7.8 | 0.0002 |
| Prolonged antibiotic therapy          | 0.7        | 0.2–2         | 0.58   |
| Piperacillin/tazobactam               | 1          | 0.3–3         | 0.89   |

\( p \) values inferior to significance level are in bold
The present study suffers several limitations. Primarily, this is a retrospective study. Secondly, this series represents a vastly complex, heterogeneous patient population scattered over a considerable period. Thirdly, the lack of including other risks factor can affect the statistics of the multivariate analysis. Furthermore, the number of patients presenting a postoperative IAA constitutes a small cohort of cases. However, since the study was carried out at a tertiary referral center, the high volume of patients undergoing laparoscopy for acute appendicitis makes the statistical analysis credible and valuable. Lastly, we acknowledge that the patients were not routinely followed once symptoms resolved after the surgical intervention, making it possible that patients could have been lost during follow up.

Conclusions

Patients with perforated appendicitis, pelvic peritonitis and a clipped mesoappendix have a higher chance of developing postoperative IAA. The type of technique adopted for the division of the appendix (endostapler vs. endoloop) does not seem to be a risk factor for the development of postoperative IAA. The lack of postoperative antibiotic treatment was not identified as an independent risk factor for abscess formation.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Dario Tartaglia, Lorenzo Maria Fatucchi, Alessio Mazzoni, Mario Miccoli, Lorenzo Piccini, Marsia Pucciarelli. The first draft of the manuscript was written by Dario Tartaglia, Lorenzo Maria Fatucchi and Alessio Mazzoni. Salomone Di Saverio, Federico Coccioni, and Massimo Chiarugi provided a critical revision of the first draft. 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.

Ethical approval As observational study no ethical approval was requested by our institution.

Research involving human participants and/or animals All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (Institutional and National) and with the Helsinki Declaration of 1964 and later versions.

Informed consent All patients gave written informed consent to publish.
References

1. Coelho A, Sousa C, Marinho AS, Barbosa-Sequeira J, Recaman M, Carvalho F (2017) Post-appendectomy intra-abdominal abscesses: six years' experience in a pediatric surgery department. Cir Pediatr 30(3):152–155

2. Sauerland S, Jaschinski T, Neugebauer EA (2010) Laparoscopic versus open surgery for suspected appendicitis. Cochrane Database Syst Rev 10:CD001546. https://doi.org/10.1002/14651858.CD001546.pub3

3. Horvath P, Lange J, Bachmann R, Struller F, Königsrainer A, Soll C, Wyss P, Gelpke H, Raptis D, Breitenstein S (2016) Appendiceal stump closure using polymeric clips reduces intra-abdominal abscesses. Langenbecks Arch Surg 401(5):661–666. https://doi.org/10.1007/s00423-016-1459-3

4. Soll C, Wyss P, Gelpke H, Raptis D, Breitenstein S (2016) Appendiceal stump closure using polymeric clips reduces intra-abdominal abscesses. Langenbecks Arch Surg 401(5):661–666. https://doi.org/10.1007/s00423-016-1459-3

5. Gupta R, Sample C, Bamehriz F, Birch DW (2006) Infectious complications following laparoscopic appendectomy. Can J Surg 49(6):397–400

6. Hartwich J, Carter R, Wolfe L, Greetsky M, Heath K, St. Peter S, et al (2013) The effects of irrigation on outcomes in cases of perforated appendicitis in children. J Surg Res 180(2):222–225. https://doi.org/10.1016/j.sjs.2012.04.043

7. Cho J, Park I, Lee D, Sung K, Baek J, Lee J (2015) Risk factors for postoperative intra-abdominal abscess after laparoscopic appendectomy: analysis for 1,817 consecutive experiences. Dig Surg 32(5):375–381. https://doi.org/10.1159/000438707

8. Hernandez M, Finnesgard E, Aho J, Zielinski M (2017) Less is more: outcomes of postoperative organ space infection after intraoperative irrigation in appendicitis. J Am Coll Surg 225(4):S84–S85. https://doi.org/10.1016/j.jamcollsurg.2017.07.180

9. Agha RA, Borrelli MR, Vella-Balacchino M, Thavayogan R, Orgill DP (2017) The STROCSS statement: strengthening the reporting of cohort studies in Surgery. Int J Surg 46:198–202. https://doi.org/10.1016/j.ijsu.2017.08.586

10. Krisher S, Browne A, Dibbins A, Tkacz N, Curci M (2001) Intra-abdominal abscess after laparoscopic appendectomy for perforated appendicitis. Arch Surg 136(4):438–441. https://doi.org/10.1001/archsurg.136.4.438

11. Levin D, Pegoli W (2015) (2015) Abscess after appendectomy: predisposing factors. Adv Surg 49:263–280. https://doi.org/10.1016/j.asu.2015.03.010

12. Reid F, Choi J, Williams M, Chan S (2017) Prospective evaluation of the Sunshine Appendicitis Grading System score. ANZ J Surg 87(5):368–371. https://doi.org/10.1111/ans.13271

13. Frazier R, Bohannon WT (1996) Laparoscopic appendectomy for complicated appendicitis. Arch Surg 131(5):509–511. https://doi.org/10.1001/archsurg.1996.01430170055010

14. Schlotmann F, Sadava E, Peña M, Rotholz N (2017) Laparoscopic appendectomy: risk factors for postoperative intra-abdominal abscess. World J Surg 41(5):1254–1258. https://doi.org/10.1007/s00268-017-3869-y

15. Sartelli M, Abu-Zidan FM, Catena F, Griffiths EA, Di Saverio S, Coimbra R, Ordonez CA, Leppanen A, Fraga GP, Coccobini F, Agresta F, Abbas A, Abdel Kader S, Agboola J, Amhed A, Aijbade A, Akkucuk S, Alharithi B, Anyfantakis D, Augustin G, Baiocchi G, Bala M, Baraket O, Bayrak S, Bellanova G, Beltrán MA, Bini R, Boal M, Borodach AV, Bouliaris K, Branger F, Brunelli D, Catani M, Che Jusho A, Chichom-Mefire A, Cocolullo G, Colak E, Costa D, Costa S, Cui Y, Curca GL, Curry T, Das K, Delibegovic S, Demetrasvili Z, Di Carlo I, Drozdova N, El-Zalabany T, Enani MA, Faro M, Gachabayov M, Giménez Maurel T, Gkiokas G, Gomes CA, Gonsaga RA, Grueninger G, Guner A, Gupta S, Gutierrez S, Hutan M, Ioannidis O, Isik A, Izawa Y, Jain SA, Jokubauskas M, Karamarkovic A, Kauhanen S, Kaushik R, Kenig J, Khokha V, Kim JI, Kong V, Koshy R, Kransnik A, Kshirsagar A, Kuliesiatus L, Lasithiotakis K, León P, Lee JG, Leon M, Lizarazu Pérez A, Lohsiriwat V, López-Tomassetti Fernandez E, Losteridis E, Mn R, Major P, Marinis A, Marrelli D, Martinez-Perez A, Marwah S, McFarlane M, Melo RB, Mesina C, Michalopoulos N, Moldovanu R, Mouaqt O, Munyika A, Negoi L, Nikolopoulos I, Nita GE, Olaeye I, Omari A, Ossra PR, Ozkan Z, Padmakumar R, Pata F, Pereira Junior GA, Pereira J, Pintar T, Pougoauras K, Prabhu V, Rausei S, Rems M, Rios-Cruz D, Sakakushev B, Sánchez de Molina ML, Seretis C, Shelat V, Simões RL, Sinibaldi G, Skrovina M, Smirnov D, Spyropoulos C, Tepp J, Tezcaner T, Tolonen M, Torba M, Ulrych J, Uzunoglu MY, van Dellen D, van Ramsorst GH, Vasquez G, Venara A, Vereczeki A, Vettoretto N, Vlad N, Yadav SK, Yilmaz TU, Yuan KC, Zachariah SK, Zida M, Ziliaksa J, Ansaloni L (2015) Global validation of the WSES Sepsis Severity Score for patients with complicated intra-abdominal infections: a prospective multicentre study (WISS Study). World J Emerg Surg 10:61. https://doi.org/10.1186/s13017-015-0055-0.

16. Bangu A, Soreide K, Di Saverio S, Assarsson J, Drake F (2015) Acute appendicitis: modern understanding of pathogenesis, diagnosis, and management. Lancet 386(10000):1278–1287. https://doi.org/10.1016/S0140-6736(15)00275-5

17. Langer M, Safavi A, Skarsgard ED (2013) Management of the base of the appendix in pediatric laparoscopic appendectomy: clip, ligate, or staple? Surg Technol Int 23:81–83

18. Hanssen A, Plotnikov S, Dubois R (2007) Laparoscopic appendectomy using a polymeric clip to close the appendicular stump. JSLS 11(1):59–62

19. Wright GP, Mitchell EJ, McClure AM, Onesti JK, Moyo SC, Brown AR, Peshkepija A, Scott GL, Chung MH (2015) Comparison of stapling techniques and management of the mesoappendix in laparoscopic appendectomy. Surg Laparosc Endosc Percutan Tech 25(1):e11–e15. https://doi.org/10.1097/SLE.0000000000000404

20. Lee J, Hong T (2014) Comparison of various methods of mesoappendix dissection in laparoscopic appendectomy. J Laparoendosc Adv Surg Tech A. 24(1):28–31. https://doi.org/10.1089/sle.2015.0055-0.

21. Kimblett AR, Novosel TJ, Collins JN, Weirer LE, Terzian HW, Adams RT, Beydoun HA (2014) Do postoperative antibiotics prevent abscess formation in complicated appendicitis? Am Surg. 80(9):878–883

22. Daskalakis K, Juhan P, Pahlman L (2014) The use of pre- or postoperative antibiotics in surgery for appendicitis: a systematic review. Scand J Surg 103(1):14–20. https://doi.org/10.1177/1457464314543974

23. Anderson K, Bartz-Kurycki M, Kawaguchi A, Austin M, Holz KC, Zachariah SK, Zida M, Ziliaksa J, Ansaloni L (2015) Global mapping of jurisdictional claims in published maps and institutional affiliations. Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.