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Retroperitoneal versus transperitoneal approach for elective open abdominal aortic aneurysm repair (Review)

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Retroperitoneal versus transperitoneal approach for elective open abdominal aortic aneurysm repair.
Cochrane Database of Systematic Reviews 2021, Issue 6. Art. No.: CD010373.
DOI: 10.1002/14651858.CD010373.pub3.

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[Intervention Review]

Retroperitoneal versus transperitoneal approach for elective open abdominal aortic aneurysm repair

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Editorial group: Cochrane Vascular Group.
Publication status and date: New search for studies and content updated (no change to conclusions), published in Issue 6, 2021.

Citation: Mei F, Hu K, Zhao B, Gao Q, Chen F, Zhao L, Wu M, Feng L, Wang Z, Yang J, Zhang W, Ma B. Retroperitoneal versus transperitoneal approach for elective open abdominal aortic aneurysm repair. *Cochrane Database of Systematic Reviews* 2021, Issue 6. Art. No.: CD010373. DOI: 10.1002/14651858.CD010373.pub3.

ABSTRACT

Background

There has been extensive debate in the surgical literature regarding the optimum surgical access approach to the infrarenal abdominal aorta during an operation to repair an abdominal aortic aneurysm. The published trials comparing retroperitoneal (RP) and transperitoneal (TP) aortic surgery show conflicting results. This is an update of the review first published in 2016.

Objectives

To assess the effectiveness and safety of the retroperitoneal versus transperitoneal approach for elective open abdominal aortic aneurysm repair on mortality, complications, hospital stay and blood loss.

Search methods

The Cochrane Vascular Information Specialist searched the Cochrane Vascular Specialised Register, CENTRAL, MEDLINE, Embase and CINAHL databases and the World Health Organization International Clinical Trials Registry Platform and the ClinicalTrials.gov trials registers to 30 November 2020. The review authors searched the Chinese Biomedical Literature Database and handsearched reference lists of relevant articles to identify additional trials.

Selection criteria

We included randomized controlled trials (RCTs) that assessed the RP approach versus the TP approach for elective open abdominal aortic aneurysm (AAA) repair. There were no restrictions on language or publication status.

Data collection and analysis

Two review authors independently extracted data from the included trials. We resolved any disagreements through discussion with a third review author. Two review authors independently assessed the risk of bias in included trials with the Cochrane risk of bias tool. For dichotomous outcomes, we calculated the odds ratio (OR) with the corresponding 95% confidence interval (CI). For continuous data, we calculated a pooled estimate of treatment effect by calculating the mean difference (MD) and standard deviation (SD) with corresponding 95% CIs. We pooled data using a fixed-effect model, unless we identified heterogeneity, in which case we used a random-effects model. We used GRADE to assess the overall certainty of the evidence. We evaluated the outcomes of mortality, complications, intensive care unit (ICU) stay, hospital stay, blood loss, aortic cross-clamp time and operating time.

Main results

We identified no new studies from the updated searches. After reassessment, we included one study which had previously been excluded. Five RCTs with a combined total of 152 participants are included. The overall certainty of the evidence ranged from low to very low because of the low methodological quality of the included trials (unclear random sequence generation method and allocation concealment, and no blinding of outcome assessors), small sample sizes, small number of events, high heterogeneity and inconsistency between the included trials, no power calculations and relatively short follow-up.

There was no evidence of a difference between the RP approach and the TP approach regarding mortality (odds ratio (OR) 0.32, 95% CI 0.01 to 8.25; 3 studies, 110 participants; very low-certainty evidence). Similarly, there was no evidence of a difference in complications such as hematoma (OR 0.90, 95% CI 0.13 to 6.48; 2 studies, 75 participants; very low-certainty evidence), abdominal wall hernia (OR 10.76, 95% CI 0.55 to 211.78; 1 study, 48 participants; very low-certainty evidence), or chronic wound pain (OR 2.20, 95% CI 0.36 to 13.34; 1 study, 48 participants; very low-certainty evidence) between the RP and TP approaches in participants undergoing elective open AAA repair. The RP approach may reduce ICU stay (mean difference (MD) -19.02 hours, 95% CI -30.83 to -7.21; 3 studies, 106 participants; low-certainty evidence); hospital stay (MD -3.30 days, 95% CI -4.85 to-1.75; 5 studies, 152 participants; low-certainty evidence); and blood loss (MD -504.87 mL, 95% CI -779.19 to -230.56; 4 studies, 129 participants; very low-certainty evidence). There was no evidence of a difference between the RP approach and the TP approach regarding aortic cross-clamp time (MD 0.69 min, 95% CI -7.23 to 8.60; 4 studies, 129 participants; very low-certainty evidence) or operating time (MD -15.94 min, 95% CI -34.76 to 2.88; 4 studies, 129 participants; very low-certainty evidence).

Authors' conclusions

Very low-certainty evidence from five small RCTs showed no clear evidence of a difference between the RP approach and the TP approach for elective open AAA repair in terms of mortality, or for rates of complications including hematoma (very low-certainty evidence), abdominal wall hernia (very low-certainty evidence), or chronic wound pain (very low-certainty evidence). However, a shorter intensive care unit (ICU) stay and shorter hospital stay was probably indicated following the RP approach compared to the TP approach (both low-certainty evidence). A possible reduction in blood loss was also shown after the RP approach (very low-certainty evidence). There is no clear difference between the RP approach and TP approach in aortic cross-clamp time or operating time. Further well-designed, large-scale RCTs assessing the RP approach versus TP approach for elective open AAA repair are required.

PLAIN LANGUAGE SUMMARY

Different surgical approaches to access the infrarenal abdominal aorta during an operation to repair an abdominal aortic aneurysm

Background

There has been a lot of debate in the surgical literature about the best way to surgically access the infrarenal abdominal aorta during an operation to repair an abdominal aortic aneurysm (AAA: a ballooning of an artery (blood vessel) which occurs in the major artery in the abdomen (aorta)). Two approaches are commonly used: the retroperitoneal (RP) approach and the transperitoneal (TP) approach. Both approaches appear to have advantages and disadvantages. Many trials comparing RP and TP aortic surgery have been published, with conflicting results. The aim of this Cochrane Review is to assess the effectiveness and safety of the RP versus TP approach for planned surgical open AAA repair, taking into account mortality, complications, hospital stay and blood loss. This is an update of the review originally published in 2016.

Key results

We found no new studies from the updated searches. After reassessment, we included one study which had previously been excluded. Therefore, the review includes five small randomized controlled trials (RCTs), including 152 participants. The evidence in this Cochrane Review is current to 30 November 2020. There were no clear differences between RP and TP for the outcome of death. Similarly, there was no clear evidence that RP might increase complications such as hematoma (swelling of clotted blood), chronic wound pain and abdominal wall hernia compared with TP, but there were variations between the included trials. We found that RP might result in shorter hospital stay and intensive care unit (ICU) stay and less blood loss compared with TP. There were no clear differences between the two approaches for operating time and aortic cross-clamp time (length of time that a surgical instrument, used to clamp the aorta and separate the circulation from the outflow of the heart, is used).

Reliability of the evidence

Four of the five included trials had methodological weaknesses - such as unclear randomization methods, and no reporting of blinding of the people assessing the outcome - which compromised the value of their results. In addition, the included trials only included a small number of people, few outcomes were reported, participants were followed up for a relatively short time, and there were inconsistencies between the included trials, resulting in evidence of very low to low certainty. More large-scale RCTs of the RP approach versus the TP approach for planned surgical open AAA repair are needed.

SUMMARY OF FINDINGS

Summary of findings 1. Retroperitoneal approach compared with transperitoneal approach for elective open AAA repair

Retroperitoneal (RP) approach compared with transperitoneal (TP) approach for AAA repair

Participant or population: people with AAA

Settings: hospital

Intervention: RP approach

Comparison: TP approach

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No. of participants (RCTs)	Certainty of the evidence (GRADE)	Comments
	Risk with TP approach	Risk with RP approach				
Mortality Follow-up: up to 30 days	Study population		OR 0.32 (0.01 to 8.25)	110 (3 RCTs)	⊕⊖⊖⊖ **very low** a,b	No deaths reported in two of the three RCTs in this comparison. There were no clear differences in mortality detected between the groups.
	17 per 1000	5 per 1000 (0 to 123)				
Complications: hematoma Follow-up: 30 days post operation	Study population		OR 0.90 (0.13 to 6.48)	75 (2 RCTs)	⊕⊖⊖⊖ **very low** a,b	There was no clear difference in hematoma detection between the groups.
	28 per 1000	25 per 1000 (4 to 156)				
	Medium risk population					
	42 per 1000	38 per 1000 (6 to 220)				
Complications: abdominal wall hernia Follow-up: 30 days post operation	Study population		OR 10.76 (0.55 to 211.78)	48 (1 RCT)	⊕⊖⊖⊖ **very low** a,b	No abdominal wall hernia complications reported in the TP approach group. There were no clear differences in abdominal wall hernia detected between the groups.
	See comment	See comment				
Complications: chronic wound pain	Study population		OR 2.20 (0.36 to 13.34)	48 (1 RCT)	⊕⊖⊖⊖ **very low** a,b	There were no clear differences in chronic wound pain detected between the groups.
	83 per 1000	167 per 1000 (32 to 548)				

Follow-up: 30 days post operation						
ICU stay (hrs) recorded at end of ICU stay	The mean ICU stay ranged from 50 to 98.4 hrs	The mean ICU stay was 19.02 hrs **lower** (30.83 lower to 7.21 lower)	-	106 (3 RCTs)	⊕⊕⊖⊖ **low** [a,c]	There may be a shorter ICU stay for participants in the RP approach group.
Hospital stay (days) recorded at end of hospital stay	The mean hospital stay ranged from 9 to 23.9 days	The mean hospital stay was 3.3 days **lower** (4.85 lower to 1.75 lower)	-	152 (5 RCTs)	⊕⊕⊖⊖ **low** [a,d]	There may be a shorter hospital stay for participants in the RP approach group.
Blood loss (mL) recorded after operation	The mean blood loss ranged from 1127 mL to 2800 mL	The mean blood loss was 504.87 mL **lower** (779.19 lower to 230.56 lower)	-	129 (4 RCTs)	⊕⊖⊖⊖ **very low** [a,c,d]	There may be reduced blood loss in the RP approach group compared to the TP approach group.

*__The risk in the intervention group__ (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).
Abbreviations: AAA: abdominal aortic aneurysm; **CI**: confidence interval; **ICU**: intensive care unit; **OR**: odds ratio; **RCT**: randomized controlled trial; **RP**: retroperitoneal; **TP**: transperitoneal

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect

[a]We downgraded the evidence by one level as random sequence generation was unclear in three of the four included trials (Darling 1992; Komori 1997; Laohapensang 2005a), and therefore these trials are at unclear risk of selection bias. In addition, blinding of outcome assessors was unclear in the included trials and therefore these trials are at risk of detection bias.
[b]We downgraded the evidence by two levels as the sample size of the included trials was small, there was a relatively short follow-up period for primary outcomes and a small number of events leading to imprecision.
[c]We downgraded the evidence by one level as the included trials had a small sample size leading to wide CIs.
[d]We downgraded the evidence by one level as heterogeneity and inconsistency between included trials was high.

Summary of findings 2. Retroperitoneal approach compared with transperitoneal approach for elective open AAA repair (additional secondary outcomes)

Retroperitoneal (RP) approach compared with transperitoneal (TP) approach for AAA repair

Participant or population: people with AAA

Settings: hospital

Intervention: RP approach

Comparison: TP approach

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No. of participants (RCTs)	Certainty of the evidence (GRADE)	Comments
	Risk with TP approach	Risk with RP approach				
Aortic cross-clamp time (minutes) recorded after operation	The mean aortic cross-clamp time ranged from 56 to 68 minutes	The mean aortic cross-clamp time was 0.69 minutes **higher** (7.23 lower to 8.60 higher)	-	129 (4 RCTs)	⊕⊖⊖⊖ **very low** [a,b,c]	There was no clear difference in aortic cross-clamp time between the groups.
Operating time (minutes) recorded after operation	The mean operating time ranged from 160 to 258.1 minutes	The mean operating time was 15.94 minutes **lower** (34.76 lower to 2.88 higher)	-	129 (4 RCTs)	⊕⊖⊖⊖ **very low** [a,b,c]	There was no clear difference in operating time between the groups.

*__The risk in the intervention group__ (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).
Abbreviations: AAA: abdominal aortic aneurysm; **CI**: confidence interval; **RCT**: randomized controlled trial; **RP**: retroperitoneal; **TP**: transperitoneal.

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect

[a]We downgraded the evidence by one level as random sequence generation was unclear in three of the four included trials (Darling 1992; Komori 1997; Laohapensang 2005a), and therefore these trials are at unclear risk of selection bias. In addition, blinding of outcome assessors was unclear in the included trials and therefore these trials are at risk of detection bias.
[b]We downgraded the evidence by one level as the included trials had a small sample size leading to wide CIs.
[c]We downgraded the evidence by one level as heterogeneity and inconsistency between included trials was high.

BACKGROUND

Description of the condition

Abdominal aortic aneurysm (AAA) is an abnormal enlargement in the diameter of a person's aorta. They are often asymptomatic until they rupture. National Institute for Health and Care Excellence (NICE) guidelines define AAA as an enlargement either 1.5 times the size of the normal aorta or a diameter greater than 3 cm (NICE 2020). The development of an AAA is multifactorial. Some of the established risk factors for the onset of AAA include age, male sex, white race, family history, atherosclerotic disease, and cigarette smoking, with the latter being considered the primary modifiable risk factor (Ullery 2018). Due to the reduction in tobacco smoking prevalence over time, population-based studies have shown that the prevalence and incidence rates of AAA also declined (Sampson 2014). Reported AAA prevalence rates in 65-year-old men who attended the UK national AAA screening programme was 1.3% (Benson 2016). Untreated AAAs are likely to increase in size and rupture, eventually causing massive internal bleeding. Rupture of the abdominal aorta is the most serious complication, which presents as a surgical emergency. About one third of people with a ruptured abdominal aorta do not even reach hospital alive, giving an 80% overall mortality rate (Reimerink 2013). Data from the Global Burden of Disease showed that an average annual death rate of 2.8 per 100,000 (more than 20 million) is attributed to aortic aneurysm rupture (Golledge 2017; Sampson 2014). Regarding treatment for aortic aneurysm, elective open and endovascular surgical repairs are initially indicated in people with AAA to prevent death from rupture.

Description of the intervention

Dubost 1952 performed the first successful excision of an AAA via the retroperitoneal (RP) route in 1951. However, the RP approach, as reported by Oudot 1951, received little exposure. In the following years, most surgeons preferred to use the transperitoneal (TP) approach or transabdominal aortic replacement for open infrarenal AAA repair (Creech 1966). The RP approach was not forgotten. Rob 1963 wrote a detailed description of the RP approach, including its advantages, such as easier postoperative course, and its disadvantages, such as limited exposure. Williams 1980 reported an extended RP approach, which offers a better exposure, not only of the infrarenal aorta, but also of the pararenal and suprarenal aorta. Endovascular repair is now the standard method used to treat AAA, as described by a number of reviews and meta-analyses comparing endovascular versus open surgery (Antoniou 2020; Bulder 2019), although these reviews do not address the different approaches for open surgery. The 30-day mortality for elective endovascular aneurysm repair is lower than for open repair, but long-term mortality has been shown to be similar (Jetty 2010). Because endovascular repair is associated with higher costs, open surgical repair is still an important method for treating people with AAAs.

How the intervention might work

The TP approach is most familiar to surgeons. It allows for easy access to the infrarenal aorta and iliac vessels, and at the same time, permits the surgical evaluation of the whole intra-abdominal cavity to deal with concomitant surgical disease, such as colon carcinoma (Buck 2016). The inferior mesenteric artery could also be repaired, which can be incorporated in an infrarenal aortic graft. An equal TP aortic approach to the abdominal aorta can be attained through midline and transverse abdominal incisions. Lacy 1994 reported no statistically significant differences in morbidity through transverse and midline abdominal incisions, and therefore suggested that the type of incision used can be left to the surgeon's preference. However, the TP approach usually involves intestinal manipulation, mesenteric traction and blood contamination of the peritoneal cavity - all of which may lead to impaired intestinal motility (Arya 2009). In order to avoid these complications, many doctors prefer to use the RP approach. Compared with the TP approach, the RP approach does not require opening the whole intra-abdominal cavity. However, it is time-consuming and would not be better for emergency cases (Nevelsteen 2005). Although one study reported that respiratory function after aortic aneurysm repair was similar between the two groups (Volta 2003), other studies have reported that people who had AAA repair using the RP approach had fewer postoperative respiratory complications, reduced incidence of intestinal obstruction, reduced intubation time, and decreased hospital stay and costs (Helsby 1975; Leather 1989; Taheri 1983). Moreover, several similar prospective randomized studies of the two approaches for aortic surgery have been performed, with conflicting results (Cambria 1990; Sieunarine 1997; Taheri 1983).

Why it is important to do this review

This Cochrane Review analyses the available evidence to assess the advantages and disadvantages of the RP versus TP approach for open AAA repair. We hope that this will help inform decision-making for healthcare professionals and their patients.

OBJECTIVES

To assess the effectiveness and safety of the retroperitoneal versus transperitoneal approach for elective open abdominal aortic aneurysm repair on mortality, complications, hospital stay and blood loss.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomized controlled trials (RCTs). There was no restriction on language or publication status. We included all trials that met the inclusion criteria even if the trials did not report all of the pre-specified outcomes of the review.

Types of participants

We included people who received elective open surgery for abdominal aortic aneurysm (AAA) (including with juxtarenal or pararenal aneurysm).

We excluded people with previous aortic repair (including previous laparotomy or previous endovascular stent graft) undergoing a redo aortic procedure or people undergoing emergency or urgent repair. Individuals who underwent aortoiliac or aortobifemoral bypasses for obstructive aortoiliac disease were not eligible for inclusion.

Types of interventions

We included RCTs comparing the retroperitoneal (RP) approach versus the transperitoneal (TP) approach for elective open AAA repair.

Types of outcome measures

Primary outcomes

- Mortality: we analyzed in-hospital mortality, 30-day and late mortality separately.
- Complications: we included hematoma, abdominal wall hernia and chronic wound pain.

Secondary outcomes

- Intensive care unit (ICU) or high dependency unit (HDU) stay: all participants are normally initially managed in the HDU or the ICU and transferred to the vascular surgery ward when deemed appropriate. We defined ICU or HDU stay as the time of participant stay in the ICU or HDU.
- Hospital stay: we defined hospital stay as from the day of operation to the day when the participant left hospital.
- Blood loss: we defined blood loss as the total amount of blood obtained from suction, cell saver and weighed swabs.
- Aortic cross-clamp time
- Operating time: we defined operating times as from the start of incision to the time of closure.

Search methods for identification of studies

Electronic searches

For this update, the Cochrane Vascular Information Specialist conducted systematic searches of the following databases for relevant trials without language, publication year or publication status restrictions.

- Cochrane Vascular Specialised Register via the Cochrane Register of Studies (CRS-Web searched on 30 November 2020).
- Cochrane Central Register of Controlled Trials (CENTRAL) via the Cochrane Register of Studies Online (CRSO 2020, Issue 10).
- MEDLINE (Ovid MEDLINE Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE Daily and Ovid MEDLINE) (searched from 11 May 2015 to 30 November 2020).
- Embase Ovid (searched from 11 May 2015 to 30 November 2020).
- CINAHL Ebsco (Cumulative Index to Nursing and Allied Health Literature; searched from 11 May 2015 to 30 November 2020).

The Information Specialist modelled search strategies for other databases on the search strategy designed for CENTRAL. Where appropriate, the search strategies were combined with adaptations of the highly sensitive search strategy designed by the Cochrane Collaboration for identifying randomized controlled trials and controlled clinical trials (as described in the *Cochrane Handbook for Systematic Reviews of Interventions* Chapter 6, Lefebvre 2011, hereafter referred to as the *Cochrane Handbook*). Search strategies for major databases are provided in Appendix 1.

The Information Specialist searched the following trials registries on 30 November 2020.

- World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) (apps.who.int/trialsearch/).
- ClinicalTrials.gov (clinicaltrials.gov/).

Authors' searches

We searched the China BioMedical (CBM) Literature database (searched from inception to 30 November 2020) using the search strategies shown in Appendix 1. We based the CBM search on the search terms used in the MEDLINE search strategy.

Searching other resources

We checked the reference lists of retrieved articles and narrative and systematic reviews to find additional potentially relevant studies for inclusion.

Data collection and analysis

Selection of studies

For the update of this review, two authors (FM and FC) initially screened abstracts and titles using Covidence software, following the pre-determined eligibility criteria to discard studies that were not applicable. If we could not decide whether or not the articles satisfied the inclusion criteria based on the abstracts, we obtained the full-text articles of the studies. If there were two or more publications relating to one trial, we selected one report as the source of the study results (primary report) after checking the relevant information. If baseline information and additional results data for a trial were reported separately in multiple publications, we documented them all and extracted outcome data and underlying information of interest separately. We resolved any disagreements through discussion and, if necessary, by involving a third review author (BM).

Data extraction and management

Two review authors (BZ and KYH) independently extracted data using a data extraction form designed by Cochrane Vascular. We resolved any disagreements through discussion with a third review author (BM). We sought additional information from the authors of included trials if required. Where trial authors presented median and interquartile range (IQR) values and we were unable to obtain additional information from the trial authors, we assumed the median to be the mean and calculated the standard deviations (SDs) from the IQR using the formula IQR/1.35, in accordance with Higgins 2011. We did this for Arya 2009 and the outcomes of ICU or HDU stay, hospital stay, blood loss, aortic cross-clamp time and operating time.

Assessment of risk of bias in included studies

For this update, two review authors (FM and LZ) independently reviewed or evaluated the risk of bias for each included trial using the Cochrane Collaboration's tool for assessing risk of bias (Higgins 2011), and based on the following domains.

- Random sequence generation (selection bias).
- Allocation concealment (selection bias).
- Blinding of participants and personnel (performance bias).
- Blinding of outcome assessment (detection bias).
- Incomplete outcome data (attrition bias).
- Selective reporting (reporting bias).

- Other sources of bias.

We evaluated each criterion as high risk of bias, low risk of bias, or unclear risk of bias, in accordance with Higgins 2011. We resolved discrepancies through discussion until we reached consensus.

Regarding blinding, this cannot be implemented for surgeons in a trial about surgical operation. In addition, we believe that unblinded participants will not affect the measurement outcomes of our review, such as mortality, ICU stay, hospital stay, blood loss, aortic cross-clamp time and operating time. Therefore, we mainly evaluated the implementation of blinding for outcome assessors in the subjective outcomes in our review, such as hematoma, abdominal wall hernia and chronic wound pain.

Measures of treatment effect

For dichotomous outcomes, we calculated a pooled estimate of the treatment effect for each outcome across trials as odds ratio (OR) with 95% confidence intervals (CIs). For continuous data, we calculated a pooled estimate of treatment effect by calculating the mean difference (MD) and standard deviation (SD) with corresponding 95% CIs. We used Review Manager software to calculate the measures of treatment effect (Review Manager).

Unit of analysis issues

We did not intend to include non-standard designs, such as cross-over trials and cluster-RCTs, in this Cochrane Review. We considered each participant as an individual unit of analysis.

Dealing with missing data

We contacted the authors of the included trials via email for clarification regarding any missing data. We planned to undertake sensitivity analyses to assess the impact of missing data on the quality of the included trials when necessary (see the Sensitivity analysis section).

Assessment of heterogeneity

We used the Chi^2 test on N-1 degrees of freedom with a significance level of P less than 0.05, and the I^2 statistic to examine the heterogeneity among trials. A guide to interpretation is as follows, as described in the *Cochrane Handbook* (Higgins 2011). I^2 statistic values of 25%, 50% and 75% correspond to low, moderate and high levels of heterogeneity, respectively. If the I^2 statistic estimate is greater than 50%, we regarded the level of heterogeneity among trials as moderate or high, and we investigated the potential reasons for heterogeneity. We considered clinical, methodological and statistical heterogeneity. For clinical heterogeneity, we studied the participants, interventions and outcomes. For methodological and statistical heterogeneity, we conducted sensitivity analyses as described below (Sensitivity analysis). We presented results separately and attempted to report the reasons if heterogeneity persisted.

Assessment of reporting biases

We planned to construct a funnel plot to investigate the likelihood of potential publication bias if we had included more than 10 trials in a meta-analysis (Higgins 2011). As only five studies were included in this review, we could not undertake an assessment of reporting bias.

Data synthesis

We analyzed the data using Review Manager. We used a fixed-effect model when there was no or low heterogeneity and a random-effects model if there was high heterogeneity in the meta-analysis because of the likely heterogeneous population. When the I^2 statistic values were greater than 75%, we used a random-effects model. For levels smaller than the cut-off point (I^2 statistic greater than 75%), we used a fixed-effect model.

Subgroup analysis and investigation of heterogeneity

We were unable to carry out any subgroup analysis because of the difference in reporting of outcomes. If there were an adequate number of trials to merit subgroup analysis, we intended to perform subgroup analysis according to the following subgroups.

- Age (≥ 65 years old versus < 65 years old).
- Gender (female versus male).
- Diabetes (with diabetes versus without diabetes).
- Duration of treatment.

Sensitivity analysis

We undertook sensitivity analyses by analyzing the following categories of trials separately.

- Trials with and without adequate randomization and concealment of treatment allocation.
- Trials with and without intention-to-treat (ITT) analysis.
- Trials with a dropout rate of more than 20% and less than 20%.

For sensitivity analyses, we described both the main effects within strata and a coefficient (and 95% CIs) describing the interaction between them.

Summary of findings and assessment of the certainty of the evidence

We created a summary of findings table for the comparison of the RP approach versus the TP approach for elective open AAA repair, using GRADEpro GDT software (GRADEpro GDT). We reported the following outcomes: mortality, complications (hematoma, abdominal wall hernia and chronic wound pain), ICU stay, hospital stay and blood loss (Summary of findings 1). We created a second summary of findings table for the additional secondary outcomes of aortic cross-clamp time and operating time (Summary of findings 2). We downgraded the evidence from high certainty to moderate, low or very low certainty for serious or very serious study limitations (risk of bias), indirectness and inconsistency of evidence, imprecision of effect estimates or potential publication bias using the guidance developed by the *Cochrane Handbook* (Higgins 2011), and the GRADE working group (Atkins 2004).

RESULTS

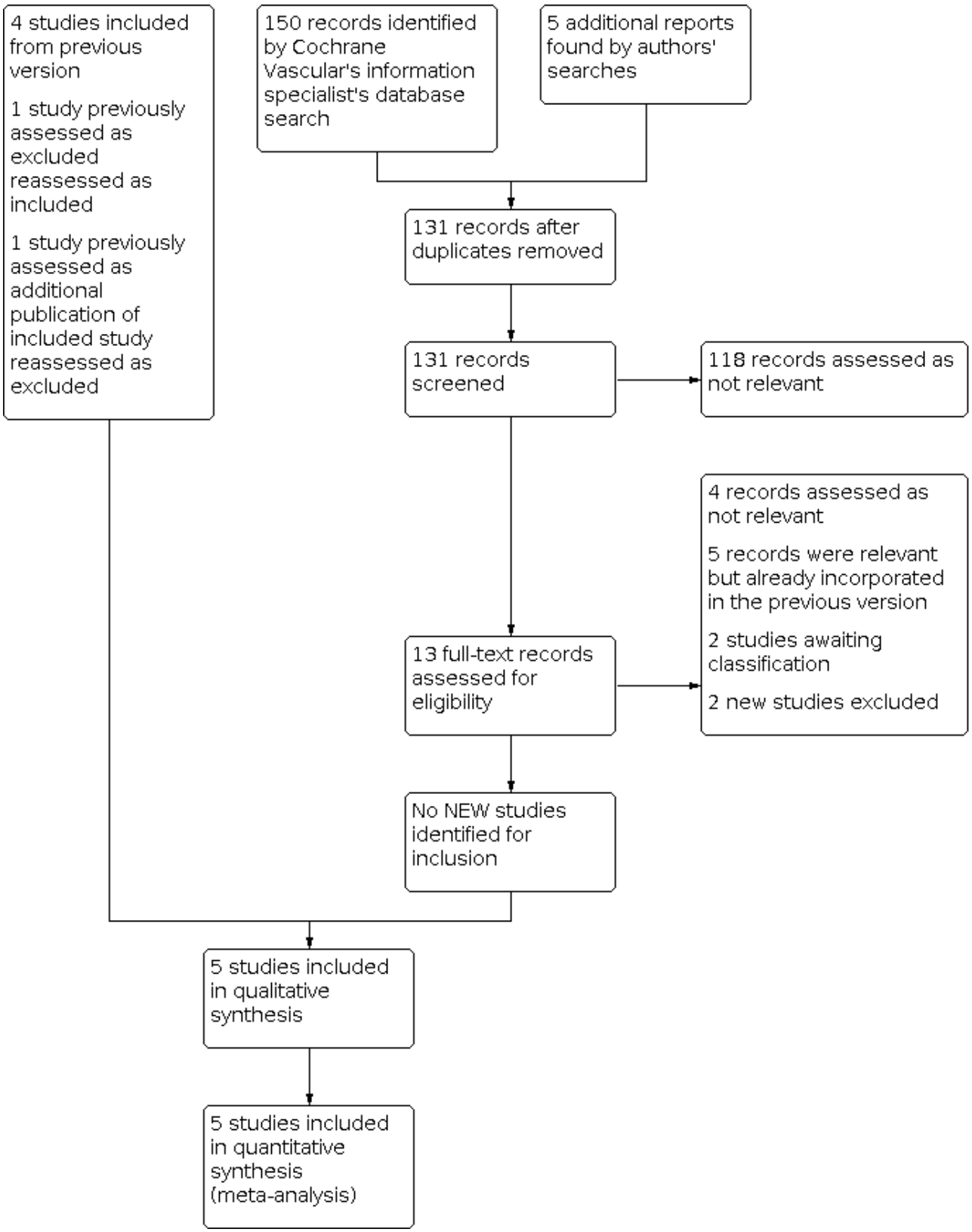
Description of studies

Results of the search

We identified no new studies for inclusion from the updated searches. We excluded two new studies (Deery 2019; Teixeira 2016), and two studies are awaiting classification (Arya 2010; Malek 1996). Upon reassessment, we included one study which was previously excluded (Volta 2003). One study which was previously listed as an

additional publication to an included study was reassessed as a different study and subsequently excluded (Laohapensang 2005b). See Figure 1 for details of the search results.

Figure 1. Study flow diagram



Included studies

See Characteristics of included studies for further details on the included studies.

We identified no new studies from the updated searches for this review update. Volta 2003 was previously assessed as excluded (outcomes of interest not reported), but reassessed as an included study for this update as it met our inclusion criteria. A total of five RCTS met the inclusion criteria (Arya 2009; Darling 1992; Komori 1997; Laohapensang 2005a; Volta 2003). These five RCTs included a total of 152 participants and were conducted in at least three different countries: Darling 1992 in the USA, Komori 1997 in Japan and Laohapensang 2005a in Thailand, while Arya 2009 and Volta 2003 did not state in which country the study was conducted. Of the five included trials, Arya 2009 and Volta 2003 did not report the AAA size. All five included trials compared the retroperitoneal (RP) and transperitoneal (TP) approach for repairing open abdominal aortic aneurysm (AAA).

In Arya 2009, participants in Group I were repaired via the RP approach, while participants in Groups II and III were repaired via the TP approach, with the bowel packed within the peritoneal cavity or exteriorized in a bowel bag, respectively. In Komori 1997, Group I comprised people without previous laparotomy who were treated by the TP approach, while Groups II and III comprised people with previous laparotomy, treated by RP and TP approach, respectively. However, only the participants of Groups II and III were randomly assigned. The other three included trials, Darling 1992, Laohapensang 2005a and Volta 2003, divided participants into two groups (TP group versus RP group).

Excluded studies

We excluded two new studies (Deery 2019; Teixeira 2016). One study which was previously assessed as an additional publication to included study Laohapensang 2005a, was reassessed as a different study and subsequently excluded for not having an eligible intervention (Laohapensang 2005b). Therefore, we excluded a total of six studies (Cambria 1990; Deery 2019; Laohapensang 2005b; Sicard 1995; Sieunarine 1997; Teixeira 2016). For three studies, we could not stratify or obtain AAA participant data from the study authors (Cambria 1990; Sicard 1995; Sieunarine 1997). Two studies did not have an eligible study design (Deery 2019; Teixeira 2016). See Characteristics of excluded studies.

Studies awaiting classification

We assessed two studies as awaiting classification (Arya 2010; Malek 1996). See Characteristics of studies awaiting classification.

Risk of bias in included studies

We assessed the risk of bias for each included study using Cochrane's risk of bias tool. See Figure 2 and Figure 3.

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

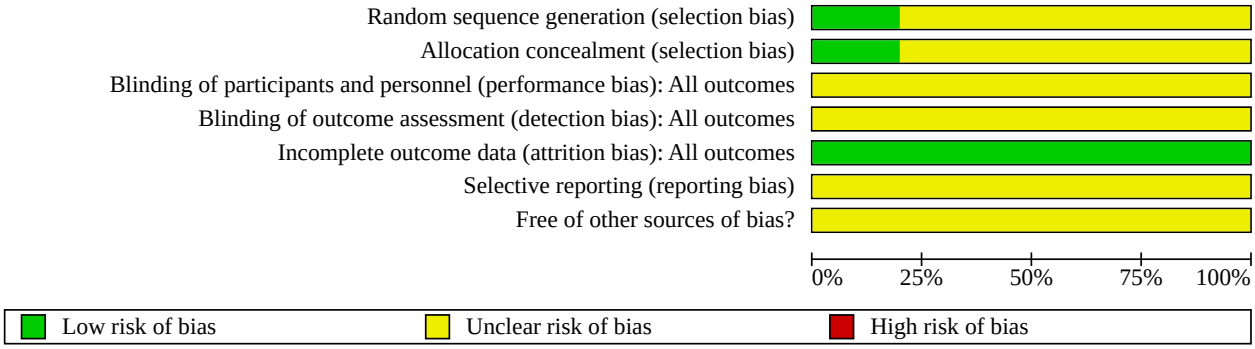
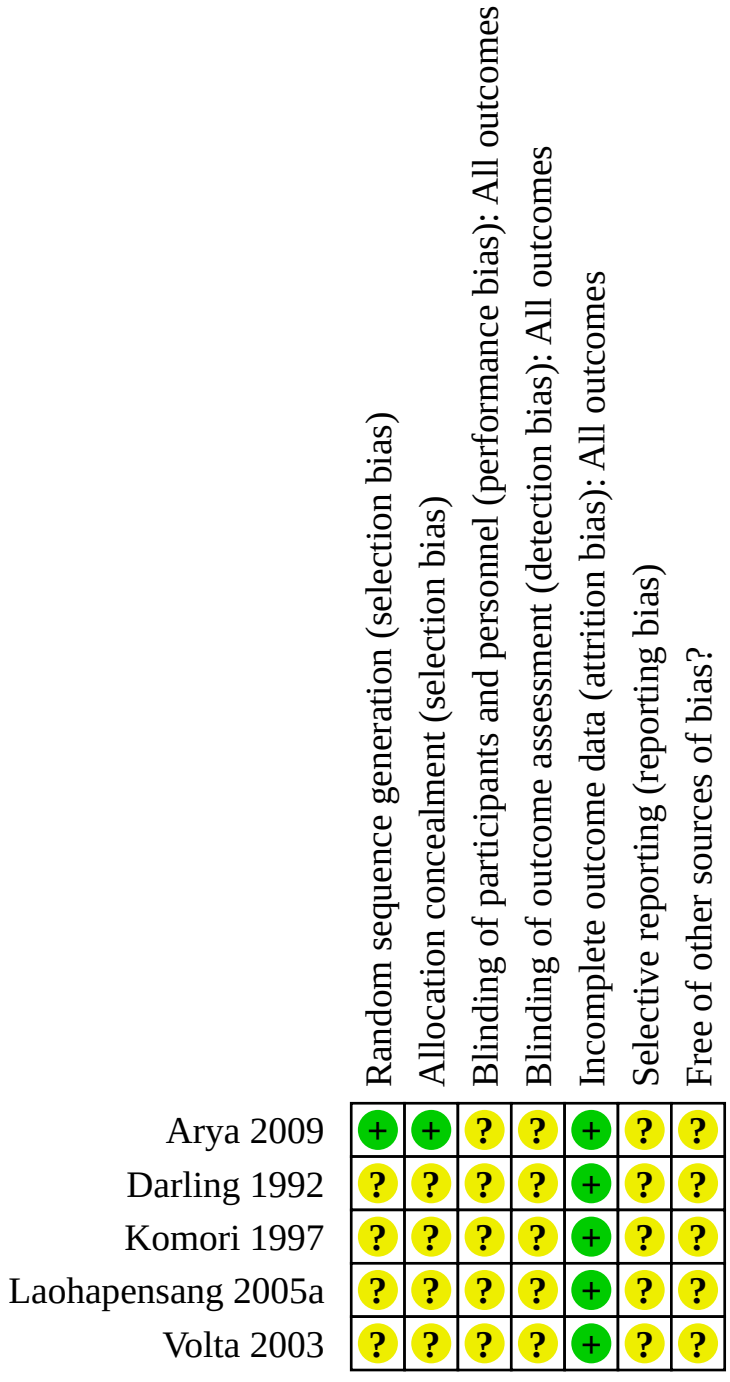


Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study



Allocation

All included trials were randomized controlled trials (RCTs) but in four trials, no details were available on the method of allocation other than a statement that the trial was 'randomized' (Darling 1992; Komori 1997; Laohapensang 2005a; Volta 2003). Four trials had unclear selection bias for random sequence generation

because they did not adequately describe their generation method or it was unclear if the method would be truly random (Darling 1992; Komori 1997; Laohapensang 2005a; Volta 2003).

Only Arya 2009 described allocation concealment and used an envelope system so was at low risk of selection bias. The other included trials did not mention allocation concealment.

Blinding

Blinding can not be implemented for surgeons in a trial about surgical operation. In addition, unblinded participants also will not affect the outcomes of our review so we have assessed the studies as unclear risk of performance bias. We also evaluated the implementation of blinding for outcome assessors, especially for the subjective outcomes. Unfortunately, it is unclear whether the outcome assessors were blinded, based on the reporting of the included trials, so we judged all five studies to be at unclear risk of detection bias (Arya 2009; Darling 1992; Komori 1997; Laohapensang 2005a; Volta 2003).

Incomplete outcome data

Two included trials reported their incomplete outcome data (Arya 2009; Darling 1992), and three included trials had no losses to follow-up and withdrawals (Komori 1997; Laohapensang 2005a; Volta 2003). All included trials therefore had low risk of attrition bias.

Selective reporting

According to the reports, all included trials presented all the outcomes that they had planned to present. However, we failed to find the protocols of the included trials. Therefore, we are unsure if there was selective reporting in the included trials so all trials were at unclear risk of reporting bias (Arya 2009; Darling 1992; Komori 1997; Laohapensang 2005a; Volta 2003).

Other potential sources of bias

None of the five included trials had power calculations, and the small sample size can lead to a reduction of the testing efficiency. Therefore, we judged all studies as having unclear risk of other bias.

Effects of interventions

See: **Summary of findings 1** Retroperitoneal approach compared with transperitoneal approach for elective open AAA repair; **Summary of findings 2** Retroperitoneal approach compared with transperitoneal approach for elective open AAA repair (additional secondary outcomes)

For Arya 2009, Group I participants had repair through the retroperitoneal (RP) approach. Group II and Group III participants had their aneurysms repaired through a midline transperitoneal (TP) approach, with the small bowel packed within the peritoneal cavity and the small intestine exteriorized into a plastic bowel bag, separately. We split the study data into two for pair-wise comparisons. We avoided double-counting in the overall comparison by halving the Group 1 sample size (Higgins 2011).

Primary outcomes

Mortality

We intended to present and analyze data by early and late mortality. However, the included trials did not report these mortality details and therefore we reported morality as a single variable.

Three trials, including 110 participants, evaluated mortality after treatment with the RP approach versus the TP approach (Arya 2009; Darling 1992; Laohapensang 2005a). We found no clear difference between the treatment groups (odds ratio (OR) 0.32, 95% CI 0.01 to 8.25; P = 0.49, I^2 = 0%; very low-certainty evidence; Analysis 1.1).

Complications

Two trials, including 75 participants, evaluated hematoma (Darling 1992; Laohapensang 2005a). We found no clear difference between the treatment groups (OR 0.90, 95% CI 0.13 to 6.48; P = 0.92, I^2 = 14%; very low-certainty evidence; Analysis 1.2).

One trial, Laohapensang 2005a, including 48 participants, evaluated abdominal wall hernia. We found no clear difference between the treatment groups (OR 10.76, 95% CI 0.55 to 211.78; P = 0.12; very low-certainty evidence; Analysis 1.2).

This trial also evaluated chronic wound pain. We found no clear difference between the treatment groups (OR 2.20, 95% CI 0.36 to 13.34; P = 0.39; very low-certainty evidence; Analysis 1.2).

Secondary outcomes

Intensive care unit or high dependency unit stay

Three trials, including 106 participants, evaluated intensive care unit (ICU) or high dependency unit (HDU) stay (Arya 2009; Laohapensang 2005a; Volta 2003). Results showed a shorter ICU or HDU stay following the RP approach compared to the TP approach (MD -19.02 hours, 95% CI -30.83 to -7.21; P = 0.002, I^2 = 0%; low-certainty evidence; Analysis 1.3).

Hospital stay

Five trials, including 152 participants, evaluated hospital stay (Arya 2009; Darling 1992; Komori 1997; Laohapensang 2005a; Volta 2003). The results showed a shorter hospital stay following the RP approach compared to the TP approach (MD -3.3 days, 95% CI -4.85 to -1.75; P < 0.001; low-certainty evidence). There was high heterogeneity (I^2 = 79%), so we used a random-effects model (Analysis 1.4).

Blood loss

Four trials, including 129 participants, evaluated blood loss (Arya 2009; Darling 1992; Komori 1997; Laohapensang 2005a). Results showed lower blood loss for the RP approach compared to the TP approach (MD -504.87 mL, 95% CI -779.19 to -230.56; P < 0.001; very low-certainty evidence; Analysis 1.5). There was high heterogeneity (I^2 = 76%), so we used a random-effects model (Analysis 1.5).

Aortic cross-clamp time

Four trials, including 129 participants, evaluated aortic cross-clamp time (Arya 2009; Darling 1992; Komori 1997; Laohapensang 2005a). Results showed no clear difference between the treatment groups (MD 0.69 min, 95% CI -7.23 to 8.60; P = 0.86; very low-certainty

evidence). There was high heterogeneity (I^2 = 81%), so we used a random-effects model (Analysis 1.6).

Operating time

Four trials, including 129 participants, evaluated operating time (Arya 2009; Darling 1992; Komori 1997; Laohapensang 2005a). Results showed no clear difference between the treatment groups (MD -15.94 min, 95% CI -34.76 to 2.88; P = 0.10; very low-certainty evidence). We found high heterogeneity (I^2 = 81%), so we used a random-effects model (Analysis 1.7).

Sensitivity analysis

We planned to conduct sensitivity analyses by analyzing these categories of trials separately:

- trials with and without adequate randomization and concealment of treatment allocation;
- trials with and without intention-to-treat (ITT) analysis;
- trials with a dropout rate of more than 20% and less than 20%.

No trials reported ITT analysis or a dropout rate of more than 20%. Therefore, we did not perform a sensitivity analysis for these categories of trials.

Of the five included RCTs, only one trial mentioned adequate randomization and allocation concealment (Arya 2009). Therefore, we carried out sensitivity analyses by excluding the other four included trials (Darling 1992; Komori 1997; Laohapensang 2005a; Volta 2003). Regarding mortality, Arya 2009 did not report any cases of death. Therefore, a test for overall effects was no longer applicable. For the outcome 'complications', we could not perform a sensitivity analysis as none of the trials included in this comparison had adequate randomization and allocation concealment. For hospital stay (days) and blood loss (mL), there were no longer differences between the techniques (hospital stay: MD -0.72 days, 95% CI -2.93 to 1.50; P = 0.53; Analysis 2.3; blood loss: MD -231.78 mL, 95% CI -1142.47 to 678.90; P = 0.62; Analysis 2.4). We did not observe any changes for ICU stay (hours) (Analysis 2.2); aortic cross-clamping (Analysis 2.5); or operating time (Analysis 2.6).

DISCUSSION

Summary of main results

Five RCTs which compared participants who underwent the retroperitoneal (RP) and transperitoneal (TP) approach for elective open abdominal aortic aneurysm (AAA) repair were identified and included in meta-analyses (Arya 2009; Darling 1992; Komori 1997; Laohapensang 2005a; Volta 2003). Our analyses did not show any clear difference between the RP approach and the TP approach regarding mortality (very low-certainty evidence), or any clear evidence of a difference for rates of complications such as hematoma (very low-certainty evidence), abdominal wall hernia (very low-certainty evidence), or chronic wound pain (very low-certainty evidence). However, a shorter intensive care unit (ICU) stay and shorter hospital stay was probably indicated following the RP approach compared to the TP approach (both low-certainty evidence). A possible reduction in blood loss was also shown after the RP approach compared to the TP approach (very low-certainty evidence). There were no clear differences between the RP approach and the TP approach regarding aortic cross-clamp time or operating time (both very low-certainty evidence). See Summary of findings 1 and Summary of findings 2.

Overall completeness and applicability of evidence

Given the thorough search strategy and clear inclusion and exclusion criteria, this review provides a comprehensive overview of the current evidence comparing the RP and TP approach in people undergoing AAA repair. We found five RCTs that investigated this topic. While most studies appropriately reported the outcomes of interests, the data were insufficient to perform pre-specified subgroup analyses exploring whether the approach effect differed importantly according to key participant characteristics. Notably, the time points of mortality and the calculation of sample size reported in the included studies were generally poorly described. Between studies, moreover, there was a degree of clinical heterogeneity among individual surgeons and units. Therefore, we have limited confidence in generalizing these results to other situations.

We found that no further studies have been done since the latest Arya study was published in 2009 (Arya 2009). With advances in minimally-invasive techniques for the treatment of aneurysmal aortoiliac disease, open procedures have become fewer and more technically demanding (Schermerhorn 2012). These procedures have been progressively reserved for younger people and those unable to comply with long-term surveillance (Twine 2012). Future research regarding the management of AAA should focus on time points for assessing outcomes and key participant characteristics, as data regarding for example age, gender and diabetes are lacking. Such research can facilitate a meta-analysis and create much clearer clinical guidance and prognostic information.

Quality of the evidence

Methodological weaknesses in the five included RCTs compromised the value of their results. The trial authors described each of their respective trials as randomized. However, only Arya 2009 reported their random sequence generation thoroughly. The other included trials had unclear selection bias for random sequence generation because they did not adequately describe their generation method, or it was unclear if the method would be truly random. There was no reporting of blinding of outcome assessors, leading to unclear detection bias. The sample sizes of the included trials were small, with two studies including fewer than 30 participants (Darling 1992; Komori 1997). In addition, the number of events was small, leading to imprecision in the effect estimates. Heterogeneity and inconsistency between the included RCTs was high for most outcomes. Due to the small number of included trials, we were unable to assess the reasons for inconsistency and heterogeneity via subgroup analyses. None of the included RCTs provided prior power calculations and all reported primary outcomes after a relatively short follow-up period. Moreover, none of the included trials reported whether the qualification of the surgeon was required to ensure the relative consistency of operation quality among different surgeons. Thus, overall, the certainty of the available evidence was low to very low. See Summary of findings 1 and Summary of findings 2.

Potential biases in the review process

The Cochrane Vascular Information Specialist carried out a comprehensive search of the literature. To further expand the search, we checked the reference lists of relevant articles for

additional studies. We contacted study authors to obtain data that were missing in the original publications or abstracts. Two review authors independently screened the titles and abstracts of references identified by the searches. However, this Cochrane Review included published data only. As a result, selective biases may exist in our review. In future updates of this Cochrane Review, we will attempt to identify any additional studies by further searching the grey literature. Some study results, such as the secondary outcomes of ICU or HDU stay, hospital stay, blood loss, aortic cross-clamp time and operating time reported by Arya 2009, were not reported as mean and SD values but as median and IQR values. Assuming normal distribution, we took the median value to be the mean and calculated the SD according to Higgins 2011. Therefore, one should consider the bias of pooled effect.

Agreements and disagreements with other studies or reviews

The results of this Cochrane Review are consistent with other meta-analyses, which showed that the RP approach could reduce the duration of ICU stay, but that it did not reduce the incidence of mortality and operation time compared with the TP approach in people undergoing elective open AAA repair (Twine 2013). A large retrospective cohort study by the Society for Vascular Surgery Vascular Quality Initiative (SVS-VQI) found that people who underwent the TP approach experienced higher rates of repair-related re-interventions and readmissions (Deery 2019). Additional studies show that the RP approach could reduce the operative time (Borkon 2010). Additional studies also show that the RP approach has some postoperative advantages, including a faster recovery, quicker return to bowel function, fewer pulmonary complications, less pain and, potentially lower costs compared with the TP approach (Arko 2001; Ballard 2000; Hioki 2002; Johnson 1986; Leather 1989).

AUTHORS' CONCLUSIONS

Implications for practice

Our results did not show any evidence of a difference between the retroperitoneal (RP) approach and the transperitoneal (TP) approach regarding mortality (very low-certainty evidence), or for rates of complications such as hematoma (very low-certainty evidence), abdominal wall hernia (very low-certainty evidence), or chronic wound pain (very low-certainty evidence). However, a shorter intensive care unit (ICU) stay and shorter hospital stay was probably indicated following the RP approach compared to the TP approach (both low-certainty evidence). A possible reduction in blood loss was also shown after the RP approach (very low-certainty evidence). As this conclusion is based on only five small included RCTs, the available evidence should be weighed in the context of individual patient considerations in the clinical setting.

Implications for research

Further large-scale RCTs of the RP approach versus TP approach for elective open AAA repair are required to provide conclusive evidence. Future trials evaluating the following outcomes as primary endpoints should be large and of reasonable duration to confirm the conclusions of this Cochrane Review. For example, there should be long-term follow-up (beyond 30 days of operation) for outcomes such as serious adverse events, mortality and quality of life. Endovascular aneurysm repair (EVAR), as a relatively new type of AAA repair, has several potential benefits, including lower early perioperative mortality and morbidity (Patel 2016). Therefore, researchers should consider comparisons of people operated on using the TP approach with EVAR as an important future topic.

ACKNOWLEDGEMENTS

The review authors would like to thank Ming Guo and Bobo Zheng for commenting on the draft protocol (Ma 2013). The review authors would like to thank and acknowledge the contributions of KeHu Yang, Hui Pan, Yulon Zhang, Ya-nan Wang and Kuang-yang Chen who were authors on the previous version of this review (Ma 2016).

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CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Arya 2009

Study characteristics	
Methods	**Study design:** prospective RCT. **Study type:** interventional. **Setting/location:** not mentioned. **Sample:** 35 participants (11 had repair through the RP approach; 12 repaired through a midline TP approach and the small bowel was packed within the peritoneal cavity; 12 repaired through a midline TP approach and the small intestine was exteriorized into a plastic bowel bag). **Sample calculation:** no power calculation.
Participants	**Ages (mean (range)) eligible for trial:** 69 (67 to 73) (RP); 75 (71 to 81) (TP II); 69 (60 to 77) (TP III). **Sex (M/F):** 10:1 (RP); 11:1 (TP II); 10:2 (TP III).

Arya 2009 *(Continued)*

	AAA size in cm (mean (range)): 6.4 (6 to 7.8) (RP); 6.4 (5.7 to 7.6) (TP II); 6.5 (5.7 to 7.7) (TP III). **Stroke:** 3/11 (27.3%) (RP); 0/12 (0%) (TP II); 0/12 (0%) (TP III). **Smoking:** 8/11(72.7%) (RP); 11/12 (91.7%) (TP II); 10/12 (83.3%) (TP III). **Hyperlipidemia:** 6/11 (54.5%) (RP); 5/12 (41.7%) (TP II); 9/12 (75%) (TP III). **Diabetes:** not mentioned. **Inclusion criteria:** the trial authors prospectively recruited all individuals undergoing elective open repair of infrarenal AAA to the trial. **Exclusion criteria:** individuals with aortoiliac aneurysms, chronic renal impairment (serum creatinine > 100 µmol/L), ongoing inflammatory process (e.g. inflammatory bowel disease, active rheumatoid arthritis), or previous laparotomy.
Interventions	Group I participants had repair through the RP approach, using a left flank incision. Groups II and III participants had their aneurysms repaired through a midline TP approach. In Group II, the bowel handling was kept to a minimum and the small bowel was packed within the peritoneal cavity, while in Group III, the small intestine was exteriorized into a plastic bowel bag and retracted to the right side of the abdominal wound to expose the infrarenal aorta.
Outcomes	Postoperative stay, ICU/HDU stay, operative time, clamp time, blood lost, blood transfused, intra-operative fluid, postoperative complications, MODS and SIRS scores.
Funding	Vascular Research Fund, Belfast City Hospital, Belfast, UK.
Declarations of interest	None declared.
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Recruited participants were randomized into three groups using an envelope system.
Allocation concealment (selection bias)	Low risk	The principal trial author was involved with the study and randomization, but was not involved with the operation or postoperative care of the participants.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Could not blind participants due to nature of intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned.
Incomplete outcome data (attrition bias) All outcomes	Low risk	During the study period, six eligible participants did not consent to the study and were excluded.
Selective reporting (reporting bias)	Unclear risk	We failed to find the protocol of the trial, so we are unsure if the trial authors reported all the measures according to the trial protocol. According to the

Arya 2009 *(Continued)*

		report, however, the trial authors reported all the outcomes that they had planned to present.
Free of other sources of bias?	Unclear risk	No power calculation, and small sample size leads to a reduction of the testing efficiency.

Darling 1992

Study characteristics	
Methods	**Study design**: prospective RCT. **Study type**: interventional. **Setting/Location**: the Vascular Surgery Section, Albany Medical College, Albany, New York, USA. **Sample size**: 27 participants (12 in TP group and 15 in RP group). **Sample calculation**: no power calculation.
Participants	**Ages eligible for study:** (mean ± SD): 73 ± 6.0 (TP); 70.4 ± 5.9 (RP) **Sex M/F**: 8/3 (TP); 10/2 (RP). **AAA size**: not mentioned. **Stroke**: not mentioned. **Smoking**: 8/11 (72.7%) (TP); 9/12 (75%) (RP). **Hyperlipidemia**: 8/11 (72.7%) (TP); 9/12 (75%) (RP). **Diabetes**: 1/11 (9.1%) (TP); 2/12 (16.7%) (RP). **Inclusion criteria**: trial authors prospectively recruited all individuals undergoing elective open repair of infrarenal AAA. **Exclusion criteria**: emergency operations, suprarenal, and thoracoabdominal aneurysms and aneurysms with concomitant renal artery reconstruction.
Interventions	"In the RP exclusion group, exposure was obtained through an oblique incision originating 5 cm below the umbilicus and carried over the eleventh and twelfth rib. The underlying musculature was divided with electrocautery and the peritoneum and left kidney were swept medially and cephalad (postero-lateral approach). A cross-clamp was placed below the renal arteries and a second clamp was placed 2 to 5 cm distal to the first clamp. The aorta was divided and the aneurysm oversewn with a double layer of polypropylene suture. Exclusion of the aneurysm from intra-arterial pressure was completed by oversewing the end of the proximally transected iliac artery, or distal aorta or ligation in continuity if an end- to side-anastomosis was performed. If a biiliac graft was used, the contralateral external iliac artery was exposed through a separate incision just above the inguinal ligament. The external iliac was controlled and occluded prior to aortic clamping and the graft was tunnelled anatomically or through the space of Retzius." "All TP operations were performed through a midline incision, and the aorta was exposed below the transverse mesocolon with the small bowel eviscerated. An open endoaneurysmorrhaphy technique was used. Patients in both groups were heparinized with 30-35 units/kg and the iliac arteries or distal aorta were then controlled to minimize distal embolization prior to aortic cross-clamping of the neck."
Outcomes	Operation time, cross-clamp time, crystalloid infused, patients transfused, estimated blood loss, return to diet, length of stay, complications.

Darling 1992 *(Continued)*

Funding	Not reported.
Declarations of interest	None declared.
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	From November 1988 to July 1989, 27 participants were prospectively randomized to RP or TP approach to repair their infrarenal abdominal aortic aneurysms (AAAs).
Allocation concealment (selection bias)	Unclear risk	Not mentioned.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Could not blind participants due to nature of intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned.
Incomplete outcome data (attrition bias) All outcomes	Low risk	RP: three participants had an open endoaneurysmorrhaphy in order to facilitate optimal placement of the bypass. The trial authors excluded these three participants from some analyses. TP: one participant had his aneurysm treated by exclusion and therefore the trial authors excluded this participant from the analysis.
Selective reporting (reporting bias)	Unclear risk	We failed to find the trial protocol, so we are unsure if the trial authors reported all the measures according to the protocol. According to the report, however, the trial authors presented all the outcomes that they had planned to present.
Free of other sources of bias?	Unclear risk	No power calculation, and small sample size leads to a reduction of the testing efficiency.

Komori 1997

Study characteristics	
Methods	**Study design:** prospective RCT. **Study type:** interventional. **Setting/Location:** Second Department of Surgery, Faculty of Medicine, Kyushu University, Fukuoka, Japan. **Sample:** 19 participants (10 in TP group and 9 in RP group). **Sample calculation:** no power calculation.
Participants	**Ages eligible for study (mean ± SD):** 72.4 ± 2.5 (TP);72.6 ± 2.3 (RP).

Komori 1997 *(Continued)*

	Sex M/F: 7/2 (TP); 6/4 (RP). **AAA size (mean ± SD):** 5.4 ± 0.3 (TP); 5.6 ± 0.5 (RP). **Stroke:** not mentioned. **Smoking:** not mentioned. **Hyperlipidemia:** not mentioned. **Diabetes:** 0% (TP); 10.0% (RP). **Inclusion criteria:** all participants undergoing elective reconstructions of infrarenal AAAs were prospectively recruited into the trial. **Exclusion criteria:** not mentioned.
Interventions	RP: "Under satisfactory general anesthesia, with the patient in the right lateral position, a left pararectal skin incision was made at the left lateral abdomen. The abdominal aorta was exposed through the extraperitoneal approach. The aorta below the renal arteries and bilateral external and internal iliac arteries were controlled with ligatures. After systemic heparinization, the aorta was clamped and the aneurysm was opened. The aorta was reconstructed with a woven Dacron Y graft. Except for the difference of the operative route, the operative procedures were much the same as those of the transperitoneal approach." TP: "Under general anesthesia with the patient in the supine position, an upper to lower abdominal incision was performed. The aorta below the renal arteries and bilateral external and internal iliac arteries were controlled with tapes. After systemic heparinization (0.5 mg/kg), the aorta was clamped and the aneurysm was opened. The aorta was reconstructed with a woven Dacron Y graft."
Outcomes	Operative time, clamping time, intraoperative blood loss.
Funding	A grant-in-aid for General Scientific Research from the Ministry of Education, Science and Culture of Japan.
Declarations of interest	None declared.
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Nineteen participants who had various laparotomies were randomly divided into two groups.
Allocation concealment (selection bias)	Unclear risk	Not mentioned.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Could not blind participants due to nature of intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned.
Incomplete outcome data (attrition bias)	Low risk	There were no participants withdrawn and all participants were accounted for.

Komori 1997 *(Continued)*

All outcomes

Selective reporting (reporting bias)	Unclear risk	We failed to find the trial protocol, so we are unsure if the trial authors reported all the measures according to the protocol. According to the report, however, the trial authors presented all the outcomes that they had planned to present.
Free of other sources of bias?	Unclear risk	No power calculation, and small sample size leads to a reduction of the testing efficacy.

Laohapensang 2005a

Study characteristics	
Methods	**Study design:** prospective RCT. **Study type:** interventional. **Setting/Location:** Department of Surgery, Chiang Mai University Hospital, Chiang Mai, Thailand. **Sample:** 48 participants (24 in TP group and 24 in RP group). **Sample calculation:** no power calculation.
Participants	**Ages eligible for study (mean ± SD):** 77.6 ± 6.4 (RP); 75.3 ± 5.5 (TP). **Sex M/F:** 16/8 (RP); 17/7 (TP). **AAA size in cm (mean ± SD):** 5.6 ± 0.8 (RP); 5.9 ± 0.7 (TP). **Stroke:** not mentioned. **Smoking:** 16 (66.6%) (RP); 15 (62.5%)(TP). **Hyperlipidemia:** not mentioned. **Diabetes:** 5 (20.8%) (RP); 6 (25%) (TP). **Inclusion criteria:** all participants with non-ruptured infrarenal AAAs were prospectively recruited into the trial. **Exclusion criteria:** ruptured or inflammatory aneurysms, pararenal or suprarenal aneurysms, individuals who required concomitant coronary mesenteric renal or infrainguinal arterial bypass grafting and severe cardiovascular, cerebral, respiratory or renal disease.
Interventions	The RP group had the left RP approach. The TP group had the traditional long midline transabdominal approach and extracavitary retraction of the small bowel for aortic exposure.
Outcomes	Operative time (minutes), aortic cross-clamp time (minutes), intraoperative fluid need (mL), estimated blood loss (mL), intraoperative PRBC (units), graft type (tube grafting, bifurcation grafting (aortoiliac, aortobifemoral)), mortality rate, ICU stay (days), liquid diet, solid diet, ambulation, hospital stay (days), postoperative complications (MI (nonfatal, fatal), atelectasis, ileus > 4 days, chronic wound pain, abdominal wall hernia, hematoma).
Funding	Not reported.
Declarations of interest	None declared.

Laohapensang 2005a *(Continued)*

Notes

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Participants were included in a prospective, randomized cohort study of 3 different surgical approaches and were divided into 3 groups of 24 participants each.
Allocation concealment (selection bias)	Unclear risk	Not mentioned.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Could not blind participants due to nature of intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned.
Incomplete outcome data (attrition bias) All outcomes	Low risk	There were no participants withdrawn and all participants were accounted for.
Selective reporting (reporting bias)	Unclear risk	We failed to find the protocol of the trial, so we are not sure if the study authors reported all the measures according to the protocol. According to the report, however, all the outcomes that the study authors planned are presented.
Free of other sources of bias?	Unclear risk	No significant difference between groups of baseline risk factors or clinical status.

Volta 2003

Study characteristics

Methods	**Study design:** prospective RCT. **Study type:** interventional. **Setting/location:** not mentioned. **Sample:** 23 participants (11 in TP group and 12 in RP group). **Sample calculation:** no power calculation.
Participants	**Ages eligible for study (mean ± SD):** 71± 8 (RP); 68 ± 7 (TP). **Sex M/F:** 9/3 (RP); 9/2 (TP). **AAA size (mean ± SD):** not mentioned. **Stroke:** not mentioned. **Smoking:** 7 (58%) (RP); 6 (54%) (TP). **Hyperlipidemia:** not mentioned.

Volta 2003 *(Continued)*

	Diabetes: not mentioned. **Inclusion criteria:** participants undergoing infrarenal repairs of aortic aneurysm were prospectively recruited into the trial. **Exclusion criteria:** aneurysm rupture, concomitant abdominal surgery in which the surgical technique was mandatory.
Interventions	RP: "...the RP approach is based on an oblique, left-flank incision made from the lateral margin of the left rectus sheath, beginning midway between the umbilicus and symphysis pubis, and extended laterally into the 11th intercostal space for 10-12 cm. The abdominal wall and intercostal musculature are divided in the line of the incision and the retroperitoneal space entered at the tip of the 12th rib.". TP: "...the TP approach is performed with a midline incision involving the linea alba and the rectus abdominal muscle...".
Outcomes	The article reported outcomes (respiratory function measures such as static elastance of the total respiratory system and maximal, minimal, and additional lung resistance) that were not our pre-specified outcomes. The study authors measured data within 30 minutes and 8 hours after the end of surgery.
Funding	"This study was supported in part by a grant from M.U.R.S.T. (60%, 2001)"
Declarations of interest	None declared.
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Twenty-nine consecutive participants undergoing infrarenal repairs of aortic aneurysm were prospectively studied and randomized to the RP or TP approach.
Allocation concealment (selection bias)	Unclear risk	Not mentioned.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Could not blind participants due to nature of intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned.
Incomplete outcome data (attrition bias) All outcomes	Low risk	There were no participants withdrawn and all participants were accounted for.
Selective reporting (reporting bias)	Unclear risk	We failed to find the trial protocol, so we are unsure if the trial authors reported all the measures according to the protocol. According to the report, however, the trial authors presented all the outcomes that they had planned to present.
Free of other sources of bias?	Unclear risk	No significant difference between groups of baseline risk factors or clinical status.

Abbreviations: AAA: abdominal aortic aneurysm; ICU: intensive care unit; HDU: high dependency unit; MI: myocardial infarction; MODS: multiorgan dysfunction syndrome; PRBC: packed red blood cells; RCT: randomized controlled trial; RP: retroperitoneal; SD: standard deviation; SIRS: systemic inflammatory response syndrome; TP: transperitoneal.

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Cambria 1990	Study authors asked participants undergoing infrarenal aortic reconstruction for either AAA or AIOD to participate in the study. We contacted the trial authors to obtain the data for AAA participants but we did not receive a response.
Deery 2019	Compared long-term rates of mortality, re-intervention and re-admission after open AAA repair via transabdominal versus retroperitoneal (RP) approach. It was not a randomized controlled trial.
Laohapensang 2005b	Compared the minimal incision aortic surgery (MIAS) approach with the transperitoneal (TP) approach in AAA repair.
Sicard 1995	Study authors asked participants undergoing infrarenal aortic reconstruction for either AAA or AIOD to participate in the study. We contacted the study authors to obtain the data for the AAA participants but we did not receive a response.
Sieunarine 1997	We contacted the study authors to obtain the data for AAA participants but we did not receive a response.
Teixeira 2016	Retrospective study that measured the impact of exposure technique on perioperative complications in people undergoing elective open AAA repair. It was not a randomized controlled trial.

Abbreviations: AAA: abdominal aortic aneurysm; AIOD: aortoiliac occlusive disease; MIAS: minimal incision aortic surgery; RP: retroperitoneal; TP: transperitoneal.

Characteristics of studies awaiting classification *[ordered by study ID]*

Arya 2010

Methods	**Study design:** prospective RCT. **Study type:** interventional. **Setting/Location:** not mentioned. **Sample calculation:** no power calculation.
Participants	**Ages eligible for study (mean (range)):** 68 (63 to 72) (RP); 75 (71 to 81) (TP II); 67 (59 to 74) (TP III). **Sex M/F:** 10:1 (RP); 11:1 (TP II); 10:1 (TP III). **AAA size in cm (mean (range)):** 6.4 (5.8 to 7.8) (RP); 6.4 (5.7 to 7.6) (TP II); 6.6 (5.6 to 7.8) (TP III). **Stroke:** 3 (RP); 0 (TP II); 0 (TP III). **Smoking:** 8 (RP); 11 (TP II); 10 (TP III). **Hyperlipidemia:** 6 (RP), 5 (TP II), 9 (TP III). **Diabetes:** not mentioned. **Inclusion criteria:** all participants undergoing elective open repair of infrarenal AAA were prospectively recruited into the study.

Arya 2010 *(Continued)*

	Exclusion criteria: people with aortoiliac aneurysms, chronic renal impairment (serum creatinine > 100 µmol/L), ongoing inflammatory process (e.g. inflammatory bowel disease, active rheumatoid arthritis) or previous laparotomy.
Interventions	Group I participants had repair through the RP approach, using a left flank incision. Group II and Group III participants had their aneurysms repaired through a midline TP approach. In Group II, the bowel handling was kept to a minimum and the small bowel was packed within the peritoneal cavity. In Group III, the small intestine was exteriorized into a plastic bowel bag and retracted to the right side of the abdominal wound to expose the infrarenal aorta.
Outcomes	Operative time, clamp time, blood lost, blood transfused, intraoperative fluid, ICU/HDU stay, postoperative stay.
Notes	The sample size and statistics of this study are similar to Arya 2009. We emailed the study author for clarification, but did not receive a reply to date. Therefore we included Arya 2009 and regard this as a study awaiting classification. We will decide if this study is an additional publication of Arya 2009 or a separate study when we receive a reply from the study author.

Malek 1996

Methods	Prospective randomized study
Participants	No information
Interventions	RP versus TP approach for abdominal aortic surgery
Outcomes	No information
Notes	Abstract. We were unable to extract the information we required.

Abbreviations: ICU: intensive care unit; HDU: high dependency unit; mL: millilitres; RCT: randomized controlled trial; RP: retroperitoneal; TP: transperitoneal.

DATA AND ANALYSES

Comparison 1. Retroperitoneal versus transperitoneal approach

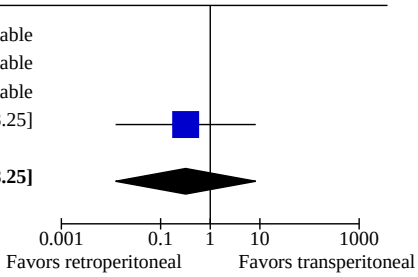
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.1 Mortality	3	110	Odds Ratio (M-H, Fixed, 95% CI)	0.32 [0.01, 8.25]
1.2 Complications	2		Odds Ratio (M-H, Fixed, 95% CI)	Subtotals only
1.2.1 hematoma	2	75	Odds Ratio (M-H, Fixed, 95% CI)	0.90 [0.13, 6.48]
1.2.2 abdominal wall hernia	1	48	Odds Ratio (M-H, Fixed, 95% CI)	10.76 [0.55, 211.78]
1.2.3 chronic wound pain	1	48	Odds Ratio (M-H, Fixed, 95% CI)	2.20 [0.36, 13.34]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.3 ICU stay (hrs)	3	106	Mean Difference (IV, Fixed, 95% CI)	-19.02 [-30.83, -7.21]
1.4 Hospital stay (days)	5	152	Mean Difference (IV, Random, 95% CI)	-3.30 [-4.85, -1.75]
1.5 Blood loss (mL)	4	129	Mean Difference (IV, Random, 95% CI)	-504.87 [-779.19, -230.56]
1.6 Aortic cross-clamp time (mins)	4	129	Mean Difference (IV, Random, 95% CI)	0.69 [-7.23, 8.60]
1.7 Operating time (mins)	4	129	Mean Difference (IV, Random, 95% CI)	-15.94 [-34.76, 2.88]

Analysis 1.1. Comparison 1: Retroperitoneal versus transperitoneal approach, Outcome 1: Mortality

Study or Subgroup	Retroperitoneal Events	Retroperitoneal Total	Transperitoneal Events	Transperitoneal Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Arya 2009 (1)	0	6	0	12		Not estimable
Arya 2009 (2)	0	5	0	12		Not estimable
Darling 1992	0	15	0	12		Not estimable
Laohapensang 2005a	0	24	1	24	100.0%	0.32 [0.01 , 8.25]
Total (95% CI)		**50**		**60**	**100.0%**	**0.32 [0.01 , 8.25]**
Total events:	0		1			

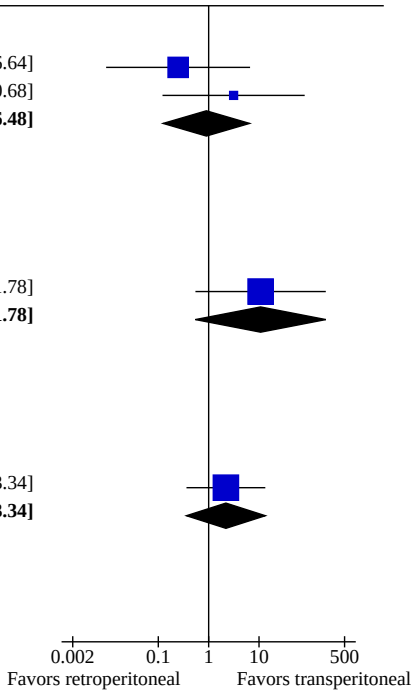
Heterogeneity: Not applicable
Test for overall effect: Z = 0.69 (P = 0.49)
Test for subgroup differences: Not applicable



Footnotes
(1) RP vs TR1
(2) RP vs TR2

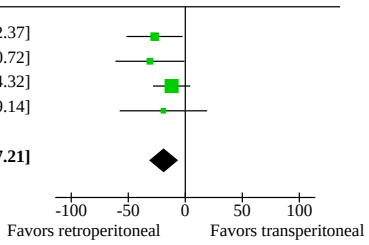
Analysis 1.2. Comparison 1: Retroperitoneal versus transperitoneal approach, Outcome 2: Complications

Study or Subgroup	Retroperitoneal Events	Retroperitoneal Total	Transperitoneal Events	Transperitoneal Total	Weight	Odds Ratio M-H, Fixed, 95% CI
1.2.1 hematoma						
Darling 1992	0	15	1	12	77.3%	0.25 [0.01 , 6.64]
Laohapensang 2005a	1	24	0	24	22.7%	3.13 [0.12 , 80.68]
Subtotal (95% CI)		**39**		**36**	**100.0%**	**0.90 [0.13 , 6.48]**
Total events:	1		1			
Heterogeneity: Chi² = 1.16, df = 1 (P = 0.28); I² = 14%						
Test for overall effect: Z = 0.10 (P = 0.92)						
1.2.2 abdominal wall hernia						
Laohapensang 2005a	4	24	0	24	100.0%	10.76 [0.55 , 211.78]
Subtotal (95% CI)		**24**		**24**	**100.0%**	**10.76 [0.55 , 211.78]**
Total events:	4		0			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.56 (P = 0.12)						
1.2.3 chronic wound pain						
Laohapensang 2005a	4	24	2	24	100.0%	2.20 [0.36 , 13.34]
Subtotal (95% CI)		**24**		**24**	**100.0%**	**2.20 [0.36 , 13.34]**
Total events:	4		2			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.86 (P = 0.39)						



Analysis 1.3. Comparison 1: Retroperitoneal versus transperitoneal approach, Outcome 3: ICU stay (hrs)

Study or Subgroup	Retroperitoneal Mean	Retroperitoneal SD	Retroperitoneal Total	Transperitoneal Mean	Transperitoneal SD	Transperitoneal Total	Weight	Mean Difference IV, Fixed, 95% CI
Arya 2009 (1)	23	18.5	6	50	34.8	12	23.0%	-27.00 [-51.63 , -2.37]
Arya 2009 (2)	23	18.5	5	54	45.2	12	15.2%	-31.00 [-61.28 , -0.72]
Laohapensang 2005a	45.6	19.2	24	57.6	36	24	52.3%	-12.00 [-28.32 , 4.32]
Volta 2003	79.2	31.2	12	98.4	57.6	11	9.5%	-19.20 [-57.54 , 19.14]
Total (95% CI)			**47**			**59**	**100.0%**	**-19.02 [-30.83 , -7.21]**
Heterogeneity: Chi² = 1.71, df = 3 (P = 0.63); I² = 0%								
Test for overall effect: Z = 3.16 (P = 0.002)								
Test for subgroup differences: Not applicable								



Footnotes

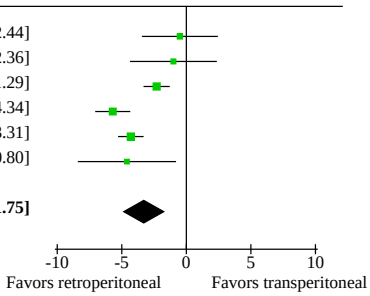
(1) RP vs TR2

(2) RP vs TR1

Analysis 1.4. Comparison 1: Retroperitoneal versus transperitoneal approach, Outcome 4: Hospital stay (days)

Study or Subgroup	Retroperitoneal Mean	SD	Total	Transperitoneal Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Arya 2009 (1)	9	3	6	9.5	3	12	13.1%	-0.50 [-3.44 , 2.44]
Arya 2009 (2)	9	3	5	10	3.7	12	11.4%	-1.00 [-4.36 , 2.36]
Darling 1992	6.7	0.9	15	9	1.6	12	22.4%	-2.30 [-3.31 , -1.29]
Komori 1997	18.2	1.6	9	23.9	1.4	10	20.8%	-5.70 [-7.06 , -4.34]
Laohapensang 2005a	10.2	1.3	24	14.5	2.1	24	22.5%	-4.30 [-5.29 , -3.31]
Volta 2003	10.2	4.1	12	14.8	5.1	11	9.9%	-4.60 [-8.40 , -0.80]
Total (95% CI)			**71**			**81**	**100.0%**	**-3.30 [-4.85 , -1.75]**

Heterogeneity: Tau² = 2.52; Chi² = 24.26, df = 5 (P = 0.0002); I² = 79%
Test for overall effect: Z = 4.18 (P < 0.0001)
Test for subgroup differences: Not applicable

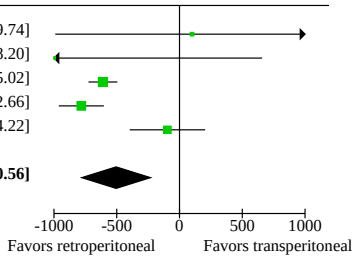


Footnotes
(1) RP vs TR1
(2) RP vs TR2

Analysis 1.5. Comparison 1: Retroperitoneal versus transperitoneal approach, Outcome 5: Blood loss (mL)

Study or Subgroup	Retroperitoneal Mean	SD	Total	Transperitoneal Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Arya 2009 (1)	1800	1112	6	1700	1112	12	5.4%	100.00 [-989.74 , 1189.74]
Arya 2009 (2)	1800	1112	5	2800	2371	12	2.5%	-1000.00 [-2658.20 , 658.20]
Darling 1992	517	60	15	1127	196	12	34.6%	-610.00 [-724.98 , -495.02]
Komori 1997	1011	143	9	1793	247	10	31.8%	-782.00 [-961.34 , -602.66]
Laohapensang 2005a	1150	430	24	1246	615	24	25.6%	-96.00 [-396.22 , 204.22]
Total (95% CI)			**59**			**70**	**100.0%**	**-504.87 [-779.19 , -230.56]**

Heterogeneity: Tau² = 53135.42; Chi² = 16.62, df = 4 (P = 0.002); I² = 76%
Test for overall effect: Z = 3.61 (P = 0.0003)
Test for subgroup differences: Not applicable

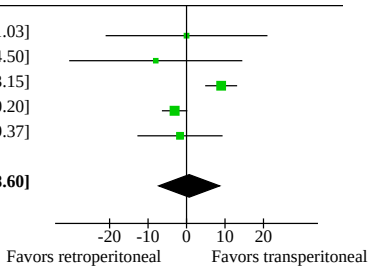


Footnotes
(1) RP vs TR2
(2) RP vs TR1

Analysis 1.6. Comparison 1: Retroperitoneal versus transperitoneal approach, Outcome 6: Aortic cross-clamp time (mins)

Study or Subgroup	Retroperitoneal Mean	SD	Total	Transperitoneal Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Arya 2009 (1)	60	22.2	5	60	14.1	12	9.9%	0.00 [-21.03 , 21.03]
Arya 2009 (2)	60	22.2	6	68	24.4	12	9.0%	-8.00 [-30.50 , 14.50]
Darling 1992	65	6	15	56	5	12	30.1%	9.00 [4.85 , 13.15]
Komori 1997	59.8	3.1	9	62.9	4.2	10	31.0%	-3.10 [-6.40 , 0.20]
Laohapensang 2005a	60.3	21	24	62	18	24	20.0%	-1.70 [-12.77 , 9.37]
Total (95% CI)			**59**			**70**	**100.0%**	**0.69 [-7.23 , 8.60]**

Heterogeneity: Tau² = 49.69; Chi² = 21.01, df = 4 (P = 0.0003); I² = 81%
Test for overall effect: Z = 0.17 (P = 0.86)
Test for subgroup differences: Not applicable

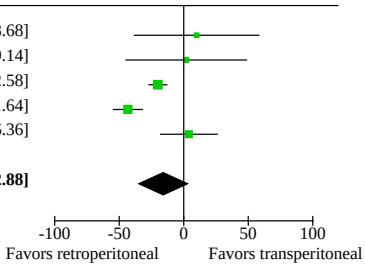


Footnotes
(1) RP vs TR2
(2) RP vs TR1

Analysis 1.7. Comparison 1: Retroperitoneal versus transperitoneal approach, Outcome 7: Operating time (mins)

Study or Subgroup	Retroperitoneal Mean	SD	Total	Transperitoneal Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Arya 2009 (1)	170	48.1	5	160	43	12	10.1%	10.00 [-38.68 , 58.68]
Arya 2009 (2)	170	48.1	6	168	48.1	12	10.6%	2.00 [-45.14 , 49.14]
Darling 1992	182	8	15	202	11	12	29.8%	-20.00 [-27.42 , -12.58]
Komori 1997	214.8	12.9	9	258.1	13	10	27.9%	-43.30 [-54.96 , -31.64]
Laohapensang 2005a	209	38	24	205	41	24	21.7%	4.00 [-18.36 , 26.36]
Total (95% CI)			**59**			**70**	**100.0%**	**-15.94 [-34.76 , 2.88]**

Heterogeneity: Tau² = 295.32; Chi² = 20.68, df = 4 (P = 0.0004); I² = 81%
Test for overall effect: Z = 1.66 (P = 0.10)
Test for subgroup differences: Not applicable



Footnotes
(1) RP vs TR2
(2) RP vs TR1

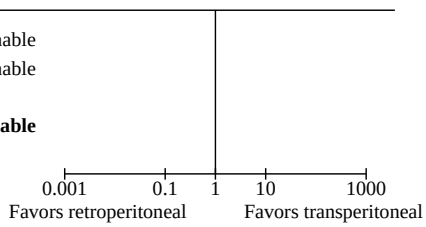
Comparison 2. Sensitivity analysis of retroperitoneal versus transperitoneal approach

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
2.1 Mortality	1	35	Odds Ratio (M-H, Fixed, 95% CI)	Not estimable
2.2 ICU stay (hrs)	1	35	Mean Difference (IV, Fixed, 95% CI)	-28.59 [-47.70, -9.48]
2.3 Hospital stay (days)	1	35	Mean Difference (IV, Fixed, 95% CI)	-0.72 [-2.93, 1.50]
2.4 Blood loss (mL)	1	35	Mean Difference (IV, Fixed, 95% CI)	-231.78 [-1142.47, 678.90]
2.5 Aortic cross-clamp time (mins)	1	35	Mean Difference (IV, Fixed, 95% CI)	-3.73 [-19.09, 11.63]
2.6 Operating time (mins)	1	35	Mean Difference (IV, Fixed, 95% CI)	5.87 [-27.99, 39.73]

Analysis 2.1. Comparison 2: Sensitivity analysis of retroperitoneal versus transperitoneal approach, Outcome 1: Mortality

Study or Subgroup	Retroperitoneal Events	Total	Transperitoneal Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Arya 2009 (1)	0	5	0	12		Not estimable
Arya 2009 (2)	0	6	0	12		Not estimable
Total (95% CI)		**11**		**24**		**Not estimable**
Total events:	0		0			

Heterogeneity: Not applicable
Test for overall effect: Not applicable
Test for subgroup differences: Not applicable

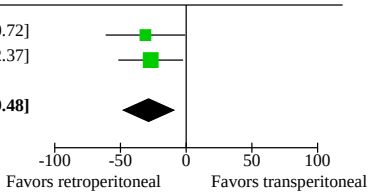


Footnotes
(1) RP vs TR2
(2) RP vs TR1

Analysis 2.2. Comparison 2: Sensitivity analysis of retroperitoneal versus transperitoneal approach, Outcome 2: ICU stay (hrs)

Study or Subgroup	Retroperitoneal Mean	SD	Total	Transperitoneal Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Arya 2009	23	18.5	5	54	45.2	12	39.8%	-31.00 [-61.28 , -0.72]
Arya 2009	23	18.5	6	50	34.8	12	60.2%	-27.00 [-51.63 , -2.37]
Total (95% CI)			**11**			**24**	**100.0%**	**-28.59 [-47.70 , -9.48]**

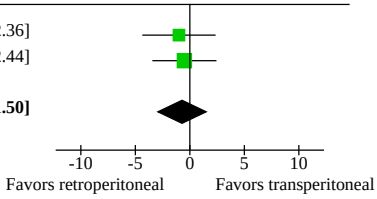
Heterogeneity: Chi² = 0.04, df = 1 (P = 0.84); I² = 0%
Test for overall effect: Z = 2.93 (P = 0.003)
Test for subgroup differences: Not applicable



Analysis 2.3. Comparison 2: Sensitivity analysis of retroperitoneal versus transperitoneal approach, Outcome 3: Hospital stay (days)

Study or Subgroup	Retroperitoneal Mean	SD	Total	Transperitoneal Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Arya 2009	9	3	5	10	3.7	12	43.3%	-1.00 [-4.36 , 2.36]
Arya 2009	9	3	6	9.5	3	12	56.7%	-0.50 [-3.44 , 2.44]
Total (95% CI)			**11**			**24**	**100.0%**	**-0.72 [-2.93 , 1.50]**

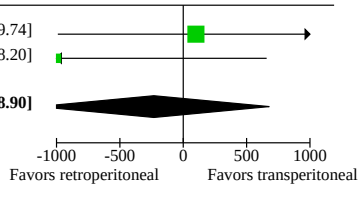
Heterogeneity: Chi² = 0.05, df = 1 (P = 0.83); I² = 0%
Test for overall effect: Z = 0.63 (P = 0.53)
Test for subgroup differences: Not applicable



Analysis 2.4. Comparison 2: Sensitivity analysis of retroperitoneal versus transperitoneal approach, Outcome 4: Blood loss (mL)

Study or Subgroup	Retroperitoneal Mean	SD	Total	Transperitoneal Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Arya 2009	1800	1112	6	1700	1112	12	69.8%	100.00 [-989.74 , 1189.74]
Arya 2009	1800	1112	5	2800	2371	12	30.2%	-1000.00 [-2658.20 , 658.20]
Total (95% CI)			**11**			**24**	**100.0%**	**-231.78 [-1142.47 , 678.90]**

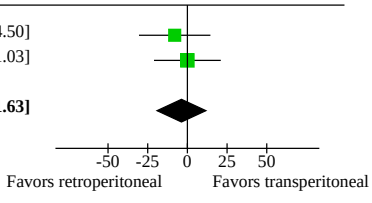
Heterogeneity: Chi² = 1.18, df = 1 (P = 0.28); I² = 15%
Test for overall effect: Z = 0.50 (P = 0.62)
Test for subgroup differences: Not applicable



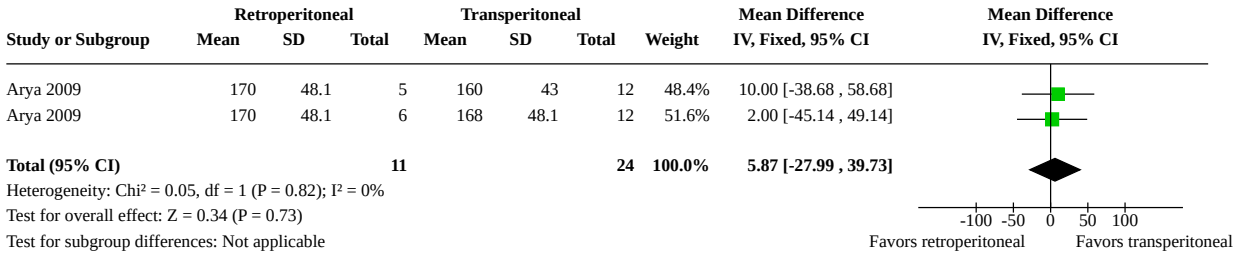
Analysis 2.5. Comparison 2: Sensitivity analysis of retroperitoneal versus transperitoneal approach, Outcome 5: Aortic cross-clamp time (mins)

Study or Subgroup	Retroperitoneal Mean	SD	Total	Transperitoneal Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Arya 2009	60	22.2	6	68	24.4	12	46.6%	-8.00 [-30.50 , 14.50]
Arya 2009	60	22.2	5	60	14.1	12	53.4%	0.00 [-21.03 , 21.03]
Total (95% CI)			**11**			**24**	**100.0%**	**-3.73 [-19.09 , 11.63]**

Heterogeneity: Chi² = 0.26, df = 1 (P = 0.61); I² = 0%
Test for overall effect: Z = 0.48 (P = 0.63)
Test for subgroup differences: Not applicable



Analysis 2.6. Comparison 2: Sensitivity analysis of retroperitoneal versus transperitoneal approach, Outcome 6: Operating time (mins)



APPENDICES

Appendix 1. CBM search strategy

序号	命中文献数	检索表达式	检索时间
4	5	#1 and #2 and #3	2020-11-30
3	14168	腹膜后	2020-11-30
2	1768	经腹膜	2020-11-30
1	3026	腹主动脉瘤	2020-11-30

Appendix 2. Database search strategies

Source	Search strategy	Hits retrieved
Cochrane Vascular Specialised Register	#1 MESH DESCRIPTOR Aortic Aneurysm EXPLODE ALL AND INREGISTER #2 MESH DESCRIPTOR Aneurysm, Ruptured EXPLODE ALL AND INREGISTER #3 MESH DESCRIPTOR Aorta, Abdominal EXPLODE ALL AND INREGISTER #4 aneurysm* adj4 (abdom* or thoracoabdom* or thoraco-abdom* or aort*) AND INREGISTER #5 abdom* adj3 (balloon* or dilat* or bulg*) AND INREGISTER #6 AAA* AND INREGISTER #7 aort* adj3 (ballon* or dilat* or bulg*) AND INREGISTER #8 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 #9 MESH DESCRIPTOR Retroperitoneal Space EXPLODE ALL AND INREGISTER #10 MESH DESCRIPTOR Peritoneum EXPLODE ALL AND INREGISTER #11 Transperitoneal AND INREGISTER #12 retroperitoneal AND INREGISTER	30 Nov 2020: 31

(Continued)

	#13 #9 OR #10 OR #11 OR #12 #14 #8 AND #13	
CENTRAL (The Cochrane Library)	#1 MESH DESCRIPTOR Aortic Aneurysm EXPLODE ALL TREES 773 #2 MESH DESCRIPTOR Aneurysm, Ruptured EXPLODE ALL TREES 189 #3 MESH DESCRIPTOR Aorta, Abdominal EXPLODE ALL TREES 334 #4 AAA*:TI,AB,KY 1142 #5 (aneurysm* adj4 (abdom* or thoracoabdom* or thoraco-abdom* or aort*)):TI,AB,KY 948 #6 (aort* adj3 (ballon* or dilat* or bulg*)):TI,AB,KY 125 #7 (abdom* adj3 (balloon* or dilat* or bulg*)):TI,AB,KY 48 #8 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 2326 #9 MESH DESCRIPTOR Retroperitoneal Space EXPLODE ALL TREES 97 #10 MESH DESCRIPTOR Peritoneum EXPLODE ALL TREES 498 #11 Transperitoneal:TI,AB,KY 280 #12 retroperitoneal:TI,AB,KY 765 #13 #9 OR #10 OR #11 OR #12 1418 #14 #8 AND #13 38 #15 01/01/2015 TO 30/11/2020:CD 904604 #16 #14 AND #15 7	30 Nov 2020: 7
MEDLINE In-process and other non-indexed citations and MEDLINE 1950-present (Ovid SP)	1 exp Aortic Aneurysm/ 2 exp Aneurysm, Ruptured/ 3 exp Aorta, Abdominal/ 4 AAA*.ti,ab. 5 (aneurysm* adj4 (abdom* or thoracoabdom* or thoraco-abdom* or aort*)).ti,ab. 6 (aort* adj3 (ballon* or dilat* or bulg*)).ti,ab. 7 (abdom* adj3 (balloon* or dilat* or bulg*)).ti,ab. 8 or/1-7 9 Retroperitoneal Space/ 10 Peritoneum/ 11 Transperitoneal.ti,ab. 12 retroperitoneal.ti,ab. 13 or/9-12 14 8 and 13 15 randomized controlled trial.pt.	30 Nov 2020: 29

(Continued)

	16 controlled clinical trial.pt. 17 randomized.ab. 18 placebo.ab. 19 drug therapy.fs. 20 randomly.ab. 21 trial.ab. 22 groups.ab. 23 or/15-22 24 exp animals/ not humans.sh. 25 23 not 24 26 14 and 25 27 (2015* or 2016* or 2017* or 2018* or 2019* or 2020*).ed. 28 26 and 27	
EMBASE 1974 to present	1 exp aortic aneurysm/ 2 exp aneurysm rupture/ 3 exp abdominal aorta/ 4 AAA*.ti,ab. 5 (aneurysm* adj4 (abdom* or thoracoabdom* or thoraco-abdom* or aort*)).ti,ab. 6 (aort* adj3 (ballon* or dilat* or bulg*)).ti,ab. 7 (abdom* adj3 (balloon* or dilat* or bulg*)).ti,ab. 8 or/1-7 9 exp retroperitoneum/ 10 exp peritoneum/ 11 Transperitoneal.ti,ab. 12 retroperitoneal.ti,ab. 13 or/9-12 14 8 and 13 15 randomized controlled trial/ 16 controlled clinical trial/ 17 random$.ti,ab. 18 randomization/ 19 intermethod comparison/ 20 placebo.ti,ab.	30 Nov 2020: 78

(Continued)

	21 (compare or compared or comparison).ti. 22 ((evaluated or evaluate or evaluating or assessed or assess) and (compare or compared or comparing or comparison)).ab. 23 (open adj label).ti,ab. 24 ((double or single or doubly or singly) adj (blind or blinded or blindly)).ti,ab. 25 double blind procedure/ 26 parallel group$1.ti,ab. 27 (crossover or cross over).ti,ab. 28 ((assign$ or match or matched or allocation) adj5 (alternate or group$1 or intervention$1 or patient$1 or subject$1 or participant$1)).ti,ab. 29 (assigned or allocated).ti,ab. 30 (controlled adj7 (study or design or trial)).ti,ab. 31 (volunteer or volunteers).ti,ab. 32 trial.ti. 33 or/15-32 34 14 and 33 35 (2015* or 2016* or 2017* or 2016* or 2017* or 2018* or 2019* or 2020*).dc. 36 34 and 35	
CINAHL	S31 S29 AND S30 S30 EM 2015 OR EM 2016 OR EM 2017 OR EM 2018 OR EM 2019 OR EM 2020 S29 S13 AND S28 S28 S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 S27 MH "Random Assignment" S26 MH "Triple-Blind Studies" S25 MH "Double-Blind Studies" S24 MH "Single-Blind Studies" S23 MH "Crossover Design" S22 MH "Factorial Design" S21 MH "Placebos" S20 MH "Clinical Trials" S19 TX "multi-centre study" OR "multi-center study" OR "multicentre study" OR "multicenter study" OR "multi-site study" S18 TX crossover OR "cross-over" S17 AB placebo* S16 TX random*	30 Nov 2020:4

(Continued)

	S15 TX trial* S14 TX "latin square" S13 S7 AND S12 S12 S8 OR S9 OR S10 OR S11 S11 TX retroperitoneal S10 TX Transperitoneal S9 (MH "Peritoneum+") S8 (MH "Retroperitoneal Space") S7 S1 OR S2 OR S3 OR S4 OR S5 OR S6 S6 TX abdom* n3 (balloon* or dilat* or bulg*) S5 TX aort* n3 (ballon* or dilat* or bulg*) S4 (aneurysm* n4 (abdom* or thoracoabdom* or thoraco-abdom* or aort*)) S3 TX AAA* S2 (MH "Aorta, Abdominal") S1 (MH "Aortic Aneurysm+")	
ClinicalTrials.gov (www.clinicaltrials.gov)	Transperitoneal OR retroperitoneal | AAA OR Aortic Aneurysm OR Aneurysm, Ruptured OR Aorta, Abdominal	30 Nov 2020: 1
ICTRP	Transperitoneal OR retroperitoneal | AAA OR Aortic Aneurysm OR Aneurysm, Ruptured OR Aorta, Abdominal	30 Nov 2020: 0

WHAT'S NEW

Date	Event	Description
15 January 2021	New citation required but conclusions have not changed	Searches updated. Two new studies excluded. One previously excluded study reassessed as included. One additional publication to an included study reassessed as a different study and excluded. New authors joined team. Text updated to reflect current Cochrane recommendations. No change to conclusions.
15 January 2021	New search has been performed	Searches updated. Two new studies excluded. One previously excluded study reassessed as included. One additional publication to an included study reassessed as a different study and excluded.

HISTORY

Protocol first published: Issue 2, 2013
Review first published: Issue 2, 2016

CONTRIBUTIONS OF AUTHORS

FM: screened the studies for inclusion, interpreted the analyses, drafted the review manuscript, updated the review.
KYH: extracted data from the included trials.
BZ: extracted data from the included trials.
QQG: data management for the review.
FC: screened the studies for inclusion.
LZ: quality assessment of trials.
MW: interpreted the analyses.
LYF: quality assessment of trials.
ZW: development of final review and review update.
JWY: development of final review and review update.
WZ: wrote to authors of papers for additional information.
BM: developed and performed the review authors' search strategy, interpreted the analyses, drafted the review manuscript, updated the review.

DECLARATIONS OF INTEREST

FM: has no known conflicts of interest.
KYH: has no known conflicts of interest.
BZ: has no known conflicts of interest.
QQG: has no known conflicts of interest.
FC: has declared that their institution received money from the Natural Science Foundation of China (Number:81873184) to support this review. This is not a conflict of interest.
LZ: has no known conflicts of interest.
MW: has no known conflicts of interest.
LYF: has no known conflicts of interest.
ZW: has no known conflicts of interest.
JWY: has no known conflicts of interest.
WZ: has no known conflicts of interest.
BM: has no known conflicts of interest.

SOURCES OF SUPPORT

Internal sources

- No sources of support provided

External sources

- Chief Scientist Office, Scottish Government Health Directorates, The Scottish Government, UK

  The Cochrane Vascular editorial base is supported by the Chief Scientist Office.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

2021

For this update, one previously excluded study was included (Volta 2003). This study had been excluded as it did not report any primary outcomes. In keeping with current Cochrane recommendations, we reassessed it as included as it meets the inclusion criteria. In addition, one publication, previously assessed as an additional publication to included study Laohapensang 2005a, was reassessed as a different study and subsequently excluded for not having an eligible intervention (Laohapensang 2005b).

INDEX TERMS

Medical Subject Headings (MeSH)

Aortic Aneurysm, Abdominal [*surgery]; Elective Surgical Procedures [*methods] [mortality]; Peritoneum; Randomized Controlled Trials as Topic; Retroperitoneal Space

MeSH check words

Humans