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Intravenous versus inhalation anaesthesia for one-lung ventilation

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ABSTRACT

Background

This is an update of a Cochrane Review first published in *The Cochrane Library*, Issue 2, 2008.

The technique called *one-lung ventilation* can confine bleeding or infection to one lung, prevent rupture of a lung cyst or, more commonly, facilitate surgical exposure of the unventilated lung. During one-lung ventilation, anaesthesia is maintained either by delivering an inhalation anaesthetic to the ventilated lung or by infusing an intravenous anaesthetic. It is possible that the method chosen to maintain anaesthesia may affect patient outcomes. Inhalation anaesthetics may impair hypoxic pulmonary vasoconstriction (HPV) and increase intrapulmonary shunt and hypoxaemia.

Objectives

The objective of this review was to evaluate the effectiveness and safety of intravenous versus inhalation anaesthesia for one-lung ventilation.

Search methods

We searched the Cochrane Central Register of Controlled Trials (CENTRAL); *The Cochrane Library* (2012, Issue 11); MEDLINE (1966 to November 2012); Embase (1980 to November 2012); Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS, 1982 to November 2012) and ISI web of Science (1945 to November 2012), reference lists of identified trials and bibliographies of published reviews. We also contacted researchers in the field. No language restrictions were applied. The date of the most recent search was 19 November 2012. The original search was performed in June 2006.

We reran the search in CENTRAL, MEDLINE, Embase, LILACS, and ISI web of Science in February 2017 and found four potential studies of interest which have been added to a list of 'Studies awaiting Classification' and will be incorporated into the formal review findings during the review update.

Selection criteria

We included randomized controlled trials and quasi-randomized controlled trials of intravenous (e.g. propofol) versus inhalation (e.g. isoflurane, sevoflurane, desflurane) anaesthesia for one-lung ventilation in both surgical and intensive care participants. We excluded studies of participants who had only one lung (i.e. pneumonectomy or congenital absence of one lung).

Data collection and analysis

Two review authors independently assessed trial quality and extracted data. We contacted study authors for additional information.

Main results

We included in this updated review 20 studies that enrolled 850 participants, all of which assessed surgical participants- no studies investigated one-lung ventilation performed outside the operating theatre. No evidence indicated that the drug used to maintain anaesthesia during one-lung ventilation affected participant outcomes. The methodological quality of the included studies was difficult to assess as it was reported poorly, so the predominant classification of bias was 'unclear'.

Authors' conclusions

Very little evidence from randomized controlled trials suggests differences in participant outcomes with anaesthesia maintained by intravenous versus inhalational anaesthesia during one-lung ventilation. If researchers believe that the type of drug used to maintain anaesthesia during one-lung ventilation is important, they should design randomized controlled trials with appropriate participant outcomes, rather than report temporary fluctuations in physiological variables.

PLAIN LANGUAGE SUMMARY

Intravenous versus inhalation anaesthesia for one-lung ventilation

Clinicians may choose to ventilate only one of a patient's two lungs either during surgery or during a period of intensive care. Possible reasons are to facilitate the performance of surgery, to prevent lung rupture, and to prevent contamination of one lung by the other. During one-lung ventilation, anaesthesia is maintained by delivery of an inhalation anaesthetic, such as sevoflurane, to the ventilated lung, or by infusion of an intravenous anaesthetic, for example, propofol. It is possible that the method chosen to maintain anaesthesia may affect patient outcomes. We included 20 studies that enrolled 850 participants in this updated systematic review. The methodological quality of the included studies was uncertain because of poor reporting. No evidence indicated that the drug used to maintain anaesthesia during one-lung ventilation affected patient outcomes. Researchers should include outcomes that are important to participants when assessing the effects of anaesthetic technique during one-lung ventilation. These include adverse postoperative effects, death and intraoperative awareness.

We reran the search in February 2017 and found four potential studies of interest which have been added to a list of 'Studies awaiting Classification' and will be incorporated into the formal review findings during the review update.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON [\[Explanation\]](#)

Intravenous compared with inhalation anaesthesia for one-lung ventilation			
Patient or population: participants ventilated by one-lung Settings: Intervention: intravenous anaesthesia Comparison: inhalation anaesthesia			
Outcomes	Relative effect (95% CI)	No. of participants (studies)	Quality of the evidence (GRADE)
Death (at one month) Follow-up: 5 days (De Conno 2009)	RR 0 (0 to 0)	54 (1 study)	⊕○○○ very low
Adverse postoperative outcomes Follow-up: 5 days (De Conno 2009); 20 minutes after re-summing 2LV (Huang 2008) and 15 min after termination of OLV (Egawa 2009).	RR1.56 (1.07 to 2.29)	132 (3 studies)	⊕⊕○○ low
*The basis for the assumed risk (e.g. the median control group risk across studies) is provided in footnotes. The corresponding risk (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI). CI: Confidence interval; RR: Risk Ratio.			
GRADE Working Group grades of evidence: High quality: Further research is very unlikely to change our confidence in the estimate of effect. Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate. Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. Very low quality: We are very uncertain about the estimate.			

BACKGROUND

Description of the condition

This is an update of a Cochrane Review first published in *The Cochrane Library*, Issue 2, 2008 ([Bassi 2008](#)). The original review included nine studies ([Abay 2000](#); [Beck 2001](#); [El-Hakeem 2003](#); [Gasowska 1999](#); [Kellow 1995](#); [Pilotti 1999](#); [Rees 1984](#); [Reid 1996](#); [Spies 1991](#)), and no evidence from randomized controlled trials

showed differences in patient outcomes with anaesthesia maintained by intravenous versus inhalational anaesthesia during one-lung ventilation.

Clinicians may choose to ventilate only one of a patient's two lungs during surgery or during a period of intensive care. This technique, called *one-lung ventilation* (OLV), can confine bleeding or infection to one lung, prevent rupture of a lung cyst or, more commonly, facilitate surgical exposure of the unventilated lung ([Morgan 2001](#)). During OLV, anaesthesia is maintained by delivery

of an inhalation anaesthetic to the ventilated lung or by infusion of an intravenous anaesthetic. It is possible that the method chosen to maintain anaesthesia can affect patient outcomes by modifying the physiological changes that occur during OLV.

Blood that flows through the unventilated lung cannot be oxygenated and, therefore, contributes to arterial hypoxaemia. Blood flow through the unventilated lung can be reduced by factors acting outside the lung tissue or by factors acting inside the lung. In addition, impedance of blood flow through the ventilated lung will indirectly affect blood supply to the unventilated lung. Blood supply to the unventilated lung may be reduced by mechanical compression and distortion of the pulmonary vessels, by reduced pulmonary arterial pressure or by reduced right ventricular stroke volume. Blood flow within lung tissue may be reduced by mechanical distortion or by constriction of smaller pulmonary vessels. Pulmonary arterioles contract when the oxygen tension is low, and inhalation anaesthetics and intravenous anaesthetics may affect this 'hypoxic pulmonary vasoconstriction' differently (Friedlander 1994).

Clinically applicable measures used to maintain oxygenation during OLV include high oxygen concentration of inspired air, intermittent inflation or continuous positive airway pressure to the unventilated lung and positive end-expiratory pressure to the ventilated lung (Saito 2000).

Description of the intervention

The inhalation anaesthetics seem to impair hypoxic pulmonary vasoconstriction (HPV) more than intravenous anaesthetics by increasing intrapulmonary shunt and hypoxaemia (Domino 1986; Loer 1995; Pruszkowski 2007), although this effect might be mediated by an alveolar inflammatory response (Schilling 2011).

How the intervention might work

The level of oxygenation during one-lung ventilation may be altered by the type of anaesthesia agent used. Abolition of hypoxic pulmonary vasoconstriction by anaesthetic agents has been suggested as a cause of hypoxaemia during anaesthesia. Early studies demonstrated that inhalation anaesthetics inhibited this vasoconstriction whilst injectable agents did not (Marshall 1984).

Studies have compared different types of inhalation agents and inhalation anaesthesia with intravenous agents (Abe 1998a; Benumof 1987; Carlsson 1987; Kellow 1995). No systematic review has summarized the results of these trials.

Why it is important to do this review

Currently there is no straightforward recommendation based on systematic reviews of previous trials of the effects of anaesthetic agents for one-lung ventilation. The rate of death or morbidity

might be particularly high after OLV, so any intervention that reduces this risk would be useful (Harpole 1999; Wada 1998).

OBJECTIVES

The objective of this review was to evaluate the effectiveness and safety of intravenous versus inhalation anaesthesia for one-lung ventilation.

METHODS

Criteria for considering studies for this review

Types of studies

We included all randomized and quasi-randomized controlled trials.

Types of participants

- We included participants ventilated by one lung.
- We included both surgical and intensive care participants.
- We excluded participants who had only one lung (i.e. pneumonectomy or congenital absence of one lung).

Types of interventions

Maintenance of anaesthesia during one-lung ventilation with inhalation anaesthesia (e.g. isoflurane, sevoflurane, desflurane) versus total intravenous anaesthesia (e.g. propofol).

Types of outcome measures

Primary outcomes

We measured the following primary outcomes:

- Mortality rate (during the total observation period);
- Adverse postoperative outcomes, such as brain damage, heart failure, myocardial infarction and blood transfusion (analysed separately); and
- Intraoperative awareness (as subsequently reported by the participant).

Secondary outcomes

Our secondary outcomes were:

- death at one month and six months;
- abandonment of one-lung technique;
- length of stay in hospital; and
- economic analysis (by narrative).

Search methods for identification of studies

We conducted systematic searches for randomized controlled trials. No language, publication year or publication status restrictions were applied. The date of the last search was February 2012.

Electronic searches

We searched the Cochrane Central Register of Controlled Trials (CENTRAL); *The Cochrane Library* (2012, Issue 11); MEDLINE (1966 to November 2012); Embase (1980 to November 2012); Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS, 1982 to November 2012) and ISI Web of Science (1945 to November 2012).

We reran the search in CENTRAL, MEDLINE, Embase, LILACS, and ISI web of Science on February 7, 2017 and found four potential studies of interest which have been added to a list of 'Studies Awaiting Classification' and will be incorporated into the formal review findings during the review update.

Please see [Appendix 1](#) for our bibliographic search strategies.

Searching other resources

We searched the reference lists of identified relevant studies for additional citations; contacted specialists in the field and authors of the included trials for unpublished data and contacted pharmaceutical manufacturers to verify the data and obtain additional unpublished data.

Data collection and analysis

Selection of studies

Two review authors (NSPM and RPED) independently screened trials identified by the literature search, extracted the data, assessed trial quality and analysed the results. If consensus was not reached, we did not include the data from the trials in question unless and until the authors of those trials were able to resolve the contentious issues.

Data extraction and management

Two review authors (NSPM and RPED) independently extracted data. We resolved any discrepancies by discussion. We used a standard form (see [Appendix 2](#)) to extract the following information: characteristics of the study (design, methods of randomization); participants; interventions and outcomes (types of outcome measures, timing of outcomes, adverse events). Our data extraction form was based on recommendations made by the Cochrane Anaesthesia Review Group.

Assessment of risk of bias in included studies

We used the new risk of bias approach for Cochrane Reviews to assess study quality ([Higgins 2011](#)). Two review authors (NSPM and RPED) independently assessed the following six separate criteria. We resolved any discrepancies by discussion:

- Adequate sequence generation;
- Allocation concealment;
- Blinding;
- Incomplete outcome data;
- Selective outcome reporting; and
- Other sources of bias.

In the first step, we copied information relevant for making a judgement on a criterion from the original publication into an assessment table. If additional information was available from study authors, we entered this in the table along with an indication that this was unpublished information. Two review authors (NSPM and RPED) independently made a judgment as to whether the risk of bias for each criterion was considered to be 'low', 'uncertain' or 'high'. We resolved disagreements by discussion. We considered that trials categorized as 'low risk' for all six criteria were low bias risk trials.

Measures of treatment effect

Binary outcomes

For dichotomous data, we used the risk ratio (RR) as the effect measure with 95% confidence intervals (CIs).

Continuous outcomes

For continuous data, we presented the results as mean differences (MDs) with 95% CIs. When pooling data across studies, we estimated the MD if the outcomes were measured in the same way. We used the standardized mean difference (SMD) to combine trials that used different methods to measure the same outcome.

Unit of analysis issues

The unit of analysis was one outcome for each participant.

Dealing with missing data

We assumed that participants who dropped out were nonresponders.

Assessment of heterogeneity

We intended to quantify inconsistency among the pooled estimates using the I^2 statistic. This illustrates the percentage of variability in effect estimates that results from heterogeneity rather than sampling error (Higgins 2003; Higgins 2011). We also intended to examine forest plots for CI overlap and to calculate the Chi^2 test for homogeneity with a 10% level of significance. We used I^2 statistical values to categorize heterogeneity: less than 25%; 25% to 50%; 50% to 75% and greater than 75%.

Assessment of reporting biases

Apart from assessing the risk of selective outcome reporting considered under assessment of risk of bias in included studies, we intended to assess the effects of small studies by using funnel plots, when at least 10 trials were identified.

Data synthesis

We planned to use the fixed-effect model to analyse data. If I^2 was greater than 50%, we intended to use random-effects models. We planned to undertake quantitative analyses of outcomes on an intention-to-treat basis.

Subgroup analysis and investigation of heterogeneity

We planned the following subgroup analyses: different intravenous anaesthetics; different dosages of intravenous anaesthetics; different combinations of anaesthetics; different patient positions (e.g. lateral, supine) and different durations of anaesthesia (e.g. 20, 30 or 45 minutes). We also planned to perform subgroup analyses for different inhalation anaesthetics; different types of surgery (e.g. open thoracotomy, thoracoscopic); different criteria and diagnoses for admission to critical care units and the different units involved. Finally, we planned to perform subgroup analyses for studies of participants in intensive care compared with studies of participants

undergoing surgery and for the criteria used to diagnose adverse events. However, the number of studies was insufficient for performance of any of these subgroup analyses.

Sensitivity analysis

We planned to perform sensitivity analyses to explore the causes of heterogeneity and the robustness of the results by means of the following factors:

- Trials with low risk of bias versus those with high risk of bias; and
- Rates of withdrawal for each outcome (< 20% vs greater than and/or equal to 20%).

However, the planned analyses could not be carried out because of lack of relevant data in the included studies.

RESULTS

Description of studies

See the 'Characteristics of included studies' table.

Results of the search

We identified 2099 citations from the database searches (see Figure 1 for search results). After screening by title and abstract, we obtained full-paper copies for 46 citations that were potentially eligible for inclusion in the review. Of these, 36 did not fulfil our inclusion criteria and were excluded for the reasons described in the 'Characteristics of excluded studies' table (see Figure 1). For the first update of the review in 2012, 705 references (post deduplication) were identified by the searches. We selected 12 references for careful reading and obtained them in full text when available. After assessing the full articles, we included 11 studies (De Conno 2009; Egawa 2009; Fukuoka 2009; Huang 2008; Iwata 2008; Pruszkowski 2007; Rutkowska 2009; Schilling 2011; Schwarzkopf 2009; Steurer 2007; Yamada 2008) and added one study (Celik 2009) to the exclusion table.

Figure 1. Study flow diagram for the original review published in Issue 2, 2008 (Bassi 2008).

We reran the search on February 7, 2017. The new search identified 1093 citations, and there were four potential included studies ([Erturk 2014](#); [Hammouda 2013](#); [Potonik 2014](#); [Wakabayashi 2014](#)). We will deal with the pending studies of interest when we update the review. Potential new studies of interest were added to a list of 'Studies awaiting classification' and will be incorporated into the formal review findings during the review update. See [Figure 2](#)

Figure 2. Study flow diagram for the update published in 2013 and the updated search in 2017

Included studies

We included 20 studies (Abay 2000; Beck 2001; De Conno 2009; Egawa 2009; El-Hakeem 2003; Fukuoka 2009; Gasowska 1999; Huang 2008; Iwata 2008; Kellow 1995; Pilotti 1999; Pruszkowski 2007; Rees 1984; Reid 1996; Rutkowska 2009; Schilling 2011; Schwarzkopf 2009; Spies 1991; Steurer 2007; Yamada 2008) in this review. These studies enrolled a total of 850 participants (please see the 'Characteristics of included studies' table).

Design of the studies

All included studies claimed to be randomized controlled trials.

Types of study participants

Abay 2000; Gasowska 1999 and Yamada 2008 included healthy participants with American Society of Anesthesiology (ASA) physical status one and two (ASA I and II) who were scheduled for thoracotomy, video-assisted thoracoscopic surgery (inside the right hemithorax) and lobectomy, respectively. Pilotti 1999 and Spies 1991 included less healthy participants (ASA III). De Conno 2009 evaluated adults with ASA status I to III scheduled to undergo elective thoracic surgery with lung resection performed through thoracotomy or thoracoscopy. Egawa 2009 did not specify ASA status, but this study assessed participants scheduled for elective lung surgery in the lateral position. Fukuoka 2009 included participants with ASA status I and II requiring OLV during anaesthesia for selective thoracic surgery. Huang 2008 included participants with ASA physical status I and II between 20 and 60 years of age scheduled to undergo thoracoscopic surgery or oesophageal surgery, with limited lung trauma but lengthy OLV. Iwata 2008 assessed only participants scheduled for elective thoracic procedures in the lateral position. Pruszkowski 2007 assessed participants between 18 and 70 years of age who were undergoing lobectomy requiring OLV, with ASA I to III status. Rutkowska 2009 assessed participants with ASA grade I to III status for elective lobectomy. Schilling 2011 assessed participants scheduled for open thoracic surgery and OLV. In Schwarzkopf 2009, participants were included if ASA grade I to III and scheduled for thoracic surgery, with limited lung trauma but lengthy OLV. The other studies did not report ASA physical status but included participants scheduled for various thoracic operations (Beck 2001; El-Hakeem 2003;

Kellow 1995; Reid 1996), major thoracic surgery (Steurer 2007) and elective lung resection for carcinoma (Rees 1984).

Types of intervention

Studies compared one or more inhalation anaesthetics (sevoflurane, desflurane, isoflurane, halothane, enflurane) with one of three intravenous anaesthetics (propofol, ketamine, thiopental) for maintaining anaesthesia during one-lung ventilation. Most studies used one of these intravenous drugs (or etomidate) to induce anaesthesia in all participants, including those in whom inhalation agents were used to maintain anaesthesia.

Types of outcome measures and duration of follow-up

Studies reported a range of intraoperative physiological measurements, including haemodynamic and blood gas variables, as well as concentrations of inflammatory mediators.

De Conno 2009 also reported adverse events for five postoperative days. Egawa 2009 reported postoperative cognitive function.

Awaiting assessment

Egawa 2009 is an ongoing trial, and we will include its final analysis in the next update of this review.

Excluded studies

We excluded 37 studies; see the 'Characteristics of excluded studies' table for full details.

Studies awaiting classification

We reran the search in February 2017 and found four potential studies of interest. There are four studies awaiting classification (Erturk 2014; Hammouda 2013; Potočnik 2014; Wakabayashi 2014). These studies will be incorporated into the formal review findings during the review update. For further details of the studies see the table [Studies awaiting classification](#).

Risk of bias in included studies

See [Figure 3](#) and [Figure 4](#).

Figure 3. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Figure 4. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

	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 bias
Abay 2000	?	?	?	?	+	?	?
Beck 2001	?	?	?	?	+	+	?
De Conno 2009	?	?	?	+	+	+	?
Egawa 2009	+	+	+	+	+	?	+
El-Hakeem 2003	?	?	?	?	?	+	?
Fukuoka 2009	+	+	?	+	+	+	+
Gasowska 1999	?	?	?	?	?	+	?
Huang 2008	+	+	+	+	+	+	+
Iwata 2008	+	?	?	?	?	+	?
Kellow 1995	?	?	?	-	+	+	?
Pilotti 1999	?	?	?	?	?	+	?
Pruszkowski 2007	+	-	?	-	-	+	?
Rees 1984	+	?	?	?	+	+	?
Reid 1996	+	?	?	?	-	+	?
Rutkowska 2009	?	?	?	?	?	?	?
Schilling 2011	+	+	-	+	+	+	?
Schwarzkopf 2009	?	?	?	?	+	+	?
Spies 1991	?	?	?	?	?	+	?
Steurer 2007	?	?	?	?	?	?	?
Yamada 2008	?	?	?	?	+	+	?

Allocation

Eleven studies (Abay 2000; Beck 2001; El-Hakeem 2003; Gasowska 1999; Kellow 1995; Pilotti 1999; Rutkowska 2009; Schwarzkopf 2009; Spies 1991; Steurer 2007; Yamada 2008) did not describe the procedures for random group allocation and allocation concealment.

Huang 2008 used a random table for allocation, and another anaesthesiologist, who was not involved with the study, performed the allocation concealment.

Egawa 2009 used a computer-generated sequence and envelopes to conceal the sequence.

Two studies (De Conno 2009; Fukuoka 2009) performed a block randomization, generated by computer, and the sequence was concealed by sealed opaque envelopes.

Three studies (Iwata 2008; Rees 1984; Reid 1996) reported only the generation of the allocation sequence (computer-generated random numbers) but did not describe the method used to conceal the sequence.

Pruszkowski 2007 used a computer-generated randomization list, but the authors did not conceal the sequence.

Schilling 2011 used a computer-generated random sequence, and the randomization list was password-protected and concealed in white sealed envelopes.

Blinding

Thirteen studies (Abay 2000; Beck 2001; El-Hakeem 2003; Gasowska 1999; Iwata 2008; Pilotti 1999; Rees 1984; Reid 1996; Rutkowska 2009; Schwarzkopf 2009; Spies 1991; Steurer 2007; Yamada 2008) did not describe whether participants, personnel or assessors of outcomes were blinded to treatment allocation.

Although the De Conno 2009 study did not report in the article whether there was blinding, this item was retrieved when the authors confirmed by email that only the assessors were blinded. This study did not report on the blinding of participants and personnel.

The Egawa 2009 study reported that participants and assessors were blinded, but investigators were not.

In two studies (Fukuoka 2009; Huang 2008), the anaesthesiologist who assessed the study data was blinded to the group assignments, but the studies did not report on blinding of participants and personnel. Participants from Huang 2008 were also blinded to treatment allocation.

In two studies (Kellow 1995; Pruszkowski 2007), all measurements were made by the same observer, who was not blinded to the anaesthetic regimen used. The authors did not discuss blinding of participants and personnel.

Schilling 2011 reported that participants were blinded, but anaesthesiologists who provided the anaesthetic were not. However, the

individuals who performed the immunological and pathohistological analyses were blinded to the study protocol.

Incomplete outcome data

Nine studies (Abay 2000; Beck 2001; De Conno 2009; Fukuoka 2009; Kellow 1995; Pruszkowski 2007; Rees 1984; Reid 1996; Schwarzkopf 2009) reported the number of withdrawals or drop-outs.

In Abay 2000, all participants completed the follow-up. Beck 2001 excluded one participant from each group because of hypotension that was treated with vasoactive drugs during induction of anaesthesia. De Conno 2009 reported 10 and six dropouts with sevoflurane and propofol, respectively. Fukuoka 2009 excluded four participants because of re-inflation of the nondependent lung. No drop-outs were reported in Huang 2008. Kellow 1995 excluded one participant in the isoflurane group because of oxygen desaturation that did not resolve when the inspired oxygen concentration was increased. Pruszkowski 2007 excluded 15 participants: eight and seven in the propofol and sevoflurane groups, respectively. Rees 1984 excluded three participants because the duration of OLV was too short for sufficient data to be gathered. Reid 1996 excluded 10 participants: three because oxygen saturation fell below 90% and seven because surgery required ventilation to both lungs. In Schwarzkopf 2009, two and four participants were withdrawn in the sevoflurane and propofol groups, respectively. In Schilling 2011, reporting was complete.

Egawa 2009 is an ongoing study: so far, less than 10% of participants have been excluded.

The other eight studies did not report withdrawals and drop-outs (El-Hakeem 2003; Gasowska 1999; Iwata 2008; Pilotti 1999; Rutkowska 2009; Spies 1991; Steurer 2007; Yamada 2008).

Selective reporting

No evidence of selective reporting was noted in the following included studies (Beck 2001; De Conno 2009; El-Hakeem 2003; Fukuoka 2009; Gasowska 1999; Huang 2008; Iwata 2008; Kellow 1995; Pilotti 1999; Pruszkowski 2007; Rees 1984; Reid 1996; Schilling 2011; Schwarzkopf 2009; Spies 1991; Yamada 2008). We could not determine whether selective reporting occurred in Abay 2000; Egawa 2009; Rutkowska 2009; and Steurer 2007.

Other potential sources of bias

No evidence of other biases was found in any of the included studies.

Effects of interventions

See: [Summary of findings for the main comparison](#)

With the exception of [Rees 1984](#), who reported results from oxygen delivery, all other studies included in the original review ([Abay 2000](#); [Beck 2001](#); [El-Hakeem 2003](#); [Gasowska 1999](#); [Kellow 1995](#); [Pilotti 1999](#); [Reid 1996](#); [Spies 1991](#)) did not report on any of the outcomes listed in the protocol. Hence it was not possible to carry out a meta-analysis of studies from the original review. However, the new trials ([De Conno 2009](#); [Egawa 2009](#); [Huang 2008](#); [Iwata 2008](#); [Pruszkowski 2007](#)) reported on adverse postoperative outcomes and death.

Propofol versus sevoflurane

No differences in rates of postoperative adverse events were reported by two studies ([De Conno 2009](#); [Egawa 2009](#)).

[De Conno 2009](#) reported no deaths one month after surgery (0/27 and 0/27).

Propofol versus isoflurane

No adverse postoperative outcomes were described in [Huang 2008](#) (0/15 and 0/15).

DISCUSSION

Summary of main results

This review examined the effectiveness and safety of intravenous versus inhalation anaesthesia for one-lung ventilation. We included 20 studies with a total of 850 participants and a mean of 42 participants per study (range 18 to 80), although most of the included studies evaluated between 30 and 40 participants. We did not find any randomized controlled trial that reported on participant outcomes. The quality of the included studies was very poor; as a result, it was not possible to use analytical methods such as meta-analysis and exploration of heterogeneity ([Summary of findings for the main comparison](#)).

Overall completeness and applicability of evidence

Because of our comprehensive search strategy and contact with experts in the field, we are confident that we have mapped most clinical trials comparing inhalation with intravenous drugs to maintain anaesthesia during one-lung ventilation.

Quality of the evidence

The methodological quality of the included studies was generally unclear ([Abay 2000](#); [Beck 2001](#); [El-Hakeem 2003](#); [Gasowska 1999](#); [Iwata 2008](#); [Kellow 1995](#); [Pilotti 1999](#); [Rees 1984](#); [Reid 1996](#); [Rutkowska 2009](#); [Schwarzkopf 2009](#); [Spies 1991](#); [Steurer 2007](#); [Yamada 2008](#)). Six studies were categorized as having low risk of bias ([De Conno 2009](#); [Egawa 2009](#); [Fukuoka 2009](#); [Huang 2008](#); [Pruszkowski 2007](#); [Schilling 2011](#)). Methodological aspects of four studies had a high risk of introducing bias: incomplete outcome data ([De Conno 2009](#); [Reid 1996](#)); poor allocation concealment ([Pruszkowski 2007](#)) and inadequate blinding of outcome assessment ([Kellow 1995](#); [Pruszkowski 2007](#)).

Potential biases in the review process

A comprehensive search strategy was applied to identify all potential studies and their reports. However, although we emailed the first author of 9 studies ([De Conno 2009](#); [Egawa 2009](#); [Fukuoka 2009](#); [Huang 2008](#); [Iwata 2008](#); [Pruszkowski 2007](#); [Rutkowska 2009](#); [Schilling 2011](#); [Schwarzkopf 2009](#)) to ask for clarification about methodological issues and to provide us with further information, only six ([De Conno 2009](#); [Egawa 2009](#); [Fukuoka 2009](#); [Huang 2008](#); [Pruszkowski 2007](#); [Schilling 2011](#)) responded.

Agreements and disagreements with other studies or reviews

No systematic review has compared the results of intravenous versus inhalation anaesthesia for participants undergoing OLV.

[Zeng 2010](#) conducted a systematic review to evaluate the effects of thoracic epidural anaesthesia combined with general anaesthesia on arterial oxygenation and intrapulmonary shunting during one-lung ventilation. However, no abstract was available. We have contacted the authors to request the full-text article.

A systematic review that focused on postoperative recovery and complications found that early recovery was faster in the desflurane and sevoflurane groups in adult participants, although the authors included only English studies published in the MEDLINE database ([Gupta 2004](#)).

[Ozkose 2001](#) performed an economic evaluation to assess sevoflurane and isoflurane anaesthesia on recovery and cost analyses after laminectomy and discectomy. The authors found that total intravenous anaesthesia was associated with highest intraoperative cost, faster recovery and the least frequent postoperative side effects.

AUTHORS' CONCLUSIONS

Implications for practice

Very little evidence is available from randomized controlled trials to show differences in participant outcomes for anaesthesia maintained by intravenous versus inhalation anaesthesia during one-lung ventilation.

Implications for research

Further research should be carried out only if participant outcomes are measured, including deaths and morbidity such as brain damage, heart failure, myocardial infarction, intraoperative awareness and requirement for blood transfusion.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Abay 2000

Methods	Design: RCT. Multicentre or single-centre: not reported. Period: not reported. Sample size: not reported. Follow-up: before intubation and 20 min after the onset of one-lung ventilation	
Participants	N: 20 participants. Sex: not reported. Age, y (mean): not reported. Setting: not reported. Inclusion criteria: ASA I and II scheduled for thoracotomy. Exclusion criteria: not reported	
Interventions	Sevoflurane (2%) in group 1 versus propofol (1 mg/kg/h) and alfentanil (1.5 µg/kg/min) in group 2	
Outcomes	Haemodynamic measurement and blood gas values	
Notes	Anaesthesia was induced with propofol in all participants	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	All participants completed the study
Selective reporting (reporting bias)	Unclear risk	Not reported (abstract)
Other bias	Unclear risk	Not reported

Beck 2001

Methods	Design: RCT. Multicentre or single-centre: not reported. Period: not reported. Sample size: reported. Follow-up: after 30 min of TLV in the supine position; after 30 min stable OLV in the supine position and after opening of the pleura in the lateral decubitus position and before surgical manipulation of the lung (OLV)	
Participants	N: 40 participants. Sex: group 1: 6 females and 13 males; group 2: 7 females and 12 males. Age, y (mean): sevoflurane group 58 and propofol group 62. Setting: not reported. Inclusion criteria: subjects requiring OLV for thoracic surgery. Exclusion criteria: not reported	
Interventions	Propofol was infused continuously at an initial rate of 9 mg/kg ⁻¹ /h ⁻¹ reduced to 6 mg/kg ⁻¹ /h ⁻¹ after 10 min and sevoflurane of 1.8 vol% (end-expiratory concentration)	
Outcomes	Cardiac index, mean arterial pressure, mean pulmonary artery pressure and PaCO ₂	
Notes		
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	Two participants, one from each group, were excluded from analysis because vasoactive drugs were given for hypotensive episodes during anaesthetic induction
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

De Conno 2009

Methods	Design: RCT. Single-centre. Period: not reported. Sample size: reported (40% difference in expression on inflammatory mediators at a 5% level of statistical significance and a power of 80%). Follow-up: five days
Participants	N: 70 randomly assigned, but 54 analysed. Sex: sevoflurane: 13 females and 14 males; propofol: 9 female and 18 males. Age, y (mean): sevoflurane group 55 and propofol group 58. Setting: not reported. Inclusion criteria: adults with ASA physical status I to III, scheduled to undergo elective thoracic surgery with lung resection performed through thoracotomy or thoracoscopy. Exclusion criteria: any dose of systemic or topical steroids, acute pulmonary or extrapulmonary infections, severe chronic obstructive pulmonary disease (Gold stage 2 to 4), history of recurrent pneumothoraces, pneumonectomy and/or lung volume-reduction surgery
Interventions	Propofol (2.0 to 4.0 mcg/mL) or sevoflurane (1 MAC)
Outcomes	Inflammatory mediators in BALF; clinical postoperative outcomes (adverse events). Adverse events were defined as pulmonary infections necessitating antibiotic treatment; radiographically diagnosed pneumonia, atelectasis, effusion; fistula; reintubation; systemic inflammatory response syndrome; sepsis; acute respiratory distress syndrome; surgical revision and death
Notes	Anaesthesia was induced with propofol in all participants. We contacted the authors of the study on 8 August 2011 to ask about the generation of allocation, allocation concealment and blind assessment procedures. Furthermore, we asked which exact target concentration of protocol participants received during anaesthesia maintenance. The authors replied on 21 September 2011

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Assessors were blinded [information retrieved by email from the authors]
Incomplete outcome data (attrition bias) All outcomes	Low risk	The authors analysed in all participants the BALF outcome. Only in 27 participants (14 propofol, 13 sevoflurane) the investigators analysed all BALF, cells and blood

De Conno 2009 (Continued)

Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Egawa 2009

Methods	Design: RCT. Multicentre or single-centre: not reported. Period: participants started to be recruited in March 2007 (ongoing study) [information retrieved by email from the authors]. Sample size: calculated the sample size using STATA TM , significance level of 5% and power of 80% [information retrieved by email from the authors]. Follow-up: 15 min after the termination of OLV
Participants	N: 60. Sex: not reported. Age, y (mean): not reported. Setting: not reported. Inclusion criteria: participants ASA I to III scheduled for elective lung surgery in the lateral position. Exclusion criteria: pulmonary fibrosis or interstitial pulmonary disease; pregnant woman; mental disorder; MMSE score less than 24; moderate and severe liver dysfunction; moderate and severe renal dysfunction and blood coagulation abnormality [information retrieved by email from the authors]
Interventions	Propofol (n = 30) versus sevoflurane (n = 30), both combined with fentanyl and epidural anaesthesia
Outcomes	Regional cerebral oxygen saturation values, cognitive function
Notes	Conference proceedings. We contacted the main author on 13 November 2011 to ask about the full text. Egawa 2009 informed us, the day after we emailed them, that the study is ongoing, so we sent another email to ask for further information about the study. The author replied on 16, 23 and 25 November, 2011

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-generated [information retrieved by email from the authors]
Allocation concealment (selection bias)	Low risk	Envelopes [information retrieved by email from the authors]
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Participants are blinded, but anaesthesiologists are not blinded to treatment allocation [information retrieved by email from the authors]
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Yes [information retrieved by email from the authors]

Egawa 2009 (Continued)

Incomplete outcome data (attrition bias) All outcomes	Low risk	Few drop-outs so far, <10% according to information retrieved by email from the authors
Selective reporting (reporting bias)	Unclear risk	Not reported (abstract)
Other bias	Low risk	No conflict of interest

El-Hakeem 2003

Methods	Design: RCT. Multicentre or single-centre: not reported. Period: not reported. Sample size: not reported. Follow-up: after 30 min of TLV; after 30 min of OLV in supine position and during OLV in the lateral position with the chest open and before surgical manipulation of the lungs
Participants	N: 30. Sex: sevoflurane group: 6 males and 9 females; propofol group: 7 males and 8 females. Age, y (mean): sevoflurane group 50.7, propofol group 48.0. Setting: not reported. Inclusion criteria: participants requiring OLV for thoracic surgery. Exclusion criteria: not reported
Interventions	Sevoflurane (1 MAC; n = 15) versus propofol (4 to 6 mg/kg/h; n = 15)
Outcomes	Haemodynamic variables, pulmonary shunt, mixed venous oxygen tension, arterial oxygen tension and arterial carbon dioxide tension
Notes	All participants were premedicated with oral midazolam (0.1 mg/kg) one hour before surgery

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not reported

El-Hakeem 2003 (Continued)

Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Fukuoka 2009

Methods	Design: RCT. Single-centre. Period: not reported. Sample size: based on the PaO ₂ values measured in a previous study. Follow-up: 45 minutes of OLV
Participants	N: 36 randomly assigned and 32 considered on the final analysis. Sex: 11 male and 5 female in propofol group, 7 male and 9 female in sevoflurane group. Age, y (mean): 67 in both groups. Setting: a university hospital. Inclusion criteria: participants with ASA status I and II requiring OLV during anaesthesia for selective thoracic surgery. Exclusion criteria: patients with severe cardiovascular or respiratory disease, morbid obesity (body mass index > 30) or ASA physical status 3 or 4
Interventions	Propofol (3 to 5 mg/kg/h) versus sevoflurane (1.4% to 1.6%)
Outcomes	Relationship between the initial ETCO ₂ difference and the lowest PaO ₂ value recorded during the first 45 minutes of OLV
Notes	We contacted the authors of the study by email on 21 July 2011 to ask whether the participants from the Iwata 2008 study were the same as those in their clinical trial. Fukuoka 2009 replied to the email on 26 July 2011, saying that "...the patients from both publications are not the same". We resent an email to ask if perhaps some of the participants were the same as in the Iwata 2008 study and to clarify whether participants and personnel were blinded to treatment allocation. The authors confirmed that participants from the two publications are not the same

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-generated codes
Allocation concealment (selection bias)	Low risk	Sealed and opaque envelopes
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Low risk	The anaesthesiologist who assessed the study data were blinded to group assignments

Fukuoka 2009 (Continued)

Incomplete outcome data (attrition bias) All outcomes	Low risk	Only four participants were lost (these participants were excluded because of re-inflation of the nondependent lung)
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Low risk	No evidence

Gasowska 1999

Methods	Design: RCT. Multicentre or single-centre: not reported. Period: not reported. Sample size: not reported. Follow-up: 10 min after induction of anaesthesia, when the participant was in the supine position and both lungs were ventilated; 10 min after a position shift (left lateral); 10 min of left OLV; 20 min of left OLV; 10 min ventilation of both lungs in the lateral position
Participants	N: 47. Sex: not reported. Age, $\bar{y}$ (mean): not reported. Setting: not reported. Inclusion criteria: participants with ASA grades I and II, admitted for right-sided diagnostic or therapeutic elective VATS procedures. Exclusion criteria: patients with oxygen haemoglobin saturation < 97% were immediately (preoperatively) excluded from the study
Interventions	Halothane (0.4% to 0.6%), isoflurane (0.5% to 1.0%) or propofol (10-8-6 mg/kg/h)
Outcomes	VATS procedures: resection of emphysematous bullae, lung biopsy, biopsy of a peripheral lung nodule, dissection of adhesions, resection of a pericardial cyst. Blood gas values, alveolar-arterial differences of oxygen partial pressure and Q_s/Q_t
Notes	The halothane and isoflurane groups also received nitrous oxide, whilst the propofol group received air

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported

Gasowska 1999 (Continued)

Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not reported
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Huang 2008

Methods	Design: RCT. Single-centre. Period: from August 2003 to July 2004 [information retrieved by email from the authors]. Sample size: 80% of power, 0.05 alpha, analysed by statistics specialist from their hospital [information retrieved by email from the authors]. Follow-up: only during the intraoperative period (T1: the first 2LV just before performing OLV; T2: near the end of OLV just before resuming 2LV, mostly 30 to 45 minutes after OLV; T3: 5 minutes after resuming 2LV and T4: 20 min after resuming 2LV)	
Participants	N: 30. Sex: 19 men and 11 women. Age, y (mean): propofol 44 and isoflurane 40. Setting: Taiwan University Hospital. Inclusion criteria: participants with ASA physical status I and II, 20 to 60 years of age, scheduled to undergo thoracoscopic surgery or oesophageal surgery, with limited lung trauma but lengthy OLV. Exclusion criteria: reoperation, steroid use, and antioxidant or immunosuppressant usage [information retrieved by email from the authors]	
Interventions	Propofol (started at 10 mg/kg/h for 10 min and then switched to 8 mg/kg/h throughout the study; n = 15) versus isoflurane (1% to 2%; n = 15)	
Outcomes	Haemodynamic data; reactive oxygen species (ROS) production and total antioxidant status (TAS)	
Notes	<p>We contacted the authors of the study on 13 November 2011 to ask about the following:</p> <ul style="list-style-type: none"> • Study period (e.g. participants were recruited from February 1999 to June 2001); • Sample size calculation; • Generation of allocation; • Allocation concealment (i.e. sealed and opaque envelopes or by a third party); • Participants blinded to treatment allocation; • Drop-outs and how many participants remained in the final analysis; • Follow-up period; • Exclusion criteria; and • Any other bias in the study (i.e. conflict of interest, etc). <p>The authors replied on 16 November, 2011.</p>	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Random table [information retrieved by email from the authors]

Huang 2008 (Continued)

Allocation concealment (selection bias)	Low risk	By another anaesthesiologist who was not involved in the study [information retrieved by email from the authors]
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Participants were blinded, but the anaesthesiologist was aware of the study objectives [information retrieved by email from the authors]
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Investigators responsible for analyses of ROC production and TAS level were blinded to the anaesthetic technique
Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop-outs [information retrieved by email from the authors]
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Low risk	None of the authors had conflicts of interest [information retrieved by email from the authors]

Iwata 2008

Methods	Design: RCT. Single-centre. Period: not reported. Sample size: based on the formula for normal distribution and assuming a type I error of 0.05 and a power of 0.95. Follow-up: 15 min after the termination of OLV	
Participants	N: 52. Sex: 16 male and 10 female in propofol group; 17 male and 9 female in sevoflurane group. Age, y (mean): 61 in propofol group and 63 in sevoflurane group. Setting: university hospital. Inclusion criteria: participants scheduled for elective thoracic procedures in the lateral position. Exclusion criteria: renal insufficiency, liver dysfunction, cerebral infarction, documented coagulopathy or coronary or vascular disease	
Interventions	Sevoflurane versus propofol combined with epidural anaesthesia	
Outcomes	Haemodynamic variables, SpO ₂ and blood gas analyses	
Notes	We contacted the authors of the study on 27 September 2011 to ask about the period of the study, the generation of allocation, allocation concealment and blind assessment of outcomes. Furthermore, we have asked whether this study evaluated the same participants as were included in Fukuoka 2009 . We are awaiting their reply	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement

Iwata 2008 (Continued)

Random sequence generation (selection bias)	Low risk	Computer-generated random numbers
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not reported
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Kellow 1995

Methods	Design: RCT. Multicentre or single-centre: not reported. Period: not reported. Sample size: not reported. Follow-up: TLV, after 20 min of the allocated maintenance regimen during TLV; OLV, after 20 min of stable OLV before ligation or division of any pulmonary vessels or bronchi; end, during wound closure after at least 20 min of stable ventilation of all remaining lung tissue	
Participants	N: 22 (10 isoflurane group and 12 propofol group). Sex: isoflurane group: 3 female and 7 male; propofol group: 2 female and 10 male. Age, y (mean): not reported. Setting: not reported. Inclusion criteria: participants undergoing elective thoracotomy requiring OLV. Exclusion criteria: patients were excluded if they were younger than 18 or older than 75 years old, and if their cardiac rhythm was not predominantly sinus	
Interventions	Isoflurane (1% to 1.5%) versus propofol (10 mg/kg/h, reducing at 10 min intervals to 8 and then 6 mg/kg/h)	
Outcomes	Cardiac index, heart rate, mean arterial pressure, pulmonary vascular resistance index, right ventricular ejection fraction, end-systolic and end-diastolic volume indices, shunt fraction and changes in haemodynamic data	
Notes		
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement

Kellow 1995 (Continued)

Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	High risk	After induction, all measurements were made by the same observer, who was not blinded to the anaesthetic regimen used
Incomplete outcome data (attrition bias) All outcomes	Low risk	One participant in the isoflurane group was eliminated from the study after arterial desaturation that did not respond to increasing concentration of inspired oxygen
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Pilotti 1999

Methods	Design: RCT. Single-centre. Sample size: not reported. Follow-up: not reported	
Participants	N: 50. Sex: 43 female and 7 male. Age, y (mean): 63.8. Inclusion criteria: ASA II and III. Exclusion criteria: not reported	
Interventions	Group A propofol (4 to 7 mg/kg/h), fentanyl (1.5 to 2 µg/kg/h), atracurium (0.5 mg/kg/h) versus group B isoflurane (0.7% to 1.2%), fentanyl (1.2 to 1.5 µg/kg/h), atracurium (0.5 mg/kg/h)	
Outcomes	Pressure values, heart rate, PaO ₂ and PaCO ₂ levels, SPO ₂ and PECO ₂	
Notes	Premedication with diazepam 10 mg plus atropine 0.5 mg	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported

Pilotti 1999 (Continued)

Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not reported
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Pruszkowski 2007

Methods	Design: RCT. Multicentre. Period: author could not provide the period of the study [information retrieved by email contact with the authors]. Sample size: two-tailed, alpha error of 5% and beta error of 20%. Follow-up: 40 min after initiation
Participants	N: 80 randomly assigned and 65 completed the study. Sex: sevoflurane, 7 female and 26 male; propofol, 7 female and 25 male. Age, y (mean): 62 and 57, respectively, sevoflurane and propofol. Inclusion criteria: participants undergoing lobectomy requiring OLV, age between 18 and 70 years of age, ASA I to III and indication for thoracic epidural anaesthesia. Exclusion criteria: patients taking vasoactive drug at the time of selection
Interventions	Propofol versus sevoflurane
Outcomes	The primary outcome was defined as the lowest PaO ₂ during the study period. Other outcomes were measured: arterial blood gas analysis, end-tidal carbon dioxide concentration, heart rate, mean arterial pressure and BIS value
Notes	We contacted the authors of the study on 5 October 2011 to ask about the period of study, allocation concealment and blind assessment of outcome. The authors replied on the same day, saying that neither outcome assessment nor allocation was concealed. With regard to the period of the study, the authors could not provide this information

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-generated randomization list
Allocation concealment (selection bias)	High risk	No protection [information retrieved by email from the authors]

Pruszkowski 2007 (Continued)

Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	High risk	No blinding [information retrieved by email from the authors]
Incomplete outcome data (attrition bias) All outcomes	High risk	15 participants were lost: 20% and 17.5%, respectively, propofol and sevoflurane
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Rees 1984

Methods	Design: RCT. Multicentre or single-centre: not reported. Period: not reported. Sample size: not reported. Follow-up: 5, 15, 30 and 45 min after establishment of OLV and again 15 min after re-establishment of two-lung ventilation
Participants	N: 24 men. Age, y (mean): group one 55 and group two 60. Setting: not reported. Inclusion criteria: elective lung resections for carcinoma. Exclusion criteria: not reported
Interventions	Ketamine 2 mg/kg followed by 0.65 mg/kg of d-tubocurarine intravenously versus 1% to 3% enflurane
Outcomes	Arterial blood samples, cardiac output, intrapulmonary shunt, cardiac index, oxygen delivery, oxygen consumption, stroke volume index, left and right ventricular stroke work indices, pulmonary vascular resistance and systemic vascular resistance
Notes	All participants were given 10 mg of diazepam and 5 mg of droperidol intravenously before monitoring lines were inserted. The groups received different induction drugs (ketamine and thiopental) and different maintenance drugs (ketamine at 2 mg/kg/h vs enflurane 1% to 3%)

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-generated randomization schedule
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported

Rees 1984 (Continued)

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	Three participants were removed from the study because of the shortness of the period of OLV and hence failure to gather sufficient data (12.5%)
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Reid 1996

Methods	Design: RCT. Single-centre: tertiary care university hospital. Period: not reported. Sample size: not reported. Follow-up: during two-lung ventilation and after 20 and 30 minutes of OLV with each anaesthetic technique
Participants	N: 30. Sex: not reported. Age, y (mean): for all participants 59. Setting: tertiary care university hospital. Inclusion criteria: participants undergoing thoracoscopic pulmonary surgery or oesophageal surgery. Exclusion criteria: not reported
Interventions	Participants received either propofol-alfentanil infusion anaesthesia or one minimum alveolar concentration (MAC) of isoflurane during the initial period of two-lung ventilation and the first 30 minutes of OLV and then were switched to the other anaesthetic for the duration of OLV
Outcomes	Arterial blood gases and haemodynamic variables
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	By lottery
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported

Reid 1996 (Continued)

Incomplete outcome data (attrition bias) All outcomes	High risk	10 participants; in 3, the study protocol was terminated prematurely because of arterial oxygen desaturation < 90%; in the other 7, the protocol was terminated because re-inflation of the nonventilated lung was required for surgical reasons before the study protocol could be completed
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Rutkowska 2009

Methods	Design: RCT. Multicentre or single-centre: not reported. Period: not reported. Sample size: not reported. Follow-up: 30 min after start of OLV
Participants	N: 40. Sex: not reported. Age, y (mean): not reported. Setting: not reported. Inclusion criteria: participants with ASA physical status I to III scheduled for elective lobectomy. Exclusion criteria: not reported
Interventions	Propofol (n = 20) versus desflurane (n = 20) combined with thoracic anaesthesia
Outcomes	Haemodynamic and respiratory parameters, stroke volume and cardiac index
Notes	Conference proceedings. We contacted the main author on 5 October 2011 to ask about the full text. We are awaiting the reply

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not reported

Selective reporting (reporting bias)	Unclear risk	Not reported (abstract)
Other bias	Unclear risk	No evidence

Schilling 2011

Methods	Design: RCT. Single-centre. Period: November 2006 to June 2008 [information retrieved by email from the authors]. Sample size: reported; on the basis of previous studies, significance level of 5% and power of 80%. Follow-up: 30 min after the surgical procedure
Participants	N: 63. Sex: 41 male and 22 female. Age, y (mean): 64 for propofol group, 60 for desflurane group and 63 for sevoflurane group. Setting: Otto-von-Guericke-University Magdeburg. Inclusion criteria: participants scheduled for open thoracic surgery and OLV. Exclusion criteria: persistent tobacco abuse, body mass index greater than 35 kg/m ² , history of treatment with immunodepressant drugs in the 6 weeks before surgery, cardiac failure (New York Heart Association greater than II), clinically relevant obstructive or restrictive lung disease (vital capacity or forced expiratory volume in 1 s < 50% of predicted value), pulmonary hypertension (mean pulmonary arterial pressure greater than 25 mm Hg) or preexisting coagulation disorders and participants with evidence of pulmonary or systemic infection
Interventions	Propofol (4 mg/kg/h) or sevoflurane (1 MAC)
Outcomes	Cytokine concentrations (concentrations of TNF- α and IL-1b, IL-6, IL-8, IL-10 and IL-12 p70 in bronchoalveolar lavage fluids and serum samples), ventilation and gas exchange data and haemodynamic data
Notes	Anaesthesia was induced with propofol in all participants We contacted the authors of the study on 5 October 2011 to ask about the period of the study, allocation concealment and blind assessment of outcome. The authors answered our queries

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-generated software (i.e. randomization was done by EXCEL scripts, which deliver columns (according to the number of groups needed) of random numbers) [information retrieved by email from the authors]
Allocation concealment (selection bias)	Low risk	Randomization list was password-protected and white sealed envelopes were used [information retrieved by email from the authors]

Schilling 2011 (Continued)

Blinding of participants and personnel (performance bias) All outcomes	High risk	Participants were blinded, but anaesthetists who provided the anaesthesia were not [information retrieved by email from the authors]
Blinding of outcome assessment (detection bias) All outcomes	Low risk	The persons who did the immunological/pathohistological analyses were blinded to the study protocol [information retrieved by email from the authors]
Incomplete outcome data (attrition bias) All outcomes	Low risk	All enrolled participants completed the study successfully
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Schwarzkopf 2009

Methods	Design: RCT. Single-centre. Period: not reported. Sample size: not reported. Follow-up: 30 min after beginning of OLV	
Participants	N: 60 randomly assigned and 54 completed the study. Sex: sevoflurane male:female 19:9; propofol 16:10. Age, y (mean): sevoflurane 61 and propofol 57. Setting: University Hospital in Jena, Germany. Inclusion criteria: participants with ASA grade I to III scheduled for thoracic surgery, with limited lung trauma but lengthy OLV. Exclusion criteria: not reported	
Interventions	Propofol (range 3 to 6 mg/kg/h) versus sevoflurane (1 MAC)	
Outcomes	Arterial blood gases, haemodynamic and respiratory parameters	
Notes	<p>In both groups, anaesthesia was induced with propofol.</p> <p>We contacted the authors of the study on 13 November 2011 to ask about the following:</p> <ul style="list-style-type: none">• Study period (e.g. participants were recruited from February 1999 to June 2001);• Sample size calculation;• Generation of allocation;• Allocation concealment (i.e. sealed and opaque envelopes or by a third party);• Participants blinded to treatment allocation;• Exclusion criteria; and• Any other bias in the study (e.g. conflict of interest, etc). <p>We are awaiting the authors' reply.</p>	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement

Schwarzkopf 2009 (Continued)

Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	A total of 6.7% and 13.4% of withdrawals in sevoflurane and propofol, respectively
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Spies 1991

Methods	Design: RCT. Single-centre or multicentre: not reported. Period: not reported. Sample size: not reported. Follow-up: during TLV; 15 min after induction in the supine position; 20 min after surgical opening of the chest in the lateral decubitus position; 20 min after start of OLV and after extubation
Participants	N: 28. Sex: not reported. Age, y (mean): not reported. Setting: not reported. Inclusion criteria: ASA risk groups II and III. Exclusion criteria: not reported
Interventions	Propofol (10 mg/kg/h) versus enflurane (1 MAC)
Outcomes	Haemodynamics and arterial and mixed venous blood gases
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported

Spies 1991 (Continued)

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not reported
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

Steurer 2007

Methods	Design: RCT. Multicentre or single-centre: not reported. Period: not reported. Sample size: not reported. Follow-up: not reported
Participants	N: 18 randomly assigned. Sex: not reported. Age, y (mean): not reported. Setting: not reported. Inclusion criteria: participants undergoing major thoracic surgery. Exclusion criteria: not reported
Interventions	Propofol (n = 9) versus sevoflurane (n = 9)
Outcomes	Inflammatory mediators
Notes	Conference proceedings. We contacted the main author on 13 November 2011 to ask about the full text. We are awaiting the reply

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not reported

Selective reporting (reporting bias)	Unclear risk	Not reported (abstract)
Other bias	Unclear risk	Not reported

Yamada 2008

Methods	Design: RCT. Multicentre or single-centre: single-centre. Period: February 2007 to February 2008. Sample size: not reported. Follow-up: the end of surgery
Participants	N: 50. Sex: propofol (14 males and 11 females); sevoflurane (10 males and 15 females). Age, y (mean): propofol 72.0 and sevoflurane 66.8. Setting: university hospital. Inclusion criteria: ASA I or II, diagnosed with lung tumour and scheduled for lung lobectomy requiring OLV. Exclusion criteria: patients with cerebrovascular disease; patients with impaired pulmonary function
Interventions	Propofol (2 to 3 mcg/mL, n = 25) versus sevoflurane (1% to 2%, n = 25)
Outcomes	Cerebral regional oxygen saturation during surgery; PaO ₂ , PaCO ₂ , HR, mean arterial pressure, arterial pressure-based cardiac index, haemoglobin concentration, body temperature
Notes	Article in Japanese, only the abstract was written in English. Mina Nishimori, a Cochrane review author, kindly translated and extracted data from the Yamada 2008 study

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	No withdrawals/drop-outs
Selective reporting (reporting bias)	Low risk	No evidence
Other bias	Unclear risk	Not reported

ASA = American Society of Anesthesiologists' grade; BALF = Bronchoalveolar lavage fluid; MAC = Minimum alveolar concentration; OLV = One-lung ventilation; PaO₂ = Arterial oxygen partial pressure; PaCO₂ = Arterial carbon dioxide tension; PECO₂ = End-tidal carbon dioxide partial pressure; Qs/Q_t = Shunt fraction; RCT = Randomized controlled trial; ROS = reactive oxygen species; TAS = total antioxidant status; TLV or 2LV = Two-lung ventilation; T1 = Time 1; VATS = Video-assisted thoracic surgery.

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

Study	Reason for exclusion
Abe 1998a	Randomized controlled trial comparing isoflurane and sevoflurane
Abe 1998b	Randomized controlled trial comparing isoflurane and sevoflurane
Benumof 1987	Randomized controlled trial comparing halothane and isoflurane
Boldt 1996	Randomized controlled trial comparing intravenous anaesthetics
Bovill 1984	Randomized controlled trial comparing intravenous anaesthetics
Canet 1994	Randomized controlled trial comparing halothane and isoflurane
Carlsson 1987	Case series evaluating isoflurane
Celik 2009	Randomized controlled trial of desflurane versus sevoflurane
Cigarini 1990	Randomized controlled trial comparing thiopental and propofol
Dikmen 2003	Case series comparing inhalation anaesthetics
Dupont 1999	Randomized cross-over design comparing sevoflurane, desflurane and isoflurane
Furugen 1989	Case series evaluating propofol
He 1996	Randomized clinical trial evaluating sevoflurane
He 1999	Evaluated only isoflurane and desflurane
Koishi 1998	Retrospective study
Koishi 1999	Retrospective study comparing intravenous anaesthetics
Ma 1998	Randomized controlled trial comparing halothane and sevoflurane
Merli 1991	Case series evaluating propofol
Pagel 1998	Randomized controlled trial comparing isoflurane and desflurane

(Continued)

Pueyo 1994	Case series evaluating propofol
Rogers 1985	Randomized controlled trial comparing halothane and isoflurane
Rosso 1995	Prospective study with propofol
Saito 2000	Randomized cross-over design comparing sevoflurane and isoflurane
Satoh 1998	Case series evaluating isoflurane
Shimizu 1997	Randomized controlled trial evaluating isoflurane and sevoflurane
Sjögren 1995	Case series comparing inhalation anaesthetics
Slinger 1988	Randomized controlled trial comparing enflurane and isoflurane
Slinger 1995	Case series evaluating isoflurane
Solares 1992	Case series evaluating isoflurane
Steeegers 1990	Case series evaluating intravenous anaesthetics
Temp 1992	Case series evaluating isoflurane
Van Keer 1989	Case series evaluating intravenous anaesthetics
Van Leeuwen 1990	Randomized controlled trial evaluating intravenous anaesthetics
Wang 1998	Randomized cross-over design evaluating sevoflurane and isoflurane
Wang 2000	Randomized prospective cross-over study evaluating desflurane and isoflurane
Yamada 1990	Controlled clinical trial
Yondov 1999	Comparative controlled study

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

[Erturk 2014](#)

Methods	Design: RCT. Multicentre or single-centre: single-centre. Setting: not reported. Period: not reported. Sample size: not reported. Follow-up: not reported
Participants	N: 44. Inclusion criteria: aged between 18 and 65, ASA physical status I or II, undergoing OLV/2LV for thoracic surgery. Exclusion criteria: patients with ASA score of III or more and severe metabolic, renal, or hepatic diseases,

Erturk 2014 (Continued)

	using cigarettes or antioxidant agents
Interventions	Sevoflurane versus propofol
Outcomes	Mean arterial pressures, heart rate, blood gas analyses
Notes	

Hammouda 2013

Methods	Design: RCT. Multicentre or single-centre: single-centre. Setting: Alexandria Main University Hospital. Period: not reported. Sample size: not reported. Follow-up: 2nd postoperative day
Participants	N: 40. Inclusion criteria: patients schedule to elective lung resection surgery through thoracotomy. Exclusion criteria: acute pulmonary or extra pulmonary infections; severe chronic obstructive pulmonary diseases, and history of recurrent pneumothoraces; pneumonectomy and lung volume reduction surgery; contraindications for epidural catheter insertio; patients on chemotherapy, radiotherapy, immunosuppressant drugs or corticosteroids; history of allergy to local anaesthetic drugs; and trauma patients
Interventions	Sevoflurane versus propofol
Outcomes	Systemic inflammatory response, pulmonary inflammatory response, C-reactive protein, leucocyte count, and recovery status
Notes	

Potošnik 2014

Methods	Design: RCT. Multicentre or single-centre: single-centre. Setting: University Medical Centre Ljubljana. Period: 2009-2013. Sample size: significance level of 0.05 and a power of 80%, it was enough to have 16 patients in each group. Follow-up: 6 hours after surgery
Participants	N: 40. Inclusion criteria: the study included patients aged 20-70 years with the American Society of Anesthesiologists (ASA) physical status I-III, scheduled for elective open lobectomy with OLV. Exclusion criteria: history of drug hypersensitivity, drug addiction, treatment with psychotropic drugs, severe psychiatric and central nerve system diseases, persistent tobacco abuse, autoimmune system diseases, diabetes mellitus, cardiac failure (New York Heart Association class greater than 2), clinically relevant obstructive and restrictive lung diseases (vital capacity or forced expiratory volume in 1 s lower than 50% of the predicted values), pulmonary hypertension (mean pulmonary arterial pressure greater than 25 mm Hg), pre-existing coagulation disorders, and history of treatment with immunosuppressant drugs in the 4 weeks before surgery. Patients with evidence of pulmonary or systemic infections (CRP serum concentration greater than 5 mg/L, leucocytosis greater than 10.0 gigaparticles/L or body temperature greater than 37°C) were also excluded, as well as the patients who had received perioperative blood derivatives, steroids, or NSAIDs
Interventions	Sevoflurane versus propofol
Outcomes	Inflammatory mediators (interleukins 6, 8, and 10, C-reactive protein [CRP], and pro-calcitonin) and clinical postoperative outcome

Notes	
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Wakabayashi 2014

Methods	Design: RCT. Multicentre or single-centre: single-centre. Setting: not reported. Period: not reported. Sample size: not reported. Follow-up: not reported
Participants	N: 20. Inclusion criteria: American Society of Anesthesiologists Physical Status category I-II, undergoing cervico-thoraco-abdominal three-field lymph node dissection through a right thoracotomy. Exclusion criteria: neurologic or psychiatric disease, cardiac disease classified as NYHA classes II-IV, preoperative severe impairment of respiratory function (such as a vital capacity of <50% or a forced expiratory volume in 1 sec of <50% of that predicted), and pre-existing coagulopathy or thrombocytopenia. Subjects were also excluded if they exhibited systemic or local active infections (either clinically defined or evidenced by elevated C-reactive protein levels, leukocytosis or body temperature of >38° C)
Interventions	Sevoflurane versus propofol
Outcomes	Inflammatory cytokines and chemokine [tumour necrosis factor (TNF)- α , interleukin (IL)-1 β , IL-6, IL-8, IL-10 and IL-12p70]
Notes	

DATA AND ANALYSES

This review has no analyses.

APPENDICES

Appendix I. Search strategy

CENTRAL, *The Cochrane Library*

- #1 OLV or one lung* or one-lung* or single-lung* or single lung or ((one lung*) near ventil*)
- #2 anesth* or anaesth* or propofol* or diisopropylphenol or diprivan* or disoprivan or disoprofol or pofol or sevofluran* or sevorange or ultane or desfluran* or suprane or isofluran*
- #3 MeSH descriptor Anesthesia and Analgesia explode all trees
- #4 MeSH descriptor Anesthesia explode all trees
- #5 MeSH descriptor Anesthesia, Conduction explode all trees
- #6 MeSH descriptor Anesthesia, Inhalation explode all trees
- #7 MeSH descriptor Anesthesia, Closed-Circuit explode all trees
- #8 MeSH descriptor Anesthesia, Intravenous explode all trees
- #9 MeSH descriptor Anesthetics, Intravenous explode all trees
- #10 MeSH descriptor Anesthetics, Dissociative explode all trees
- #11 MeSH descriptor Anesthetics, Inhalation explode all trees
- #12 (#2 OR #3 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11)
- #13 (#1 AND #12)

MEDLINE (Ovid SP)

- 1. (OLV or one?lung* or single?lung*).ti,ab. or ((one?lung* or single?lung*) adj3 ventil*).af.
- 2. an?esth*.ti,ab. or (propofol* or diisopropylphenol or diprivan* or disoprivan or disoprofol or pofol or sevofluran* or sevorange or ultane or desfluran* or suprane or isofluran*).mp. or exp Propofol/ or explode Anesthetics-Inhalation/ or explode Anesthetics-Dissociative/ or explode Anesthetics-Intravenous/ or explode Anesthesia-Intravenous/ or explode Anesthesia-Closed-Circuit/ or explode Anesthesia-Inhalation/ or explode Anesthesia-Conduction/ or Anesthesia/ or explode Anesthesia-and-Analgesia/
- 3. 1 and 2
- 4. ((randomized controlled trial or controlled clinical trial).pt. or randomized.ab. or placebo.ab. or drug therapy.fs. or randomly.ab. or trial.ab. or groups.ab.) not (animals not (humans and animals)).sh.
- 5. 3 and 4

Embase (Ovid SP)

- 1. (OLV or one?lung* or single?lung*).ti,ab. or ((one?lung* or single?lung*) adj3 ventil*).af. (314)
- 2. an?esth*.ti,ab. or (propofol* or diisopropylphenol or diprivan* or disoprivan or disoprofol or pofol or sevofluran* or sevorange or ultane or desfluran* or suprane or isofluran*).mp. or exp Propofol/ or anesthesia/ or analgesia/ or exp anesthesia-induction/ or exp inhalation-anesthesia/ or exp intravenous-anesthesia/ or anesthetic-agent/ (394435)
- 3. 1 and 2 (191)
- 4. (randomized-controlled-trial/ or randomization/ or controlled-study/ or multicenter-study/ or phase-3-clinical-trial/ or phase-4-clinical-trial/ or double-blind-procedure/ or single-blind-procedure/ or (random* or cross?over* or factorial* or placebo* or volunteer* or ((singl* or doubl* or trebl* or tripl*) adj3 (blind* or mask*))).ti,ab.) not (animals not (humans and animals)).sh. (4024409)
- 5. 3 and 4

ISI Web of Science

- #1 TS=OLV OR TS=(single SAME lung) or TS=(one SAME lung) or TS=(lung SAME ventil*)
- #2 TS=anaest* or TS=anest* or TS=(Propofol* or diisopropylphenol or diprivan* or disoprivan or disoprofol or pofol or sevofluran* or sevorange or ultane or desfluran* or suprane or isofluran*)
- #3 TS=((SINGL* or DOUBL* or TREBL* or TRIPL*) SAME (BLIND* or MASK*)) or TS=(RANDOM* or TRIAL* or CROSSOVER* or CROSS-OVER* or FACTORIAL* or PLACEBO* or VOLUNTEER*) or TS=(clinical SAME trial*)

#4 #3 AND #2 AND #1

LILACS (BIREME)

“one” or “single” or “um” or “uno” or “solo” or “único” [Words] and “lung” or “pulmão” or “pulmón” [Words] and “ANESTHESIA” or “ANESTHESIA AND ANALGESIA” or “ANESTHESIA AND ANALGESIA/” or “ANESTHESIA, CLOSED-CIRCUIT” or “ANESTHESIA, CLOSED-CIRCUIT/” or “ANESTHESIA, CONDUCTION” or “ANESTHESIA, CONDUCTION/” or “ANESTHESIA, GENERAL/” or “ANESTHESIA, INHALATION” or “ANESTHESIA, INHALATION/” or “ANESTHETICS” or “ANESTHETICS, DISSOCIATIVE” or “ANESTHETICS, DISSOCIATIVE/” or “ANESTHETICS, GENERAL” or “ANESTHETICS, INHALATION” or “ANESTHETICS, INHALATION/” or “ANESTHETICS, INTRAVENOUS” or “ANESTHETICS, INTRAVENOUS/” or “Anestesia” or “Inhalation Do Anesthesia” or “Inhalación De la Anestesia” or “Conducción De la Anestesia” or “Condução Do Anesthesia” or “Intravenoso” or “Anestésicos” or “Anestésico” [Words]

Appendix 2. Data extraction form

Review title or ID
Intravenous versus inhalation anaesthesia for one-lung ventilation
Study ID (<i>surname of first author and year first full report of study was published e.g. Smith 2001</i>)
Report IDs of other reports of this study (<i>e.g. duplicate publications, follow-up studies</i>)
Notes:

I. General information

Date form completed (<i>dd/mm/yyyy</i>)	
Name/ID of person extracting data	
Publication type (<i>e.g. full report, abstract, letter</i>)	
Possible conflicts of interest (<i>for study authors</i>)	
Notes:	

2. Study eligibility

Study Characteristics	Eligibility criteria (<i>insert eligibility criteria for each characteristic as defined in the Protocol</i>)	Yes	No	Unclear	Location in text (<i>pg & ¶/fig/table</i>)
Type of study	Randomized controlled trial				
	Quasi-randomized trial				
Participants					
Types of interventions					
Types of outcome measures					
INCLUDE		EXCLUDE			
Reason for exclusion					

(Continued)

Notes:

3. Population and setting

	Description <i>Include comparative information for each group (i.e. intervention and controls) if available</i>	Location in text <i>(pg & ¶/fig/table)</i>
Population description <i>Adults (> or equal to 18 years old) undergoing myocardial revascularization, regardless of gender, with or without extracorporeal circulation</i>		
Setting <i>(including location and social context)</i>		
Inclusion criteria		
Exclusion criteria		
Method/s of recruitment of participants		
Notes:		

4. Methods

	Descriptions as stated in report/paper	Location in text <i>(pg & ¶/fig/table)</i>
Aim of study		

(Continued)

Design (e.g. parallel, cross-over, cluster)		
Unit of allocation <i>The unit of analysis will be each participant recruited into the trials</i>		
Period of study/recruitment		
Follow-up		
Notes:		

5. Risk of bias assessment

Domain	Risk of bias			Support for judgement	Location in text (pg & ¶/fig/table)
	Low risk	High risk	Unclear		
Random sequence generation (selection bias)					
Allocation concealment (selection bias)					
Blinding of participants and personnel (performance bias)				Outcome group: all/	
(if required)				Outcome group:	

(Continued)

Blinding of outcome assessment (detection bias)				Outcome group: all/	
(if required)				Outcome group:	
Incomplete outcome data (attrition bias)					
Selective outcome reporting? (reporting bias)					
Other bias					
Notes:					

6. Participants

Provide overall data and, if available, comparative data for each intervention or comparison group.

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Total no. randomized (or total pop. at start of study for NRCTs)		
Total no. analysed		
Baseline imbalances		
Withdrawals and exclusions (if not provided below by outcome)		
Age		

(Continued)

Sex		
Comorbidities		
Other relevant sociodemographics		
Subgroups measured		
Subgroups reported		
Notes:		

7. Intervention groups

Copy and paste table for each intervention and comparison group.

Intervention Group 1: Intravenous anaesthesia

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Group name		
No. randomized to group (specify whether no. people or clusters)		
Total no. analysed per group		
Description (include sufficient detail for replication, e.g. content, dose, components)		
Duration of treatment period		
Timing (e.g. frequency, duration of each episode)		

(Continued)

Notes:

Control group: Group 2: Inhalation anaesthesia

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Group name		
No. randomly assigned to group (specify no. people or clusters)		
Total no. analysed per group		
Description (include sufficient detail for replication, e.g. content, dose, components)		
Duration of treatment period		
Timing (e.g. frequency, duration of each episode)		
Notes:		

8. Outcomes

Outcome 1.1- Death (at one month)

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Outcome name		
Time points measured		
Time points reported		
Outcome definition <i>(with diagnostic criteria if relevant)</i>		
Person measuring/reporting		
Is outcome/tool validated?	Yes No Unclear	
Imputation of missing data <i>(e.g. assumptions made for ITT analysis)</i>		
Assumed risk estimate <i>(e.g. baseline or population risk noted in Background)</i>		
Power		
Notes:		

Outcome 1.2- Mortality rate (at six months)

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Outcome name		
Time points measured		
Time points reported		

(Continued)

Outcome definition <i>(with diagnostic criteria if relevant)</i>		
Person measuring/reporting		
Is outcome/tool validated?	Yes No Unclear	
Imputation of missing data <i>(e.g. assumptions made for ITT analysis)</i>		
Assumed risk estimate <i>(e.g. baseline or population risk noted in Background)</i>		
Power		
Notes:		

Outcome 2- Abandonment of one-lung technique

	Description as stated in report/paper	Location in text <i>(pg & §/fig/table)</i>
Outcome name		
Time points measured		
Time points reported		
Outcome definition <i>(with diagnostic criteria if relevant)</i>		
Person measuring/reporting		
Is outcome/tool validated?	Yes No Unclear	
Imputation of missing data <i>(e.g. assumptions made for ITT analysis)</i>		

(Continued)

Assumed risk estimate (e.g. baseline or population risk noted in Background)		
Power		
Notes:		

Outcome 3- Length of stay in hospital

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Outcome name		
Time points measured		
Time points reported		
Outcome definition (with diagnostic criteria if relevant)		
Person measuring/reporting		
Is outcome/tool validated?	Yes No Unclear	
Imputation of missing data (e.g. assumptions made for ITT analysis)		
Assumed risk estimate (e.g. baseline or population risk noted in Background)		
Power		
Notes:		

Outcome 4- Economic analysis (by narrative)

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Outcome name		
Time points measured		
Time points reported		
Outcome definition <i>(with diagnostic criteria if relevant)</i>		
Person measuring/reporting		
Is outcome/tool validated?	<div> ☐ Yes ☐ No ☐ Unclear </div>	
Imputation of missing data <i>(e.g. assumptions made for ITT analysis)</i>		
Assumed risk estimate <i>(e.g. baseline or population risk noted in Background)</i>		
Power		
Notes:		

Outcome 5- Oxygen delivery and consumption

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Outcome name		
Time points measured		
Time points reported		

(Continued)

Outcome definition <i>(with diagnostic criteria if relevant)</i>		
Person measuring/reporting		
Is outcome/tool validated?	Yes No Unclear	
Imputation of missing data <i>(e.g. assumptions made for ITT analysis)</i>		
Assumed risk estimate <i>(e.g. baseline or population risk noted in Background)</i>		
Power		
Notes:		

9. Applicability

Have important populations been excluded from the study? <i>(consider disadvantaged populations and possible differences in the intervention effect)</i>	Yes No Unclear	
Is the intervention likely to be aimed at disadvantaged groups? <i>(e.g. lower socioeconomic groups)</i>	Yes No Unclear	
Does the study directly address the review question? <i>(any issues of partial or indirect applicability)</i>	Yes No Unclear	
Notes:		

10. Other information

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Key conclusions of study authors		
References to other relevant studies		
Correspondence required for further study information (<i>from whom, what and when</i>)		
Notes:		

WHAT'S NEW

Last assessed as up-to-date: 7 February 2017.

Date	Event	Description
14 February 2017	Amended	New search run to February 2017, four new studies not fully incorporated and awaiting classification

HISTORY

Protocol first published: Issue 1, 2007

Review first published: Issue 2, 2008

Date	Event	Description
12 November 2013	Amended	Contact details updated
4 July 2013	New search has been performed	In the previous version (Bassi 2008), the databases were searched until 2006. We reran the searches until November 2012. We have included risk of bias, summary of finding tables and a new study flow diagram

(Continued)

4 July 2013	New citation required but conclusions have not changed	<p>This review is an update of the previous Cochrane systematic review (Bassi 2008) that included nine RCTs (Abay 2000; Beck 2001; El-Hakeem 2003; Gasowska 1999; Kellow 1995; Pilotti 1999; Rees 1984; Reid 1996; Spies 1991) and enrolled 291 participants.</p> <p>The previous authors Adriana Bassi, Wilson RO Milani and Delcio Matos decided not to update the review (new authors: Norma SP Módolo, Marília P Módolo, Marcos A Marton, Enilze Volpato, Vinícius M Arantes and Regina P El Dib have updated this version)</p> <p>We found 11 new trials (De Conno 2009; Egawa 2009; Fukuoka 2009; Huang 2008; Iwata 2008; Pruszkowski 2007; Rutkowska 2009; Schilling 2011; Schwarzkopf 2009; Steurer 2007; Yamada 2008) that met our inclusion criteria.</p> <p>In general, our review reaches the same conclusions as the original review (Bassi 2008). However, we included more trials, and thus have the opportunity to plot the new trials on the following outcomes: intraoperative awareness and adverse postoperative outcomes</p>
2 January 2008	Amended	Converted to the new review format.

CONTRIBUTIONS OF AUTHORS

Contributions to present update of review

Conceiving the review: Norma SP Módolo (NSPM) Regina P El Dib (RPED).

Co-ordinating the review: RPED.

Undertaking manual searches: Enilze Volpato (EV).

Screening search results: Marília P Módolo (MPM), Marcos A Marton (MAM) and Paulo Nascimento Junior (PNJ).

Organizing retrieval of papers: EV.

Screening retrieved papers against inclusion criteria: NSPM, RPED, MPM and MAM.

Appraising quality of papers: NSPM, RPED, MPM and MAM.

Abstracting data from papers: NSPM, RPED, MPM and MAM.

Writing to authors of papers for additional information: MPM, MAM and Vinícius Monteiro Arantes (VMA).

Providing additional data about papers: MPM, MAM and VMA.

Obtaining and screening data on unpublished studies: MPM, MAM and PNJ.

Providing data management for the review: NSPM and RPED.

Entering data into Review Manager ([RevMan 5.1](#)): NSPM and RPED.

Analyzing RevMan statistical data: RPED.

Performing other statistical analyses not using RevMan: RPED.

Performing double entry of data: (data entered by person one: NSPM; data entered by person two: RPED).

Interpreting data: NSPM, PNJ and RPED.

Performing statistical analysis: RPED.

Writing the review: NSPM, PNJ and RPED.

Securing funding for the review: NSPM and RPED.

Performing previous work that was the foundation of the present study: NSPM and RPED.
Serving as guarantor for the review (one author): RPED.
Taking responsibility for reading and checking review before submission: NSPM and RPED.

Contributions to original review

Adriana Bassi (AB) was responsible for the conception of this review. Regina P El Dib (RPED) and Délcio Matos (DM) were responsible for the design and overall co-ordination of the protocol. RPED and DM were responsible for co-ordinating the protocol. AB and Wilson Roberto Milani (WRM) were responsible for designing the search strategy, running searches, screening search results, obtaining papers, screening retrieved papers against the inclusion criteria, appraising the quality of papers and extracting data. AB wrote to authors of papers for additional information and to locate potentially relevant unpublished or ongoing studies. AB, RPED and WRM were responsible for data management in the review. AB, RPED, DM and WRM analysed and interpreted data and wrote up the results.

DECLARATIONS OF INTEREST

Norma SP Módolo: none known.

Marília P Módolo: none known.

Marcos A Marton: none known.

Enilze Volpato: none known.

Vinícius Monteiro Arantes: none known.

Paulo do Nascimento Junior: none known.

Regina P El Dib: paid scientific advisor on systematic review. RPED is also the director and co-ordinator of the Systematic Review Unit at FMB/Unesp.

SOURCES OF SUPPORT

Internal sources

- Own support, Brazil.

External sources

- No sources of support supplied

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

The assessment of risk of bias in included studies section was updated from the review ([Bassi 2008](#)) in the light of new guidelines published in the *Cochrane Handbook for Systematic Reviews of Interventions* ([Higgins 2011](#)).

INDEX TERMS

Medical Subject Headings (MeSH)

*Anesthesia, Inhalation; *Anesthesia, Intravenous; One-Lung Ventilation [*methods]; Randomized Controlled Trials as Topic; Treatment Outcome

MeSH check words

Humans