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Abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis

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ABSTRACT

Background
Appendectomy, the surgical removal of the appendix, is performed primarily for acute appendicitis. Patients who undergo appendectomy for complicated appendicitis, defined as gangrenous or perforated appendicitis, are more likely to suffer from postoperative complications. The routine use of abdominal drainage to reduce postoperative complications after appendectomy for complicated appendicitis is controversial.

Objectives
To assess the safety and efficacy of abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis.

Search methods
We searched The Cochrane Library (Issue 1, 2014), MEDLINE (1950 to February 2014), EMBASE (1974 to February 2014), Science Citation Index Expanded (1900 to February 2014), and Chinese Biomedical Literature Database (CBM) (1978 to February 2014).

Selection criteria
We included all randomised controlled trials (RCTs) that compared abdominal drainage and no drainage in patients undergoing emergency open appendectomy for complicated appendicitis.

Data collection and analysis
Two review authors identified the trials for inclusion, collected the data, and assessed the risk of bias independently. We performed the meta-analyses using Review Manager 5. We calculated the risk ratio (RR) for dichotomous outcomes (or a Peto odds ratio for very rare outcomes), and the mean difference (MD) for continuous outcomes with 95% confidence intervals (CI).
Main results
We included five trials involving 453 patients with complicated appendicitis who were randomised to the drainage group (n = 228) and the no drainage group (n = 225) after emergency open appendectomies. All of the trials were at a high risk of bias. There were no significant differences between the two groups in the rates of intra-peritoneal abscess or wound infection. The hospital stay was longer in the drainage group than in the no drainage group (MD 2.04 days; 95% CI 1.46 to 2.62) (34.4% increase of an 'average' hospital stay).

Authors’ conclusions
The quality of the current evidence is very low. It is not clear whether routine abdominal drainage has any effect on the prevention of intra-peritoneal abscess after open appendectomy for complicated appendicitis. Abdominal drainage after an emergency open appendectomy may be associated with delayed hospital discharge for patients with complicated appendicitis.

PLAIN LANGUAGE SUMMARY

Drain use after an open appendectomy for complicated appendicitis
Appendicitis refers to inflammation of the appendix. Appendectomy, the surgical removal of the appendix, is performed primarily in patients who have acute appendicitis. Patients undergoing an appendectomy for complicated appendicitis, which is defined as gangrenous (soft-tissue death) or perforated (burst) appendicitis, are more likely to suffer from postoperative complications. The routine placement of a surgical drain to prevent intra-peritoneal abscess (a localised collection of pus in the abdomen or pelvis) after an appendectomy for complicated appendicitis is controversial.

This systematic review included five randomised controlled trials involving a total of 453 participants. All the five trials compared drain use versus no drain use in cases of emergency open appendectomy (removal of the appendix by laparotomy) for complicated appendicitis. All trials had a high risk of bias (suggesting the possibility of over- or under-estimating the benefits or harms). There was no difference in the rate of intra-peritoneal abscess between drain use and no drain use. The hospital stay was longer (about two days - an 34.4% increase on an 'average' stay) in the drain group than in the no drain group.

The quality of the current trial evidence is very low. It is not clear whether routine drain use has any effect on preventing intra-peritoneal abscess after open appendectomy for complicated appendicitis. Routine drain use after an emergency open appendectomy may delay hospital discharge for patients with complicated appendicitis.
### Summary of Findings for the Main Comparison

**Abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis**

**Patient or population:** Patients undergoing emergency open appendectomy for complicated appendicitis

**Intervention:** Drain use versus no drain use

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Illustrative comparative risks* (95% CI)</th>
<th>Relative effect (95% CI)</th>
<th>No of participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assumed risk</td>
<td>Corresponding risk</td>
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<td></td>
<td>Control</td>
<td>Drain use versus no drain use</td>
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<tr>
<td><strong>Intra-peritoneal abscess</strong></td>
<td>Study population</td>
<td>RR 1.23 (0.47 to 3.21)</td>
<td>453 (5 studies)</td>
<td>⊕⊕⊕⊕ very low 1, 2, 3, 4</td>
<td>The NNTH was approximately 19</td>
</tr>
<tr>
<td>107 per 1000</td>
<td>131 per 1000 (50 to 342)</td>
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<tr>
<td>Moderate</td>
<td>133 per 1000</td>
<td>164 per 1000 (63 to 427)</td>
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<tr>
<td><strong>Wound infection</strong></td>
<td>Study population</td>
<td>RR 1.67 (0.75 to 3.74)</td>
<td>410 (4 studies)</td>
<td>⊕⊕⊕⊕ very low 1, 2, 3, 4</td>
<td>The NNTH was approximately 14</td>
</tr>
<tr>
<td>272 per 1000</td>
<td>454 per 1000 (204 to 1000)</td>
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<tr>
<td>Moderate</td>
<td>178 per 1000</td>
<td>297 per 1000 (133 to 666)</td>
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<tr>
<td><strong>Morbidity</strong></td>
<td>Study population</td>
<td>RR 6.67 (2.13 to 20.87)</td>
<td>90 (1 study)</td>
<td>⊕⊕⊕⊕ very low 1, 4</td>
<td>The NNTH was approximately 3</td>
</tr>
</tbody>
</table>
| Event                  | Study population | Peto OR 4.88 | 95% CI | Number of studies | GRADE | NNTH
|------------------------|------------------|--------------|--------|-------------------|-------|--------
| Mortality              |                  |              |        |                   |       |        
| 6 per 1000             | 27 per 1000      | 1.18 to 20.09| 4 studies | 363              | very low | 31   
| Moderate               |                  |              |        |                   |       |        
| 0 per 1000             | 0 per 1000       |              |        |                   |       |        
| Hospital stay          |                  |              |        |                   |       |        
| The mean hospital stay in the control groups was 4.97 days | The mean hospital stay in the intervention groups was 2.04 days higher (1.46 days to 2.62 days higher) | 2.04 days higher | (7 to 101) | 2.04 days higher | very low | 230

*The basis for the assumed risk (e.g., the median control group risk across studies) is provided in footnotes. The corresponding risk (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).

CI: confidence interval; RR: risk ratio; Peto OR: Peto odds ratio; NNTH: number needed to treat for an additional harmful outcome.

GRADE Working Group grades of evidence

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

1 High risk of bias in the trials included.

2 There was substantial heterogeneity as indicated by the I² statistic.
The confidence intervals of the risk ratio overlapped 0.75 and 1.25.

Publication bias could not be assessed because of the small number of trials.

Total population size was fewer than 400.
BACKGROUND

Appendicitis refers to inflammation of the appendix (Andersen 2013). Appendectomy, the surgical removal of the appendix, is performed primarily as an emergency procedure to treat acute appendicitis (Andersen 2005).

Description of the condition

Acute appendicitis is the most common cause of acute abdominal pain (Andersen 2005; Rehman 2011; Sauerland 2010; Wilms 2011). The overall incidence of acute appendicitis varies between 76 and 227 cases per 100,000 population per year in different countries (Addiss 1990; Andersson 1994; Andreu-Ballester 2009; Buckius 2012; Körner 1997; Lee 2010; Pieper 1982; Williams 1998). The overall lifetime risk for acute appendicitis is approximately 7% to 8% in the United States and 16% in South Korea (Addiss 1990; Lee 2010). It affects all age groups, with the highest incidence in the second decade (Addiss 1990; Wilms 2011). The cause of acute appendicitis is an issue of considerable debate (Andersen 2005; Rehman 2011; Sauerland 2010; Wilms 2011). Acute appendicitis may be associated with obstruction of the appendix lumen (the inside space of the appendix), which could result in increased intraluminal pressure with transmural tissue necrosis (Andersen 2005; Rehman 2011; Sauerland 2010; Wilms 2011). Tissue necrosis is followed by bacterial invasion, which leads to inflammation of the appendix (Andersen 2005; Rehman 2011; Sauerland 2010; Wilms 2011).

Acute appendicitis can be simply divided into two subgroups: simple appendicitis (e.g., early appendicitis, uncomplicated appendicitis) and complicated appendicitis (e.g., gangrenous appendicitis, perforated appendix without phlegmon or abscess, perforated appendicitis with phlegmon or abscess) (Andersen 2005; Simillis 2010). The proportion of complicated appendicitis varies between 15% and 35% in different case series (Andersson 1994; Boomer 2010; Cueto 2006; Körner 1997; Livingston 2007; Oliak 2000).

How the intervention might work

The primary reasons for placing an abdominal drain after an appendectomy are as follows: (i) drainage of established intra-peritoneal collection; (ii) prevention of further fluid accumulation; (iii) identification and drainage of faecal fistula (Allemann 2011; Gurusamy 2007a; Jani 2011). The use of abdominal drainage can avoid the accumulation of intra-peritoneal dirty collections, thereby reducing bacterial contamination of the surgical site (Greenall 1978; Jani 2011; Stone 1978; Tander 2003). Theoretically, abdominal drainage has the potential to reduce the rate of surgical site infection (Greenall 1978; Jani 2011; Stone 1978; Tander 2003).

However, abdominal drainage may fail to prevent intra-peritoneal abscess because a drain may become blocked and ineffective within a few hours after appendectomy (Greenall 1978; Haller 1973; Jani 2011; Magarey 1971). Additionally, the drain itself may act as a foreign body, which interfere with wound healing and increase the risk of surgical site infection (Jani 2011; Stone 1978; Magarey 1971). The use of a drain may also increase the length of the patient’s hospital stay (Jani 2011; Stone 1978; Tander 2003; Allemann 2011).

Patients with complicated appendicitis usually require appendectomy to relieve symptoms and avoid complications (Andersson 1994; Santacroce 2012). Appendectomy is one of the most common emergency surgical procedures worldwide (Andersen 2005; Rehman 2011; Santacroce 2012; Sauerland 2010; Wilms 2011). There are two types of appendectomy: open appendectomy (removal of the appendix by laparotomy) and laparoscopic appendectomy (removal of the appendix by key-hole surgery) (Cheng 2012a; Cheng 2012b; Cheng 2012c; Cheng 2013a; Santacroce 2012; Sauerland 2010). Approximately 300,000 appendectomies are performed each year in the United States alone (Hall 2010). The prognosis of complicated appendicitis is good (Santacroce 2012). The overall mortality rate of complicated appendicitis fol-
Why it is important to do this review

The use of abdominal drainage after open appendectomy for complicated appendicitis is controversial (Narci 2007; Petrowsky 2004; Piper 2011). It may potentially decrease the risk of surgical site infection following open appendectomy, but it is also possible that it may have no therapeutic benefit and may be associated with negative outcomes (Jani 2011; Petrowsky 2004). Up to now, there has been no Cochrane review assessing the role of abdominal drainage after open appendectomy for complicated appendicitis.

OBJECTIVES

To assess the safety and efficacy of abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis.

METHODS

Criteria for considering studies for this review

Types of studies
We included all randomised controlled trials (RCTs) (irrespective of sample size, language, or publication status) that compared drain use and no drain use in patients undergoing open appendectomy for complicated appendicitis. Quasi-randomised controlled trials (in which the allocation was performed on the basis of a pseudo-random sequence, e.g., odd/even hospital number or date of birth, alternation) were also included (Chapter 16 in Higgins 2011).

Types of participants
We included all patients (irrespective of age, sex, or race) who underwent emergency open appendectomy for complicated appendicitis (irrespective of gangrenous appendicitis, perforated appendix without phlegmon or abscess, or perforated appendicitis with phlegmon or abscess).

Types of interventions
Drain use (irrespective of types or materials) versus no drain use. All patients received similar antibiotic regimens after open appendectomy in a single trial.

Types of outcome measures

Main outcomes for 'Summary of findings' table
1. Intra-peritoneal abscess.
2. Wound infection.
5. Hospital stay.

Primary outcomes
Intra-peritoneal abscess (e.g., intra-abdominal abscess, pelvic abscess) (14 days).

Secondary outcomes
1. Wound infection (14 days).
2. Morbidity (overall complication rate) (30 days).
3. Mortality (30 days).
4. Hospital stay (30 days).
5. Hospital costs (30 days).

The morbidity is defined according to the Clavien-Dindo classification of surgical complications (Clavien 2009). Surgical site infection has been defined and classified as superficial incisional, deep incisional, and organ/space surgical site infection by the Centers for Disease Control and Prevention (CDC) (Horan 1992; Mangram 1999). We included intra-peritoneal abscess (organ/space surgical site infection) as one of the outcomes. We also included wound infection (superficial incisional and deep incisional surgical site infection), however defined by the authors, as another outcome.

Search methods for identification of studies
We designed the search strategy with the help of Marija Barbateskovic (Trial Search Co-ordinator). We conducted the searches irrespective of language, year, or publication status.

Electronic searches
We searched The Cochrane Library (Issue 1, 2014), MEDLINE (Ovid) (1950 to 15 February 2014), EMBASE (Ovid) (1974 to 15 February 2014), Science Citation Index Expanded (Web of Science) (1900 to 15 February 2014), and Chinese Biomedical Literature Database (CBM) (1978 to 15 February 2014) to identify randomised controlled trials (Royle 2003). Search strategies are presented in Appendix 1, Appendix 2, Appendix 3, and Appendix 4.
Searching other resources
We searched the following databases to identify ongoing trials: The World Health Organization International Trials Registry Platform search portal (http://apps.who.int/trialsearch/), ClinicalTrials.gov (http://www.clinicaltrials.gov/), Current Controlled Trials (http://www.controlled-trials.com/), Chinese Clinical Trial Register (http://www.chictr.org/), and EU Clinical Trials Register (http://www.clinicaltrialsregister.eu/).

We also searched the reference lists of identified studies and meeting abstracts via the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) (http://www.sages.org/) and Conference Proceedings Citation Index to explore further relevant clinical trials.

Data collection and analysis
We conducted this systematic review according to the Cochrane Handbook for Systematic Reviews of Interventions (Higgins 2011), and the Cochrane Colorectal Cancer Group Module (Andersen 2013).

Selection of studies
After completing the searches, we merged the search results using the software package EndNote X5 (reference management software) and removed duplicate records. Two independent review authors (Xiong X, Ye H) scanned the title and abstract of every record identified by the search for inclusion. We retrieved the full text for further assessment if the inclusion criteria were unclear from the abstract. We detected duplicate publications by identifying common authors, centres, details of the interventions, numbers of participants, and baseline data (Chapter 7 in Higgins 2011). We excluded papers that did not meet the inclusion criteria and listed the reasons for their exclusion. A third review author (Cheng Y) resolved any discrepancy between the two authors by discussion.

Data extraction and management
Two authors (Wu S, Lu J) independently extracted, checked, and entered the data into an electronic data collection form (Microsoft Word). We resolved any discrepancy between the two authors by discussion.

Assessment of risk of bias in included studies
Two review authors (Xiong X, Ye H) independently assessed the risk of bias in the included trials. We adopted the Cochrane Risk of Bias tool to assess bias (Table 1) (Chapter 8 in Higgins 2011). We assessed the risk of bias of the trials based on the following domains: random sequence generation; allocation concealment; blinding of participants and personnel; blinding of outcome assessment; incomplete outcome data; selective reporting; and imbalances in baseline characteristics. Following the evaluation of the above domains, we judged an included trial as a trial with a low risk of bias if we evaluated the risk of bias as ‘low risk’ in all of the above domains. If we judged the risk of bias as ‘unclear risk’ or ‘high risk’, we listed the trial under the group of trials as ‘high risk of bias’ trials. We resolved any difference in opinion by discussion. In cases of unsettled disagreements, a third review author (Wu S) adjudicated. We presented the results of the risk of bias assessment in two figures (a ‘Risk of bias’ graph figure and a ‘Risk of bias’ summary figure), which we generated using Review Manager 5 (RevMan 2014).

Measures of treatment effect
We performed the meta-analyses using the software package Review Manager 5.3 (RevMan 2014). For dichotomous outcomes, we calculated the risk ratio (RR) with 95% confidence interval (Deeks 2011). In the case of rare events (e.g., mortality), we calculated the Peto odds ratio (Peto OR) (Deeks 2011). For continuous outcomes, we calculated the mean difference (MD) with 95% confidence interval (Deeks 2011).

Unit of analysis issues
The unit of analysis was the individual patient. Cluster-randomised trials were not encountered.

Dealing with missing data
We contacted the original investigators to request further information in case of missing data. However, there was no reply. Thus, we used only the available data in the analyses.

Assessment of heterogeneity
We described the heterogeneity in the data using the Chi² test (Deeks 2011). We considered a P value less than 0.10 to be statistically significant heterogeneity (Deeks 2011). We also used the I² statistic to measure the quantity of heterogeneity. In case of heterogeneity, we performed the meta-analysis but interpreted the result cautiously and planned to investigate potential sources.

Assessment of reporting biases
We did not create funnel plots to assess reporting biases because the number of trials included was fewer than 10 (Sterne 2011).

Data synthesis
We performed the meta-analyses using the Review Manager 5 software provided by The Cochrane Collaboration (RevMan 2014).
For all analyses, we employed the random-effects model for conservative estimation, except for the Peto OR which only has a fixed method (Burch 2009).

Subgroup analysis and investigation of heterogeneity
We did not perform any planned subgroup analysis because too few trials were included in this review.

Sensitivity analysis
We performed a sensitivity analysis by excluding quasi-randomised controlled trials to determine whether the conclusions were robust to the decisions made during the review process.

RESULTS

Description of studies
See: Characteristics of included studies; Characteristics of excluded studies.

Results of the search
We identified a total of 720 records through the electronic searches of The Cochrane Library (n = 45), MEDLINE (Ovid) (n = 58), EMBASE (Ovid) (n = 177), Science Citation Index Expanded (Web of Science) (n = 163), and Chinese Biomedical Literature Database (CBM) (n = 277). We identified two records through scanning reference lists of the identified randomised controlled trials (Haller 1973; Johnson 1993). We excluded 137 duplicates and 570 clearly irrelevant records through reading titles and abstracts. We retrieved the remaining 15 records for further assessment. We excluded 10 studies for the reasons listed in the table Characteristics of excluded studies. In total, five randomised controlled trials fulfilled the inclusion criteria. The study flow diagram is shown in Figure 1.
Abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis (Review)

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Included studies

All the five trials were completed trials and all of these provided data for the analyses. Details of the trials are shown in the table "Characteristics of included studies". Three trials were randomised controlled trials (Dandapat 1992; Jani 2011; Tander 2003), and two trials were quasi-randomised controlled trials (Haller 1973; Stone 1978). All the five trials compared drain use with no drain use for patients undergoing open appendectomy. Overall, the five trials included 453 participants. The age of the individuals in the trials varied between 0 years and 82 years. The mean proportion of females varied between 19% and 44%. There was no difference in the characteristics of patients in the intervention group or control in any of the trials. Overall 32 (7.1%) participants had gangrenous appendicitis, 11 (2.4%) participants had appendiceal abscess, and 410 (90.5%) participants had perforated appendicitis in the trials. All of the participants received antibiotic regimens after open appendectomy.

Excluded studies

One randomised controlled trial was excluded because it focused on extraperitoneal wound drainage (Everson 1977). Another randomised controlled trial was excluded because it compared peritoneal lavage with abdominal drainage (Toki 1995). Two randomised controlled trials were excluded because the antibiotic regimens were used in a non-random manner (several participants received antibiotic regimens after appendectomy, whereas other participants did not) (Greenall 1978; Magarey 1971). None of the other excluded studies were randomised controlled trials (Allemann 2011; Al-Shahwany 2012; Ezer 2010; Johnson 1993; Narci 2007; Piper 2011).

Risk of bias in included studies

The risk of bias of the included studies is shown in Figure 2 and Figure 3. None of the trials were of low risk of bias.

Figure 2. 'Risk of bias' graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

<table>
<thead>
<tr>
<th>Risk of Bias Category</th>
<th>Low risk of bias</th>
<th>Unclear risk of bias</th>
<th>High risk of bias</th>
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<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
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<tr>
<td>Allocation concealment (selection bias)</td>
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<tr>
<td>Blinding of participants and personnel (performance bias)</td>
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<tr>
<td>Blinding of outcome assessment (detection bias)</td>
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<tr>
<td>Incomplete outcome data (attrition bias)</td>
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<tr>
<td>Selective reporting (reporting bias)</td>
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<tr>
<td>Other bias</td>
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0% 25% 50% 75% 100%
Figure 3. 'Risk of bias' summary: review authors' judgements about each risk of bias item for each included study.

<table>
<thead>
<tr>
<th></th>
<th>Random sequence generation (selection bias)</th>
<th>Allocation concealment (selection bias)</th>
<th>Blinding of participants and personnel (performance bias)</th>
<th>Blinding of outcome assessment (detection bias)</th>
<th>Incomplete outcome data (attrition bias)</th>
<th>Selective reporting (reporting bias)</th>
<th>Other bias</th>
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<td>+</td>
<td>+</td>
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<td>-</td>
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<td>?</td>
<td>?</td>
<td>+</td>
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</table>
Allocation
Random sequence generation was at a high risk of bias in two trials (Haller 1973; Stone 1978). Allocation concealment was at an unclear risk of bias in all five trials (Dandapat 1992; Haller 1973; Jani 2011; Stone 1978; Tander 2003).

Blinding
Blinding of participants and personnel was at an unclear risk of bias in all five trials (Dandapat 1992; Haller 1973; Jani 2011; Stone 1978; Tander 2003). Blinding of outcome assessment was also of unclear risk of bias in all five trials (Dandapat 1992; Haller 1973; Jani 2011; Stone 1978; Tander 2003).

Incomplete outcome data
There was a low risk of bias for incomplete outcome data in all five trials (Dandapat 1992; Haller 1973; Jani 2011; Stone 1978; Tander 2003).

Selective reporting
The trial protocols were not available for any of the trials. All five trials reported the primary outcomes of this review (Dandapat 1992; Haller 1973; Jani 2011; Stone 1978; Tander 2003). There may have been some selective outcome reporting in the secondary outcomes (secondary outcomes of this review were not reported), but the review authors considered these five trials to be free of selective reporting for the primary outcomes.

Other potential sources of bias
No baseline imbalances were observed, therefore this was at a low risk of bias in all five trials (Dandapat 1992; Haller 1973; Jani 2011; Stone 1978; Tander 2003).

Effects of interventions
See: Summary of findings for the main comparison
Abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis

Drain use versus no drain use
Five trials (453 patients) were identified that compared drain use with no drain use (Dandapat 1992; Haller 1973; Jani 2011; Stone 1978; Tander 2003). Two hundred and twenty-eight patients were randomised to the drainage group and 225 patients to the no drainage group. With so few participants, all of the analyses were underpowered.

Intra-peritoneal abscess
Five trials (453 patients) reported this outcome. There was no significant difference in the rate of intra-peritoneal abscess (including intra-abdominal abscess and pelvic abscess) between the groups (risk ratio (RR) 1.23; 95% confidence interval (CI) 0.47 to 3.21; P value = 0.67) (heterogeneity: I^2 = 63%; P value = 0.03) (Analysis 1.1).

Wound infection
Four trials (410 patients) reported this outcome at 30 days, rather than the review’s preferred 14 days. There was no significant difference in the wound infection rate between the groups (RR 1.67; 95% CI 0.75 to 3.74; P value = 0.21) (heterogeneity: I^2 = 82%; P value = 0.001) (Analysis 1.2).

Morbidity
Only one trial (90 patients) reported this outcome. The overall morbidity (overall complication rate defined according to the Clavien-Dindo classification) was higher in the drainage group than in the no drainage group (RR 6.67; 95% CI 2.13 to 20.87; P value = 0.001) (Analysis 1.3).

Mortality
Four trials (363 patients) reported this outcome. Mortality was higher in the drainage group than in the no drainage group (Peto odds ratio (OR) 4.88; 95% CI 1.18 to 20.09; P value = 0.03) (heterogeneity: I^2 = 0%; P value = 0.95) (Analysis 1.4). However, there was no significant difference in mortality between the groups when we performed a sensitivity analysis by excluding the two quasi-randomised controlled trials.

Hospital stay
Two trials (230 patients) reported this outcome. The hospital stay was longer in the drainage group than in the no drainage group [mean difference (MD) 2.04 days (34.4% increase of an ‘average’ hospital stay); 95% CI 1.46 to 2.62; P value < 0.00001] (heterogeneity: I^2 = 0%; P value = 0.68) (Analysis 1.5).

Hospital costs
None of the trials reported this outcome.

Pain/quality of life
None of the trials reported these outcomes.
**Reporting biases**

We did not create funnel plots to assess reporting biases because the number of trials included was fewer than 10.

**Sensitivity analysis**

We observed no change in the intra-peritoneal abscess outcome by excluding two quasi-randomised controlled trials (Haller 1973; Stone 1978) (Analysis 2.1).

**DISCUSSION**

**Summary of main results**

This review includes five randomised controlled trials involving 453 patients undergoing open appendectomy for complicated appendicitis. All of the trials were at a high risk of bias. We found that there was no significant difference in the incidence of intra-peritoneal abscess between the drainage group and the no drainage group. Abdominal drainage may be associated with an increased length of hospital stay. The primary reason for the placement of a drain after appendectomy is to prevent intra-peritoneal abscess (e.g., intra-abdominal abscess, pelvic abscess). There was no significant difference in the incidence of intra-peritoneal abscess between the drainage group and the no drainage group (15.7% in the drainage group versus 10.7% in the no drainage group). The routine use of abdominal drainage after complicated appendectomy did not significantly reduce the incidence of intra-peritoneal abscess. The possible reasons for the failure to decrease the incidence of intra-peritoneal abscess are as follows. First, surgical drains may become blocked by blood or fibrin clots (Schein 2008; Yates 1905). Additionally, surgical drains cannot drain the entire abdominal cavity. Abdominal collections or abscesses can occur despite abdominal drainage (Schein 2008; Yates 1905). Moreover, this review included five trials with only 228 participants undergoing abdominal drainage. This review may not have the statistical power to detect the any clinically meaningful difference between abdominal drainage and no drainage for the prevention of intra-peritoneal abscess even if such a difference was present. In addition, where differences were detected, confidence in these results is low, as the small numbers means they could be spurious results, and the impact of a bias can be exacerbated in underpowered analyses. Thus, it is not clear whether routine abdominal drainage has any effect on the prevention of intra-peritoneal abscess in patients undergoing open appendectomy for complicated appendicitis. There was no statistically significant difference between the two groups in the incidence of wound infection (34.3% in the drainage group versus 27.2% in the no drainage group). Both the drainage group and no drainage group received similar antibiotic regimens in dosage and class in the trials. However, the type and length of antibiotic therapy varied across the different trials. Thus, we did not perform subgroup analyses stratified by the type and length of antibiotic therapy. None of the trials mentioned the method used to handle the wound after open appendectomy. Thus, we did not perform a subgroup analysis stratified by the method used to handle the wound. The length of hospital stay was found to be significantly shorter in the no drainage group than in the drainage group. The mean difference was approximately two days (34.4% decrease of an ‘average’ hospital stay). The duration of abdominal drainage varied after appendectomy. The drainage tube was either removed once it had drained less than a critical amount or after a fixed duration of time (Allemann 2011; Haller 1973; Jani 2011). The drainage procedure itself may thus prolong the patient’s hospital stay. Another possible reason for the increased length of hospital stay in the drainage group was the higher incidence of wound infection in this group, which may have resulted in a need for longer hospitalisations (Horan 1992; Mangram 1999). The overall mortality in this review was less than 5% (approximately 2.4%). The most common cause of death was sepsis. Mortality was higher in the drainage group (3.8%) than in the no drainage group (0.6%). We did not draw any conclusion about mortality because the result changed when we performed a sensitivity analysis (removing the quasi-RCTs); this would reduce the number of participants in the analysis, and therefore it is unclear whether the change in results was the removal of selection bias or a reduction in the power of the analysis. We also did not draw any conclusion about morbidity because only one study reported this outcome. Hospital costs, pain, and quality of life are important outcomes from the patient and health care provider perspectives. However, none of the trials reported these outcomes. It is not clear whether the use of abdominal drainage has any adverse effects on these outcomes; hence, no conclusions could be drawn.

**Overall completeness and applicability of evidence**

All of the trials included patients undergoing emergency open appendectomy for complicated appendicitis (e.g., gangrenous appendicitis and perforated appendicitis). The majority (93.0%) of the patients had perforated appendicitis with local or general peritonitis. Thus, the results of this review are applicable to patients undergoing emergency open appendectomy for perforated appendicitis.

**Quality of the evidence**

None of the trials were at a low risk of bias. The trials included under each comparison were too few to assess inconsistency and
publication bias. Direct comparisons of different types of drain were not available, only comparisons for each type of drain with no drain. In theory, these trials could allow indirect comparisons of the effect of different types of drain, however, small sample sizes and methodological flaws of the trials preclude such indirect comparison. The confidence intervals for the majority of outcomes were wide, indicating that the estimates of effect obtained are imprecise. Overall, we considered the quality of the evidence to be very low (Summary of findings for the main comparison).

Potential biases in the review process

There were several potential biases of note in the review process. First, there were only five trials with 453 patients included in the review; thus, there was a lack of data on this topic to date. This review is subject to both alpha error (false positivity) and beta error (false negativity). Second, we did not create funnel plots to assess potential publication bias due to the small number of included trials. Third, we did not perform any planned subgroup analyses to assess heterogeneity because of the small number of trials included under each outcome. Additionally, patient selection processes and blinding were unclear for most of the studies. We contacted the original investigators to request further information. However, there was no reply. Moreover, an important source of bias in the included studies was the use of antibiotic regimens (Andersen 2005). For example, the type and length of antibiotic therapy were important confounding factors for various outcomes (e.g., intra-peritoneal abscess, wound infection) (Andersen 2005). However, the type and length of antibiotic therapy varied a great deal in different trials. It was difficult to perform subgroup analyses to assess the heterogeneity. A final point is that the imputation of the standard deviation for hospital stay from the range might also introduce bias into this review.

Agreements and disagreements with other studies or reviews

There is increasing evidence in Cochrane reviews that routine abdominal drainage after various abdominal operations is not essential (de Jesus 2004; Gurusamy 2007a; Gurusamy 2007b; Gurusamy 2007c; Wang 2011). The routine use of surgical drains has been questioned in other areas, including thyroid, gynaecological, and orthopaedic surgeries (Charoenkwan 2010; Gates 2005; Parker 2007; Samraj 2007). The systematic review by Petrowsky et al (Petrowsky 2004) included five trials comparing drain use with no drain use in patients undergoing appendectomy for complicated appendicitis (Dandapat 1992; Greenall 1978; Haller 1973; Magarey 1971; Stone 1978). Two of these five trials, in which antibiotic regimens were used in a non-random manner (some participants received antibiotic regimens after appendectomy, whereas other participants did not), were not included in this review (Greenall 1978; Magarey 1971). Petrowsky et al concluded that abdominal drainage did not reduce postoperative complications and appeared harmful with respect to the development of faecal fistula (Petrowsky 2004). Thus, these authors recommended that abdominal drainage should be avoided at any stage of appendicitis (Petrowsky 2004). This review does not make any specific recommendation because the number of participants included in this review does not have the statistical power to detect the benefit of abdominal drainage for the prevention of intra-peritoneal abscess. A sample size of 870 (435 in each group) would be required to detect an absolute reduction in the intra-peritoneal abscess rate of 5% (from 10% to 5%) at 80% power and an alpha-error set at 0.05 (Machin 2011).

Authors’ conclusions

Implications for practice

The quality of the current evidence is very low. It is not clear whether routine abdominal drainage has any effect on the prevention of intra-peritoneal abscess after open appendectomy for complicated appendicitis. Abdominal drainage after an emergency open appendectomy may be associated with delayed hospital discharge for patients with complicated appendicitis.

Implications for research

1. Further trials at a low risk of bias and with a sufficient sample size (power calculation based on the intra-peritoneal abscess rate) are necessary to assess the benefits and harms of abdominal drainage after appendectomy for various complicated appendicitis (e.g., gangrenous appendicitis, perforated appendix without phlegmon or abscess, perforated appendicitis with phlegmon or abscess).

2. Future randomised trials should use adequate methods of randomisation and allocation concealment. Future trials need to employ blinding of outcome assessors. Future trials must report all of the patient-important outcomes, such as hospital costs, pain, and quality of life.


Acknowledgements

We would like to thank the Cochrane Colorectal Cancer Group (CCC) including Dr. Henning Kinke Andersen and Dr.
**Analysis 1.1. Comparison 1 Drain use versus no drain use, Outcome 1 Intra-peritoneal abscess.**

Review: Abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis

Comparison: 1 Drain use versus no drain use

Outcome: 1 Intra-peritoneal abscess

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Drain</th>
<th>No drain</th>
<th>Risk Ratio M-H</th>
<th>Weight</th>
<th>Risk Ratio M-H</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>95% CI</td>
<td></td>
<td>95% CI</td>
</tr>
<tr>
<td>Haller 1973</td>
<td>3/24</td>
<td>3/19</td>
<td>18.9 %</td>
<td>0.79 [0.18, 3.49]</td>
<td></td>
</tr>
<tr>
<td>Stone 1978</td>
<td>22/49</td>
<td>6/45</td>
<td>27.7 %</td>
<td>3.37 [1.50, 7.55]</td>
<td></td>
</tr>
<tr>
<td>Dandapat 1992</td>
<td>5/40</td>
<td>10/46</td>
<td>25.3 %</td>
<td>0.58 [0.21, 1.54]</td>
<td></td>
</tr>
<tr>
<td>Tander 2003</td>
<td>3/70</td>
<td>5/70</td>
<td>20.0 %</td>
<td>0.60 [0.15, 2.41]</td>
<td></td>
</tr>
<tr>
<td>Jani 2011</td>
<td>3/45</td>
<td>0/45</td>
<td>8.1 %</td>
<td>7.00 [0.37, 131.73]</td>
<td></td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>228</strong></td>
<td><strong>225</strong></td>
<td><strong>100.0 %</strong></td>
<td><strong>1.23 [0.47, 3.21]</strong></td>
<td></td>
</tr>
</tbody>
</table>

Total events: 36 (Drain), 24 (No drain)

Heterogeneity: $I^2 = 63\%$

Test for overall effect: $Z = 0.43 (P = 0.67)$

Test for subgroup differences: Not applicable

---

**Abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis (Review)**

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**Analysis 1.2. Comparison 1 Drain use versus no drain use, Outcome 2 Wound infection.**

Review: Abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis

Comparison: 1 Drain use versus no drain use

Outcome: 2 Wound infection

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Drain</th>
<th>No drain</th>
<th>Risk Ratio M-H</th>
<th>Weight</th>
<th>Risk Ratio M-H</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stone 1978</td>
<td>21/49</td>
<td>13/45</td>
<td>0.53 [0.85, 2.60]</td>
<td>30.5</td>
<td>1.48 [0.85, 2.60]</td>
</tr>
<tr>
<td>Dandapat 1992</td>
<td>30/40</td>
<td>38/46</td>
<td>0.90 [0.73, 1.13]</td>
<td>34.9</td>
<td>0.91 [0.73, 1.13]</td>
</tr>
<tr>
<td>Tander 2003</td>
<td>4/70</td>
<td>2/70</td>
<td>0.54 [0.32, 0.94]</td>
<td>14.1</td>
<td>0.91 [0.73, 1.13]</td>
</tr>
<tr>
<td>Jani 2011</td>
<td>15/45</td>
<td>3/45</td>
<td>2.00 [1.55, 10.57]</td>
<td>20.4</td>
<td>2.00 [1.55, 10.57]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>204</strong></td>
<td><strong>206</strong></td>
<td></td>
<td><strong>100.0 %</strong></td>
<td><strong>1.67 [0.75, 3.74]</strong></td>
</tr>
</tbody>
</table>

Total events: 70 (Drain), 56 (No drain)

Heterogeneity: Tau² = 0.47; Chi² = 16.28, df = 3 (P = 0.001); I² = 82%

Test for overall effect: Z = 1.25 (P = 0.21)

Test for subgroup differences: Not applicable

---

**Analysis 1.3. Comparison 1 Drain use versus no drain use, Outcome 3 Morbidity.**

Review: Abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis

Comparison: 1 Drain use versus no drain use

Outcome: 3 Morbidity

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Drain</th>
<th>No drain</th>
<th>Risk Ratio M-H</th>
<th>Weight</th>
<th>Risk Ratio M-H</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>45</strong></td>
<td><strong>45</strong></td>
<td></td>
<td><strong>100.0 %</strong></td>
<td><strong>6.67 [2.13, 20.87]</strong></td>
</tr>
</tbody>
</table>

Total events: 20 (Drain), 3 (No drain)

Heterogeneity: not applicable

Test for overall effect: Z = 3.26 (P = 0.001)

Test for subgroup differences: Not applicable
### Analysis 1.4. Comparison 1 Drain use versus no drain use, Outcome 4 Mortality.

Review: Abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis

Comparison: 1 Drain use versus no drain use

Outcome: 4 Mortality

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Drain n/N</th>
<th>No drain n/N</th>
<th>Peto Odds Ratio</th>
<th>Weight %</th>
<th>Peto Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haller 1973</td>
<td>2/24</td>
<td>0/19</td>
<td></td>
<td>25.1 %</td>
<td>6.27 [0.37, 105.63]</td>
</tr>
<tr>
<td>Stone 1978</td>
<td>1/49</td>
<td>0/45</td>
<td></td>
<td>13.0 %</td>
<td>6.81 [0.13, 344.42]</td>
</tr>
<tr>
<td>Dandapat 1992</td>
<td>4/40</td>
<td>1/46</td>
<td></td>
<td>61.9 %</td>
<td>4.11 [0.68, 24.85]</td>
</tr>
<tr>
<td>Tander 2003</td>
<td>0/70</td>
<td>0/70</td>
<td></td>
<td>Not estimable</td>
<td>Not estimable</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>183</strong></td>
<td><strong>180</strong></td>
<td></td>
<td><strong>100.0 %</strong></td>
<td><strong>4.88 [1.18, 20.09]</strong></td>
</tr>
</tbody>
</table>

Total events: 7 (Drain), 1 (No drain)

Heterogeneity: Chi² = 0.09, df = 2 (P = 0.95); I² = 0.0%

Test for overall effect: Z = 2.19 (P = 0.028)

Test for subgroup differences: Not applicable
Analysis 1.5. Comparison 1 Drain use versus no drain use, Outcome 5 Hospital stay.

Review: Abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis

Comparison: 1 Drain use versus no drain use

Outcome: 5 Hospital stay

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Drain</th>
<th>No drain</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean(SD)</td>
<td>N</td>
<td>Mean(SD)</td>
<td>IV, Random,95% CI</td>
</tr>
<tr>
<td>Tander 2003</td>
<td>70</td>
<td>7.4 (5)</td>
<td>70</td>
<td>5.6 (1.9)</td>
<td>21.4 %</td>
</tr>
<tr>
<td>Jani 2011</td>
<td>45</td>
<td>6.1 (2)</td>
<td>45</td>
<td>4 (1)</td>
<td>78.6 %</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>115</strong></td>
<td><strong>6.9 (2)</strong></td>
<td><strong>115</strong></td>
<td><strong>5.2 (1.8)</strong></td>
<td><strong>100.0 %</strong></td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 0.0; Chi² = 0.17, df = 1 (p = 0.68); I² =0.0%
Test for overall effect: Z = 6.89 (P < 0.00001)
Test for subgroup differences: Not applicable

Analysis 2.1. Comparison 2 Drain use versus no drain use (sensitivity analyses by excluding quasi-randomised trials), Outcome 1 Intra-peritoneal abscess.

Review: Abdominal drainage to prevent intra-peritoneal abscess after open appendectomy for complicated appendicitis

Comparison: 2 Drain use versus no drain use (sensitivity analyses by excluding quasi-randomised trials)

Outcome: 1 Intra-peritoneal abscess

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Drain</th>
<th>No drain</th>
<th>Risk Ratio</th>
<th>Weight</th>
<th>Risk Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>M-H, Random,95% CI</td>
<td></td>
<td>M-H, Random,95% CI</td>
</tr>
<tr>
<td>Dandapat 1992</td>
<td>5/40</td>
<td>10/46</td>
<td>0.58 [ 0.21, 1.54 ]</td>
<td>54.4 %</td>
<td>0.58 [ 0.21, 1.54 ]</td>
</tr>
<tr>
<td>Tander 2003</td>
<td>3/70</td>
<td>5/70</td>
<td>0.60 [ 0.15, 2.41 ]</td>
<td>35.3 %</td>
<td>0.60 [ 0.15, 2.41 ]</td>
</tr>
<tr>
<td>Jani 2011</td>
<td>3/45</td>
<td>0/45</td>
<td>7.00 [ 0.37, 131.73 ]</td>
<td>10.3 %</td>
<td>7.00 [ 0.37, 131.73 ]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>155</strong></td>
<td><strong>161</strong></td>
<td><strong>100.0 %</strong></td>
<td><strong>0.76 [ 0.28, 2.02 ]</strong></td>
<td></td>
</tr>
</tbody>
</table>

Total events: 11 (Drain), 15 (No drain)
Heterogeneity: Tau² = 0.21; Chi² = 2.69, df = 2 (P = 0.26); I² =26%
Test for overall effect: Z = 0.56 (P = 0.58)
Test for subgroup differences: Not applicable

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