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[Intervention Review]

Positioning for acute respiratory distress in hospitalised infants and children

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ABSTRACT

Background

Because of the association of prone positioning with sudden infant death syndrome (SIDS) it is recommended that young infants be placed on their backs (supine). However, the prone position may be a non-invasive way of increasing oxygenation in participants with acute respiratory distress. Because of substantial differences in respiratory mechanics between adults and children and the risk of SIDS in young infants, a specific review of positioning for infants and young children with acute respiratory distress is warranted.

Objectives

To compare the effects of different body positions in hospitalised infants and children with acute respiratory distress.

Search methods

We searched Cochrane Central Register of Controlled Trials (CENTRAL 2012, Issue 3), which contains the Acute Respiratory Infections Group's Specialised Register, MEDLINE (1966 to April week 1, 2012), EMBASE (2004 to April 2012) and CINAHL (2004 to April 2012).

Selection criteria

Randomised controlled trials (RCTs) or pseudo-RCTs comparing two or more positions in the management of infants and children hospitalised with acute respiratory distress.

Data collection and analysis

Two review authors independently extracted data from each study. We resolved differences by consensus or referral to a third review author. We analysed bivariate outcomes using an odds ratio and 95% confidence interval (CI). We analysed continuous outcomes using a mean difference and 95% CI. We used a fixed-effect model unless heterogeneity was significant, in which case we used a random-effects model.

Main results

We extracted data from 53 studies. We included 24 studies with a total of 581 participants. Three studies used a parallel-group, randomised design which compared prone and supine positions only. The remaining 21 studies used a randomised cross-over design. These studies compared prone, supine, lateral, elevated and flat positions.

Prone positioning was significantly more beneficial than supine positioning in terms of oxygen saturation (mean difference (MD) 1.97%, 95% CI 1.18 to 2.77), arterial oxygen (MD 6.24 mm Hg, 95% confidence interval (CI) 2.20 to 10.28), episodes of hypoxaemia (MD -3.46, 95%

CI -4.60 to -2.33) and thoracoabdominal synchrony (MD -30.76, 95% CI -41.39 to -20.14). No adverse effects were identified. There were no statistically significant differences between any other positions.

As the majority of studies did not describe how possible biases were addressed, the potential for bias in these findings is unclear.

Authors' conclusions

The prone position was significantly superior to the supine position in terms of oxygenation. However, as most participants were ventilated preterm infants, the benefits of prone positioning may be most relevant to these infants. In addition, although placing infants and children in the prone position may improve respiratory function, the association of SIDS with prone positioning means that infants should only be placed in this position while under continuous cardiorespiratory monitoring.

PLAIN LANGUAGE SUMMARY

Positioning for acute respiratory distress in hospitalised infants and children

Acute respiratory distress is one of the most frequent causes of hospitalisation and death in infants and young children globally. When children with severe respiratory distress are put in hospital, treatment may include additional oxygen or assisted ventilation which may damage the lungs. Infants and children with respiratory distress placed in particular positions may be more comfortable, breathe more easily and have better outcomes. However, different positions may also increase the risk of adverse outcomes. Therefore we searched the literature to identify controlled clinical trials comparing two or more body positions in the management of infants and children hospitalised with acute respiratory distress.

We included 24 studies with a total of 581 participants. Lying on the front (the prone position) was better than lying on the back (the supine position) for oxygenating the blood but the difference was small. The increase in oxygen saturation on average increased by 2%. This finding was based on data from nine studies (195 children, 165 preterm and 95 ventilated) measuring this outcome. The rapid rate of breathing with respiratory distress was slightly lower in the prone position (on average four breaths/minute lower) based on six studies (100 infants aged up to one month, 59 ventilated). No adverse effects were identified. There were no obvious differences with other positions. As most of the 581 children in these studies were preterm babies (60%) and (70%) ventilated by machine, the benefits of prone positioning may be most relevant to these infants.

*****It is important to remember that these children were hospitalised. Therefore, given the association of the prone position with sudden infant death syndrome (SIDS), the prone position should not be used for children unless they are in hospital and their breathing is constantly monitored.**

As the majority of studies did not describe how possible biases in the design of the study were addressed, the potential for bias in these findings is unclear. Also the findings of this review are limited by the small number of participants in studies, changes in infants and children were only measured for short time periods and the small changes in oxygenation which were seen in this review are not as meaningful as other measures of illness and recovery. Only five studies looked at children older than one year and few studies compared positions other than prone and supine.

BACKGROUND

Description of the condition

Acute respiratory distress is one of the most frequent causes of hospitalisation and death in young children (Buckmaster 2007; Meurer 2000; Mintegi Raso 2004; Shay 1999) and infants (Ahmed 2004; Caitlin 2008; Chang 2000; Simiyu 2004; Sritipsukho 2007) across the world. While there is no official definition of acute respiratory distress (or breathing difficulty), it is clinically recognised as a presentation of any of the following signs or symptoms: shortness of breath, wheeze, increased breathing rate, increased heart beat, increased chest wall retractions, thoracoabdominal asynchrony, pallor, cyanosis, nasal flare, expiratory grunt and fatigue. Respiratory distress can lead to hypoxaemia with decreased PaO₂ (arterial oxygen pressure), increased PaCO₂ (arterial carbon dioxide pressure), altered neurological status (confusion) and ultimately to respiratory and/or multiple organ failure and eventually death (Hazinski 1992). Most infants and young children who develop mild to moderate respiratory distress can be managed at home. However, children with more severe respiratory distress require hospitalisation for treatment, which may include supplemental oxygen, intravenous fluids, intravenous antibiotics and possibly assisted ventilation.

Description of the intervention

Positioning participants for therapeutic effect has long been proposed as a mechanism for increasing oxygenation in participants with acute respiratory distress. Body positioning is a non-invasive intervention which may augment oxygenation while avoiding some of the associated risks (Ball 1999; Bateman 2000; Dean 1996; Lodato 1990). In children, and particularly infants, the risk of injury from oxygen toxicity and mechanical ventilation is greater than in adults as the lungs are going through a period of high growth and development (Bateman 2000; Hazinski 1992). Positioning may reduce the need for such interventions, or at least reduce the length of time they are required, thereby reducing the associated risk of longer-term lung damage.

How the intervention might work

Numerous studies of both adult and paediatric participants in acute care settings with acute respiratory distress have found the prone position to improve arterial oxygenation when compared to the supine position (Blanch 1997; Bryan 1974; Chatte 1997; Douglas 1977; Fridrich 1996; Gattinoni 1991; Langer 1988; Murdoch 1994; Pappert 1994; Piehl 1976; Pelosi 1998; Stocker 1997; Wagaman 1979). In addition, the use of the prone position is again becoming popular for participants with acute respiratory distress syndrome in intensive care units (Lewandowski 1996). However, the use of prone positioning for infants and young children is controversial as it is linked to sudden infant death syndrome (SIDS) (Ponsonby 1992). Other positions, including lateral (side-lying) positioning have also been proposed to assist in maintaining optimal ventilation and oxygenation during episodes of respiratory distress (Ball 1999; Dean 1985; Hazinski 1992; Wong 1999).

Structural differences of the respiratory system are evident in infants and young children when compared with adults. Alveolar and bronchiolar growth continues after birth with the alveolar surface area increasing by a factor of 20 as a person reaches adulthood (Hazinski 1992). Supporting airway cartilage, small

airway muscles and the intercostal muscles are not fully developed until school age (Adams 1994; Agostoni 1965; Muller 1979) and the chest wall of the infant and young child is much more compliant than the chest wall of an adult (Hazinski 1992). These differences may lead to a relative increase in the infant's or child's respiratory effort during an episode of respiratory distress, which may further compromise the ability to maintain effective ventilation (Adams 1994; Davis 1987; Hazinski 1992; Muller 1979).

Why it is important to do this review

A specific review of positioning for infants and young children with respiratory distress is warranted as the structure and respiratory mechanics of the infant and young child differ from those of the adult. Additionally, infants and young babies differ from adults in their ability to move between positions and to maintain any one particular position. Furthermore, there is the increased risk of SIDS in infants placed in a prone position. Therefore, it is necessary to clarify the benefits and potential risks associated with body positioning in hospitalised infants and children with acute respiratory distress to provide evidence-based clinical practice.

There have been three reviews without meta-analysis of positioning in participants with respiratory distress (Ball 1999; Curley 1999; Wong 1999). All of them found that the prone position improves oxygenation. However, most of the participants in the reviewed studies were adult. Several of the studies in these reviews included small numbers of children but neonates were excluded. Nevertheless, the prone position was found to slightly improve oxygenation in a systematic review of 11 trials of neonates undergoing mechanical ventilation (Balaguer 2006).

This review is an update of a systematic review of the effects of positioning on respiratory distress in infants and children (Gillies 2009; Wells 2005).

OBJECTIVES

To compare the effects of different body positions on hospitalised infants and children with acute respiratory distress.

METHODS

Criteria for considering studies for this review

Types of studies

All randomised controlled trials (RCTs) or pseudo-RCTs comparing two or more positions in the management of infants and children hospitalised with acute respiratory distress.

Types of participants

Hospitalised infants and children up to 16 years of age with a primary or secondary diagnosis of acute respiratory distress or with an acute exacerbation of a chronic respiratory illness. The studies included the following conditions in infants and children:

- acute respiratory failure;
- acute respiratory distress syndrome;
- acute lung injury;
- acute respiratory distress due to lower respiratory tract infections: bronchiolitis, pneumonia (bacterial, viral and atypical);

- bronchitis, legionella, whooping cough; chronic neonatal lung disease (bronchopulmonary dysplasia, respiratory distress syndrome of the preterm infant, hyaline membrane disease);
- upper respiratory tract infections including croup, epiglottitis (laryngotracheobronchitis);
- laryngeal infections; acute episodes of chronic suppurative lung diseases including bronchiectasis and cystic fibrosis; inflammatory respiratory conditions such as asthma;
- congenital malformations of the bronchi, lungs, diaphragm and rib cage;
- disorders of the pleura (for example pneumothorax, pleural effusion).

The pathophysiology of acute respiratory distress varies substantially. We therefore decided to undertake a subgroup analysis based on the reported cause (and related pathophysiology) of respiratory distress.

We also proposed to include a subgroup analysis of the following age categories:

- preterm and neonatal infants (birth to 28 days);
- infants (28 days to 12 months);
- toddlers and young children (12 months to five years);
- school-age children (five to 16 years).

As there may be greater scope for non-ventilated participants to benefit from therapeutic body positioning, we also planned a subgroup analysis of ventilated versus non-ventilated children.

Types of interventions

Body positioning utilised for the management of infants and children with acute respiratory distress included the following:

- sitting - erect sitting, lean forward sitting and non-erect sitting;
- prone - prone abdomen free, prone abdomen restricted, semi-prone, horizontal (flat) and head elevated;
- lateral/side-lying position - horizontal (flat) and head elevated (this position can be good-lung dependent, where the patient lies on the side of the healthy lung; or good-lung independent, where the patient lies on the opposite side to the healthy lung);
- supine - horizontal (flat) and head elevated;
- recumbent/semirecumbent;
- kinetic positioning - continuous postural therapy (usually with an automated bed);
- body tilting.

We planned a subgroup analysis based on the temporal parameters of the positioning if appropriate.

Types of outcome measures

Primary outcomes

- Episodes of apnoea
- Mortality - respiratory events
- Oxygen saturation (SaO₂)
- Blood gases (PaCO₂ and PaO₂)
- Oxygenation indices (PaO₂/FiO₂)

Secondary outcomes

- Respiratory rate
- Respiratory effort (as defined by study authors)
- Heart rate
- Per cent inspired oxygen received (FiO₂; standardised protocol)
- Duration of supplemental oxygenation (standardised protocol)
- Intensive care unit (ICU) admission (standardised protocol)
- Length of hospital stay
- Mortality - all causes
- Haemodynamic parameters
- Ventilatory parameters

Potential adverse outcomes

- Accidental removal and compression of intravenous lines and/or endotracheal tube
- Cutaneous damage to the chest wall
- Facial oedema
- Contractures of the hip and shoulder
- Raised intra-ocular pressure/deterioration in visual acuity
- Gastrointestinal event
- Any other adverse events reported by study authors

Search methods for identification of studies

Electronic searches

For this update we searched the Cochrane Central Register of Controlled Trials (CENTRAL) 2012, Issue 3, part of *The Cochrane Library*, www.thecochranelibrary.com (accessed 12 April 2012) which contains the Acute Respiratory Infections Group's Specialised Register, MEDLINE (June 2008 to April week 1, 2012), EMBASE (January 2010 to April 2012) and CINAHL (2008 to April 2012). See [Appendix 1](#) for details of previous search.

We searched MEDLINE and CENTRAL using the following search strategy. We combined the MEDLINE search terms with the Cochrane Highly Sensitive Search Strategy for identifying randomised trials in MEDLINE, sensitivity- and precision-maximising version (2008 revision); Ovid format ([Lefebvre 2011](#)). The search strategy was adapted to search EMBASE (see [Appendix 2](#)) and CINAHL (see [Appendix 3](#)).

MEDLINE (Ovid)

```

1 exp Bronchiolitis/
2 bronchiolit*.tw.
3 Respiratory Syncytial Virus Infections/
4 respiratory syncytial viruses/ or respiratory syncytial virus,
human/
5 (respiratory syncytial virus* or rsv).tw.
6 exp Bronchial Diseases/
7 bronchopneumon*.tw.
8 (acute lung injur* or ali).tw.
9 exp Respiratory Tract Infections/
10 (respir* adj5 infect*).tw.
11 exp Respiratory Insufficiency/
12 (respir* adj3 (insufficien* or fail*)).tw.
13 exp Lung Diseases/
14 pneumon*.tw.
15 ((respir* or bronch*) adj25 distress*).tw.

```


16 (ards or rds).tw.
17 hyaline membrane disease*.tw.
18 bronchopulmonary dysplasia.tw.
19 chronic neonatal lung disease*.tw.
20 or/1-18
21 exp Posture/
22 postur*.tw.
23 supine.tw.
24 prone.tw.
25 (face adj5 down*).tw.
26 (side adj5 (lay or laying or laid or lays or lying or lies)).tw.
27 lateral*.tw.
28 (kinetic adj5 position*).tw.
29 continuous body position*.tw.
30 upright.tw.
31 (high adj5 sitting).tw.
32 (semi-recumbent or semirecumbent or semi-recline* or semirecline*).tw.
33 position*.tw.
34 or/21-33
35 20 and 34

Searching other resources

We made all reasonable efforts to contact recognised experts in the fields of respiratory and intensive care medicine to obtain any additional trials. We manually searched the reference lists of included and excluded studies to identify any other published or unpublished works relevant to the review topic. There were no language or publication restrictions.

Data collection and analysis

Selection of studies

Two review authors independently examined all potentially relevant citations and retrieved in full those thought to fulfil the selection criteria. Where we could not make a judgement based on the citation, or could not achieve consensus, we obtained the full article. Two review authors independently compared each article against the selection criteria to determine which articles to select for data extraction. If differences existed we resolved them either by consensus or by referral to a third review author. We considered non-English language articles eligible for selection to reduce the risk of publication bias.

Data extraction and management

We used a standardised data extraction form. Two review authors independently extracted data from each study without blinding to authorship or journal publication. Where differences existed we resolved them either by consensus or by referral to a third review author. Where data were missing, or further information was required, we made reasonable attempts to contact the trial authors to obtain the required information. We extracted data from graphs where necessary (Bjornson 1992; Bozynski 1988). Where duplicate publication occurred, the publication with the most data was the primary reference for the review. We kept and managed records of all articles identified from the search strategies, included and excluded, using a reference management system.

Data extraction included the following categories.

1. Method of allocation

2. Concealment of allocation
3. Country and setting where study was performed
4. Participant details
5. Inclusion and exclusion criteria
6. Details of intervention
7. Outcomes measured
8. Confounders
9. Duration of study and frequency of measurements
10. Numbers enrolled and completing in each group
11. Baseline characteristics
12. Results for each group

Assessment of risk of bias in included studies

Two review authors independently assessed the quality of the studies to be included without blinding to authorship or journal of publication. We also assessed the quality of the studies based on blinding to intervention and outcome measurement, and completeness of follow-up. We resolved differences in terms of allocation of studies into quality categories either by consensus or by referral to a third review author.

Measures of treatment effect

For binary outcomes, we calculated the odds ratio (OR) and 95% confidence interval (CI). For continuous outcomes, we calculated the mean difference (MD) and 95% CI using a fixed-effect model. If we found heterogeneity we used a random-effects model (see [Assessment of heterogeneity](#)).

Unit of analysis issues

Ideally we would have used first period data from the cross-over trials and combined these data with data from parallel-group studies. However, few of the cross-over trials reported such data. Therefore, we followed the recommendations of [Elbourne 2002](#) that "The results of two or more cross-over trials might be combined, but with this pooled result kept separate from the data from parallel group trials". Because of incomplete information, we could not correct data for paired analysis in the meta-analysis of cross-over trials, which may mean that we over-estimated the pooled variance. Therefore, significant effects across groups may be less apparent in the meta-analyses of cross-over trials compared to the meta-analyses of parallel-group studies.

Dealing with missing data

We had planned to use intention-to-treat (ITT) data wherever these were reported and to conduct sensitivity analyses between studies that did and did not report ITT data. However, because the majority of studies were cross-over trials this was not possible.

Assessment of heterogeneity

We interpreted a Mantel-Haenszel Chi² value of less than 0.10 and/or an I² statistic greater than 50% as significant heterogeneity. If heterogeneity was significant we used a random-effects model.

Assessment of reporting biases

If there had been 10 or more parallel trials reporting the same primary outcome, we would have generated a funnel plot (trial effect against trial size) to investigate the possibility of publication bias but there were not enough data to do this.

Data synthesis

We calculated the odds ratio (OR) and 95% confidence interval (95% CI) for binary outcomes using a fixed-effect model. We calculated the mean difference (MD) and 95% CI interval for meta-analysis of continuous outcomes using a fixed-effect model. If heterogeneity was found (see [Assessment of heterogeneity](#)), we used a random-effects model.

Subgroup analysis and investigation of heterogeneity

We used subgroup analyses to compare findings in different age groups. The only primary outcome for which this could be done was SaO₂. There were enough data to compare studies of neonates (up to one month old) and children older than one month but there were not enough data from studies that reported separately for older children, i.e. older than one year. We also conducted a subgroup analysis to compare studies of ventilated participants to studies of infants and children who were not ventilated; and infants and children with varying causes of acute respiratory distress.

Sensitivity analysis

We had planned to undertake a sensitivity analysis based on the level of potential allocation bias. However, there were not enough data to be able to do this.

RESULTS

Description of studies

Results of the search

Following the original search and the first and second updates, 3334 citations were identified; 289 trials were potentially relevant. Based on the title and abstract, we obtained 58 citations reporting 53 studies, commentaries and reviews in full text. Following data extraction, we excluded 29 (31 citations) and included 24 studies (27 citations).

Included studies

Overall, we extracted data from 24 studies. Twenty were randomised controlled cross-over trials ([Bhat 2003](#); [Bjornson 1992](#); [Bozynski 1988](#); [Chang 2002](#); [Crane 1990](#); [Ennis 1978](#); [Fox 1990](#); [Heaf 1983](#); [Jenni 1997](#); [Keene 2000](#); [Kornecki 2001](#); [Levene 1990](#); [Mendoza 1991](#); [Mizuno 1995](#); [Mizuno 1999](#); [Oliveira 2009](#); [Polacek 1992](#); [Sconyers 1987](#); [Schlessel 1993](#); [Wolfson 1992](#)). One study was an alternate allocation cross-over trial ([McEvoy 1997](#)). The remaining three studies ([Antunes 2003](#); [Curley 2005](#); [Ibrahim 2007](#)) were parallel randomised trials.

There was a total of 581 participants; 344 (59%) participants were preterm neonates. Two hundred and seventy-six (80%) of the preterm infants included in the analysis were mechanically ventilated ([Antunes 2003](#); [Bhat 2003](#); [Bjornson 1992](#); [Bozynski 1988](#); [Chang 2002](#); [Crane 1990](#); [Fox 1990](#); [Keene 2000](#); [McEvoy 1997](#); [Mendoza 1991](#); [Mizuno 1995](#); [Mizuno 1999](#); [Schlessel 1993](#); [Wolfson 1992](#)) and 66 (19%) of preterm neonates were spontaneously breathing ([Jenni 1997](#); [Keene 2000](#); [Oliveira 2009](#)). However, it was not clear whether the remaining 20 preterm infants in the study by [Bhat 2003](#) were ventilated or not. Sixty-six (11%) of the remaining participants were neonates and infants who were not described as preterm although some preterm infants may have been included ([Ennis 1978](#); [Heaf 1983](#); [Levene 1990](#); [Sconyers 1987](#)) and 12 of

these infants were mechanically ventilated ([Ennis 1978](#); [Heaf 1983](#)). The remaining 169 participants were aged one month to 16 years ([Curley 2005](#); [Ibrahim 2007](#); [Kornecki 2001](#); [Polacek 1992](#)) all but 15 of whom ([Polacek 1992](#)) were mechanically ventilated.

The inclusion/exclusion criteria were not uniform across included studies. [Bjornson 1992](#) excluded preterm infants with cardiac anomalies other than patent ductus arteriosus (PDA) while other authors ([Bozynski 1988](#); [Schlessel 1993](#)) excluded only those infants with significant PDA. [Kornecki 2001](#) excluded two children in a prone versus supine comparison due to physical restrictions preventing them from being placed prone, whilst [Antunes 2003](#), [Keene 2000](#) and [Oliveira 2009](#) excluded infants with any condition which prevented them from being positioned prone or supine. [Bozynski 1988](#) excluded participants with asymmetric lung disease whilst [Heaf 1983](#) only studied participants with unilateral (asymmetric) lung disease. [Curley 2005](#) and [Ibrahim 2007](#) both had extensive exclusion criteria which included cardiac, respiratory and neurological abnormalities. Six studies listed no exclusion criteria ([Bhat 2003](#); [Ennis 1978](#); [Fox 1990](#); [Heaf 1983](#); [Jenni 1997](#); [Kornecki 2001](#)).

The interventions included: prone versus supine ([Antunes 2003](#); [Bhat 2003](#); [Chang 2002](#); [Curley 2005](#); [Fox 1990](#); [Ibrahim 2007](#); [Keene 2000](#); [Kornecki 2001](#); [Levene 1990](#); [McEvoy 1997](#); [Mendoza 1991](#); [Mizuno 1995](#); [Mizuno 1999](#); [Wolfson 1992](#)); supine versus prone versus lateral ([Bjornson 1992](#); [Crane 1990](#); [Heaf 1983](#)); supine versus lateral ([Bozynski 1988](#); [Ennis 1978](#); [Schlessel 1993](#)); right lateral versus left lateral ([Polacek 1992](#)); prone flat versus prone head elevated ([Jenni 1997](#); [Sconyers 1987](#)); and supine flat versus supine head elevated ([Sconyers 1987](#)).

The study times also varied greatly, ranging from five minutes after a 15-minute settling in period in [Bozynski 1988](#) to a median of two days in the study by [Antunes 2003](#).

The outcomes measured and reported also varied across studies. Oxygenation outcomes included arterial oxygen saturation (SaO₂), partial pressure of arterial oxygen (PaO₂), transcutaneous oxygen pressure (PO₂), transcutaneous carbon dioxide pressure (PCO₂), ratio of PaO₂ to supplemental oxygen (PaO₂/FiO₂) and hypoxaemia (low SaO₂). Ventilatory outcomes included tidal volume, minute volume, dynamic lung compliance, inspiratory resistance, expiratory resistance, total pulmonary resistance, work of breathing and laboured breathing index. Other outcomes were heart rate, respiratory rate, oesophageal pressure and adverse events.

Excluded studies

In the original review, we excluded 27 of the 49 citations selected for review as they did not meet the selection criteria. Nine of these studies stated that only healthy babies or babies without respiratory distress were studied ([Avery 1962](#); [Brackbill 1973](#); [Dahl 1972](#); [Heimler 1992](#); [Hutchison 1979](#); [Kurlac 1994](#); [Sahni 1999](#); [Schwartz 1975](#); [Vanderghem 1983](#)). [Carlo 1989](#), on the other hand, is a follow-up study of babies with a history of respiratory distress which were not hospitalised at the time of the study. In the study by [Martin 1979](#) there was no evidence of respiratory distress in 11 of 16 infants, while in [Maynard 2000](#), seven of 10 infants showed no evidence of respiratory distress. Nine of the studies were not randomly or systematically allocated ([Baird 1991](#); [Itakura 1998](#); [Kishan 1981](#); [Kravitz 1958](#); [Lioy 1988](#); [Lopez-Herce Cid](#)

2003; Murdoch 1994; Numa 1997; Schrod 1993; Wagaman 1979). In addition, there was no evidence of respiratory distress in two of these studies (Kishan 1981; Kravitz 1958). We excluded Murai 1994 due to bias identified in the study description that participants were weaned from oxygen and assisted ventilation during the study time and that the criteria for weaning was "left to the discretion of the individual attending physicians". We also excluded McKinley 2000 as the positions compared were side-to-side turns versus prone-to-supine turns, and not prone versus supine versus side lying.

In this update, we identified an additional eight citations for review. However, once we obtained full copies of these citations, we excluded three papers (Anonymous 2005; Branco 2005; Main 2006) as they were commentaries on the study by Curley 2005. In addition, we excluded Sawhney 2005 because only 24% of the children in the study had acute respiratory distress.

Risk of bias in included studies

The overall risk of bias is presented graphically in Figure 1 and summarised in Figure 2.

Figure 1. 'Risk of bias' graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Figure 2. '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 outcome assessment (detection bias)	Incomplete outcome data (attrition bias)
Antunes 2003	?	+	?	?
Bhat 2003	?	?	?	+
Bjornson 1992	?	?	?	+
Bozynski 1988	?	?	?	+
Chang 2002	+	+	?	+
Crane 1990	?	?	?	-
Curley 2005	+	+	?	?
Ennis 1978	?	?	?	?
Fox 1990	+	?	?	+
Heaf 1983	?	?	?	+
Ibrahim 2007	?	?	?	?
Jenni 1997	?	?	?	+
Keene 2000	?	?	?	+
Kornecki 2001	?	?	?	?
Levene 1990	?	?	?	-
McEvoy 1997	-	-	?	+
Mendoza 1991	?	?	?	-
Mizuno 1995	?	?	?	+
Mizuno 1999	?	?	?	+
Oliveira 2009	?	+	?	+
Polacek 1992	?	?	?	+
Schlenger 1993	-	?	?	+

Figure 2. (Continued)

Foraker 1992	?	?	?	+
Schlesel 1993	-	?	?	+
Sconyers 1987	?	?	-	+
Wolfson 1992	?	?	?	-

Allocation

Only three of the included studies provided an adequate description of the random sequence generation and concealment of allocation (Antunes 2003; Chang 2002; Curley 2005). All of these three studies were at low risk of allocation bias. McEvoy 1997 and Schlesel 1993 were categorised as at high risk of allocation bias. McEvoy 1997 used alternate allocation and in Schlesel 1993 only the lateral positions were randomised. All other studies were considered as unclear risk of bias because sequence generation and allocation concealment was not described.

Blinding

Sconyers 1987 was the only study we considered at high risk of detection bias because bedside observers counted the frequency of breaths and heartbeats. We considered all other studies as an unclear risk because there was inadequate description of the blinding process. In addition, because objective outcomes were used we considered the risk of unblinded observers biasing the outcome unlikely.

Incomplete outcome data

There appeared to be complete follow-up in the majority of studies which we therefore considered at low risk of attrition bias. We considered five studies as an unclear risk of attrition bias as there was some loss to follow-up which seemed minimal (Antunes 2003; Curley 2005; Ennis 1978; Ibrahim 2007; Kornecki 2001). However, we considered four studies (Crane 1990; Levene 1990; Mendoza 1991; Wolfson 1992) at high risk of attrition bias. In Crane 1990 data from five of 19 participants were discarded because of "excessive drift or inaccurate or inappropriate calibration" of equipment. Levene 1990 did not collect data from nine infants as the babies did not go to sleep or woke during study time. Mendoza 1991 excluded data for 12 infants from analysis as they did not have any spontaneous or mechanical breaths during the prescribed data collection period and in Wolfson 1992, four of 24 infants were lost to follow-up though reasons were not given.

Effects of interventions

Parallel studies

Prone versus supine positioning

Oxygenation outcomes

The oxygenation outcomes for the parallel-group studies comparing prone versus supine positions were the PaO₂ and PaCO₂ (Curley 2005), PaO₂/FiO₂ (Curley 2005; Ibrahim 2007), oxygenation index (Curley 2005; Ibrahim 2007) and SaO₂ less than 90% (Antunes 2003). The ventilatory outcome tidal volume was also reported in the study by Curley 2005.

There was no difference between prone and supine groups in the percentage of participants experiencing a SaO₂ less than 90% at one (odds ratio (OR) 0.13, 95% confidence interval (CI) 0.01 to 1.15; Analysis 1.1) or two days (OR 0.12, 95% CI 0.01 to 2.53; Analysis 1.1). There was also no difference in the PaO₂ (mean difference (MD) 2.00, 95% CI -5.29 to 9.29; Analysis 1.2), PaCO₂ (MD 3.00, 95% CI -1.93 to 7.93; Analysis 1.3) or PaO₂/FiO₂ (MD 28.16, 95% CI -9.92 to 66.24; Analysis 1.4). The oxygenation index was significantly improved (MD -2.42, 95% CI -3.60 to -1.25; Analysis 1.5) in the prone group but this was largely due to the greater weighting given to the smaller study by Ibrahim 2007 which reported small standard deviations (SDs). The tidal volume was also significantly lower in the study by Curley 2005 (MD -0.60, 95% CI -1.05 to -0.15; Analysis 1.6).

Adverse events

The study by Curley 2005 also reported extubations due to adverse events, obstructions of the endotracheal tube, pressure ulcers and hypercapnia (high levels of arterial carbon dioxide), while Antunes 2003 reported re-intubations due to adverse events and atelectasis. There was no difference between prone and supine groups for any of these outcomes (Analysis 1.7) except for re-intubations, which were significantly lower in the prone group (OR 0.10, 95% CI 0.01 to 0.91; Analysis 1.7).

Respiratory rate

Antunes 2003 also reported respiratory rate, but no SDs (Table 1).

Cross-over studies

Prone versus supine positioning

Oxygenation outcomes

The oxygenation outcomes for the prone versus supine comparison included SaO₂, PaO₂, transcutaneous PCO₂, oxygenation index and SaO₂ less than 80%. The ventilatory outcomes were respiratory rate, tidal volume, minute volume, work of breathing, dynamic lung compliance, total pulmonary resistance, inspiratory resistance, expiratory resistance, thoracoabdominal synchrony and laboured breathing index. Additional outcomes included heart rate and oesophageal pressure. Adverse events were not extracted from cross-over studies because it was not clear which phase of the study, if any, the event could be attributed to.

The results showed a statistically significant improvement in SaO₂ for infants positioned in the prone position (MD 1.97%, 95% CI 1.18 to 2.77; Analysis 2.1). Nine studies measured this outcome (Bhat 2003; Bjornson 1992; Chang 2002; Levene 1990; McEvoy 1997; Mendoza 1991; Mizuno 1995; Mizuno 1999; Oliveira 2009) with a total of 195 participants. The 165 participants in the studies by Bhat 2003, Bjornson 1992, Chang 2002, McEvoy 1997, Mizuno 1995, Mizuno 1999, Mendoza 1991 and Oliveira 2009 were preterm

infants with respiratory distress (95 of whom were ventilated). The 30 infants in [Levene 1990](#) were aged two to 11 months and were not ventilated. Levene subcategorised the participants into those with upper respiratory tract infection (URTI) and those with lower respiratory tract infection (LRTI). There was no statistically significant difference in SaO₂ between the prone or supine position in the URTI group (MD -0.50%, 95% CI -2.58 to 1.58; [Analysis 2.1](#)) or the LRTI group (MD 1.80%, 95% CI -0.78 to 4.38; [Analysis 2.1](#)).

Results of analysis for PaO₂ showed a statistically significant increase in PaO₂ in the prone position (MD 6.24 mm Hg, 95% CI 2.20 to 10.28; [Analysis 2.2](#)). One study measured this outcome ([Fox 1990](#)). It included 25 participants, all preterm infants intubated and ventilated with intermittent mandatory ventilation or continuous positive airway pressure.

Results showed no significant change in transcutaneous PCO₂ when comparing prone and supine positioning (MD -2.53 mm Hg, 95% CI -6.06 to 0.99; [Analysis 2.3](#)). Three studies measured transcutaneous PCO₂ as an outcome ([Crane 1990](#); [Mizuno 1995](#); [Mizuno 1999](#)). They included 27 participants in total, all of whom were mechanically ventilated preterm infants.

One study measured oxygenation index as an outcome ([Kornecki 2001](#)). The participants were 10 children aged two months to 11 years requiring mechanical ventilation for moderate to severe acute respiratory failure. Measurements were taken at 0.5 hours (MD -0.83, 95% CI -8.04 to 6.38; [Analysis 2.4](#)), two hours (MD -2.08, 95% CI -8.61 to 4.45; [Analysis 2.4](#)), four hours (MD -4.20, 95% CI -9.37 to 0.97; [Analysis 2.4](#)), six hours (MD -5.13, 95% CI -10.13 to -0.13; [Analysis 2.4](#)), eight hours (MD -6.89, 95% CI -12.93 to -0.85; [Analysis 2.4](#)) and 12 hours (MD -8.13, 95% CI -15.01 to -1.25; [Analysis 2.4](#)). Measurements demonstrated no statistically significant improvement between prone versus supine positioning until the sixth hour measurement. However, this improvement continued and was maintained up to 12 hours.

Meta-analysis for the number of episodes of SaO₂ less than 80% showed a statistically significant decrease in the number of episodes of hypoxaemia, defined as an SaO₂ of less than 80%, (MD -3.46, 95% CI -4.60 to -2.33; [Analysis 2.5](#)). Two studies measured this outcome ([Keene 2000](#); [McEvoy 1997](#)). The alternate allocation cross-over study which included 55 of the 77 participants achieved a weighting of 91.9% ([McEvoy 1997](#)).

The results showed a statistically significant decrease in respiratory rate in infants in a prone position (MD -3.84 breaths/min, 95% CI -5.93 to -1.75; [Analysis 2.6](#)). There were six studies which measured this outcome ([Mendoza 1991](#); [Mizuno 1995](#); [Mizuno 1999](#); [Oliveira 2009](#); [Sconyers 1987](#); [Wolfson 1992](#)). They included a total of 112 participants who were preterm neonates and infants up to one month of age. Fifty-nine participants were ventilated and 53 were not ventilated.

Ventilatory outcomes

There was no significant difference in outcomes between the prone and supine groups: tidal volume (spontaneous breaths: MD 0.33 ml/kg, 95% CI -0.20 to 0.87, mechanical breaths: MD 0.40 ml/kg, 95% CI -0.58 to 1.38; [Analysis 2.7](#)), minute volume (spontaneous breaths: MD -1.93 ml/kg/min, 95% CI -27.69 to 23.84, mechanical breaths: MD 29.50 ml/kg/min, 95% CI -19.78 to 78.78; [Analysis](#)

[2.8](#)), work of breathing (spontaneous breaths: MD -0.38 gm.cm/kg, 95% CI -6.36 to 5.60, mechanical breaths: MD -2.60 gm.cm/kg, 95% CI -15.07 to 9.87; [Analysis 2.9](#)), dynamic lung compliance (spontaneous breaths: MD 0.07 ml/cm H₂O/kg, 95% CI -0.18 to 0.33, mechanical breaths: MD -0.01 ml/cm H₂O/kg, 95% CI -0.15 to 0.13; [Analysis 2.10](#)), expiratory resistance (spontaneous breaths: MD -22.00 cm H₂O/L/S, 95% CI -63.74 to 19.74, mechanical breaths: MD -31.50 cm H₂O/L/S, 95% CI -79.08 to 16.08; [Analysis 2.13](#)), heart rate less than 90 beats/min (MD -0.70 beats/min, 95% CI -6.92 to 5.52; [Analysis 2.17](#)) and oesophageal pressure (MD 0.51 cm H₂O, 95% CI -3.17 to 4.19; [Analysis 2.18](#)).

Heart rate was significantly lower (MD -7.05 beats/min, 95% CI -13.99 to -0.10; [Analysis 2.16](#)) in the three studies that measured this outcome but conclusions from these data are limited by the high level of heterogeneity (I² statistic = 76%).

Three studies measured total pulmonary resistance. There was no statistically significant difference in total pulmonary resistance in prone versus supine positioning for spontaneous breaths only, as measured by [Mendoza 1991](#), [Mizuno 1999](#) and [Wolfson 1992](#) (MD -17.09 cm H₂O/L/S, 95% CI -36.20 to 2.02; [Analysis 2.11](#)). The studies by [Mendoza 1991](#) and [Mizuno 1999](#) included a total of 33 ventilated preterm infants, with data collected on their spontaneous breaths only. [Wolfson 1992](#), however, included 20 preterm infants who were not intubated or ventilated and were therefore breathing spontaneously. [Mendoza 1991](#) was the only study to provide data for total pulmonary resistance for mechanical breaths only, from 28 ventilated preterm infants. These results showed a statistically significant decrease in total pulmonary resistance for mechanical breaths in ventilated preterm infants in the prone position (MD -52.10 cm H₂O/L/S, 95% CI -88.31 to -15.89; [Analysis 2.11](#)).

[Mendoza 1991](#) was the only study to provide data for inspiratory resistance. This study recorded separate data for spontaneous and mechanical breaths. It involved 28 participants who were ventilated preterm infants. There was no statistically significant difference in inspiratory resistance in prone versus supine positioning for spontaneous breaths (MD -8.30 cm H₂O/L/S, 95% CI -33.15 to 16.15; [Analysis 2.12](#)). However, there was a statistically significant decrease in inspiratory resistance for mechanical breaths (MD -76.60 cm H₂O/L/S, 95% CI -116.78 to -36.42; [Analysis 2.12](#)).

[Oliveira 2009](#) and [Wolfson 1992](#) measured thoracoabdominal synchrony as an outcome. There was a significant improvement in thoracoabdominal synchrony in the prone group (MD -30.76, 95% CI -41.39 to -20.14; [Analysis 2.14](#)). This analysis included 32 spontaneously breathing infants recovering from respiratory distress.

[Oliveira 2009](#) also reported the Laboured Breathing Index which was significantly lower when the 12 infants in this study were placed in the prone position (MD -0.84, 95% CI -1.24 to -0.44; [Analysis 2.15](#)).

Lateral versus supine positioning

Oxygenation outcomes

The outcomes for oxygenation measured for the comparison of lateral versus supine positions include: SaO₂ ([Bjornson 1992](#)), PaO₂ ([Ennis 1978](#); [Schlessel 1993](#)), PaCO₂ ([Schlessel 1993](#)),

transcutaneous PO₂ (Bozynski 1988) and transcutaneous PCO₂ (Bozynski 1988; Crane 1990). No statistically significant differences were demonstrated for any of these outcomes: SaO₂ (MD 1.42%, 95% CI -0.82 to 3.66; Analysis 3.1), PaO₂ (right lateral: MD -2.41 mm Hg, 95% CI -11.77 to 6.95, left lateral: MD -3.60 mm Hg, 95% CI -13.57 to 6.37; Analysis 3.2), PaCO₂ (right lateral: MD -1.00 mm Hg, 95% CI -3.45 to 1.45, left lateral: MD -1.00 mm Hg, 95% CI -3.86 to 1.86; Analysis 3.3), transcutaneous PO₂ (right lateral: MD 0.55 mm Hg, 95% CI -5.46 to 6.56, left lateral: MD 2.67 mm Hg, 95% CI -4.51 to 9.85; Analysis 3.4) and transcutaneous PCO₂ (right lateral: MD -0.63 mm Hg, 95% CI -4.66 to 3.41, left lateral: MD -0.95, 95% CI -5.07 to 3.17; Analysis 3.5).

Ventilatory outcomes

Ventilatory outcomes measured included: tidal volume (Schlessel 1993), dynamic lung compliance (Schlessel 1993) and total pulmonary resistance (Schlessel 1993). No statistically significant differences became evident in any of these outcomes for the lateral versus supine comparison: tidal volume (right lateral: MD 0.10 ml/kg, 95% CI -0.72 to 0.92, left lateral: MD 0.90, 95% CI -0.30 to 2.10; Analysis 3.6), dynamic lung compliance (right lateral: MD -0.40 ml/cm H₂O/kg, 95% CI -1.32 to 0.52, left lateral: MD -0.47 ml/cm H₂O/kg, 95% CI -1.41 to 0.47; Analysis 3.7) and total pulmonary resistance (right lateral: MD -1.00 cm H₂O/L/S, 95% CI -25.60 to 23.60, left lateral: MD 12.00 H₂O/L/S, 95% CI -16.24 to 40.24; Analysis 3.8).

Right lateral versus left lateral positioning

Oxygenation outcomes

The outcomes for oxygenation measured for the comparison of right lateral versus left lateral positions included: PaO₂ (Ennis 1978; Schlessel 1993), PaCO₂ (Schlessel 1993), transcutaneous PO₂ (Bozynski 1988) and transcutaneous PCO₂ (Bozynski 1988). No statistically significant differences resulted for any of these outcomes: PaO₂ (MD 1.72 mm Hg, 95% CI -7.89 to 11.33; Analysis 4.1), PaCO₂ (MD 0.00 mm Hg, 95% CI -3.14 to 3.14; Analysis 4.2), transcutaneous PO₂ (MD -2.12 mm Hg, 95% CI -8.93 to 4.69; Analysis 4.3) and transcutaneous PCO₂ (MD 0.77 mm Hg, 95% CI -3.64 to 5.18; Analysis 4.4).

Ventilatory outcomes

Ventilatory outcomes measured included: tidal volume, dynamic lung compliance and total pulmonary resistance (Schlessel 1993). No statistically significant differences emerged for any of these outcomes for the lateral versus supine comparison: tidal volume (MD -0.80 ml/kg, 95% CI -1.87 to 0.27; Analysis 4.5), dynamic lung compliance (MD 0.07 ml/cm H₂O/kg, 95% CI -0.71 to 0.85; Analysis 4.6) and total pulmonary resistance (MD -13.00 cm H₂O/L/S, 95% CI -40.93 to 14.93; Analysis 4.7).

Elevated versus flat positioning

Two studies compared elevated prone positioning to flat prone positioning (Jenni 1997; Sconyers 1987) and two compared elevated supine positioning to flat supine positioning (Ennis 1978; Sconyers 1987). Ennis 1978 also compared flat versus elevated in the right lateral and left lateral positions.

Oxygenation outcomes

The oxygenation outcomes for the comparison of head elevated versus flat positions included: SaO₂ (Jenni 1997), PaO₂ (Ennis 1978), SaO₂ less than 80% (Jenni 1997), respiratory rate (Sconyers 1987) and the outcomes heart rate (Sconyers 1987) and episodes of heart rate less than 90 beats per minute (Jenni 1997). None of these outcomes pointed to statistically significant differences: SaO₂ (MD 0.31%, 95% CI -2.23 to 2.85; Analysis 5.1), PaO₂ (MD 0.96 mm Hg, 95% CI -15.81 to 17.73; Analysis 5.2), SaO₂ less than 80% (MD -11.75, 95% CI -27.46 to 3.96; Analysis 5.3), respiratory rate (MD -12.00 breaths/min, 95% CI -24.48 to 0.48; Analysis 5.4), heart rate (prone: MD -4.00 beats/min, 95% CI -13.08 to 5.08, supine: MD -1.50 beats/min, 95% CI -11.93 to 8.93; Analysis 5.5) and number of episodes of heart rate less than 90 beats per minute (prone: MD -2.27, 95% CI -11.81 to 7.27; Analysis 5.6).

Ventilatory outcomes

The elevated versus flat comparison did not report on ventilatory outcomes.

Supine versus good-lung dependent positioning

Oxygenation outcomes

The oxygenation outcomes measured for the comparison supine versus good-lung dependent included: PaO₂ (Polacek 1992), transcutaneous PO₂ and transcutaneous CO₂ (Heaf 1983). There was no significant difference between positions for any of these outcomes: PaO₂ (MD -3.44 mm Hg, 95% CI -30.00 to 23.12; Analysis 6.1), transcutaneous PO₂ (MD -5.00 mm Hg, 95% CI -24.41 to 14.41; Analysis 6.2) and transcutaneous CO₂ (MD 0.00 mm Hg, 95% CI -6.51 to 6.51; Analysis 6.3).

Ventilatory outcomes

The ventilatory outcomes measured included: tidal volume and dynamic lung compliance (Heaf 1983). There was no significant difference between positions for either outcome: tidal volume (MD 0.10 ml/kg, 95% CI -5.44 to 5.64; Analysis 6.4) and dynamic lung compliance (MD 0.00 ml/cm H₂O/kg, 95% CI -1.94 to 1.94; Analysis 6.5).

Supine versus good-lung independent positioning

Oxygenation outcomes

The oxygenation outcomes measured for the comparison supine versus good-lung independent included: PaO₂ (Polacek 1992), transcutaneous PO₂ and transcutaneous CO₂ (Heaf 1983). There was no significant difference between positions for any of these outcomes: PaO₂ (MD 2.78 mm Hg, 95% CI -23.28 to 28.84; Analysis 7.1), transcutaneous PO₂ (MD 4.00 mm Hg, 95% CI -15.41 to 23.41; Analysis 7.2) and transcutaneous CO₂ (MD 0.00 mm Hg, 95% CI -6.79 to 6.79; Analysis 7.3).

Ventilatory outcomes

The ventilatory outcomes measured include: tidal volume and dynamic lung compliance (Heaf 1983). There was no significant difference between positions for either outcome: tidal volume (MD 0.50 ml/kg, 95% CI -6.57 to 7.57; Analysis 7.4) and dynamic lung compliance (MD 0.41 ml/cm H₂O/kg, 95% CI -1.98 to 2.80; Analysis 6.5).

Good-lung dependent versus good-lung independent positioning

Oxygenation outcomes

The oxygenation outcomes measured for the good-lung dependent versus good-lung independent comparison included: PaO₂ (Polacek 1992), transcutaneous PO₂ and transcutaneous CO₂ (Heaf 1983). There was no significant difference between positions for any of these outcomes: PaO₂ (MD 6.22 mm Hg, 95% CI -21.25 to 33.69; Analysis 8.1), transcutaneous PO₂ (MD 9.00 mm Hg, 95% CI -10.41 to 28.41; Analysis 8.2) and transcutaneous PCO₂ (MD 0.00 mm Hg, 95% CI -6.66 to 6.66; Analysis 8.3).

Ventilatory outcomes

The ventilatory outcomes measured included: tidal volume and dynamic lung compliance (Heaf 1983). There was no significant difference between positions for either outcome: tidal volume (MD 0.50 ml/kg, 95% CI -6.57 to 7.57; Analysis 8.4) and dynamic lung compliance (MD 0.41 ml/cm H₂O/kg, 95% CI -1.98 to 2.80; Analysis 8.5).

Subgroup analysis

We conducted all subgroup analyses on the meta-analyses of cross-over trials of participants placed in the prone and supine positions as these were the only meta-analyses for which there were enough data to conduct a subgroup analysis.

Ventilated versus non-ventilated subgroup analysis

For all of these analyses we used data from cross-over trials comparing prone and supine positions.

SaO₂

There was a statistical difference between subgroups of ventilated and non-ventilated participants in estimates of SaO₂ (P = 0.03; Analysis 9.1). However, the SaO₂ was significantly higher in the prone position compared to the supine position in both subgroups (ventilated infants: MD 2.68%, 95% CI 1.53 to 3.83; unventilated infants: MD 1.23%, 95% CI 0.60 to 1.87; Analysis 9.1) and the overall analysis (MD 2.06%, 95% CI 1.27 to 2.85; Analysis 9.1).

Respiratory rate

There was no significant difference between ventilated and non-ventilated subgroups in respiratory rate (P = 0.65). However, while there was no statistical difference between the prone and supine positions in the non-ventilated group (MD -2.39 breaths/min, 95% CI -8.98 to 4.19; Analysis 9.2) there was a statistical difference between the prone and supine positions in the subgroup analysis of ventilated subgroup (MD -4.01 breaths/min, 95% CI -6.21 to -1.80; Analysis 9.2) and the overall analysis (MD -3.84 breaths/min, 95% CI -5.93 to -1.75; Analysis 9.2).

Tidal volume

There was no significant difference between subgroups in tidal volume (P = 0.22; Analysis 9.2). There was no difference between the prone and supine position in the ventilated (MD 0.16 ml/kg, 95% CI -0.48 to 0.80; Analysis 9.3) and non-ventilated (MD 0.74 ml/kg, 95% CI -0.25 to 1.73; Analysis 9.3) subgroups or the overall analysis (MD 0.33 ml/kg, 95% CI -0.20 to 0.87; Analysis 9.3).

Minute volume

There was no significant difference between subgroups (P = 0.19; Analysis 9.4). There was no difference between the prone and supine position in the subgroup analysis of ventilated infants (MD -8.48 ml/kg/min, 95% CI -36.07 to 19.11; Analysis 9.4) and non-ventilated infants (MD 42.74 ml/kg/min, 95% CI -29.30 to 114.78; Analysis 9.4) or the overall analysis (MD -1.93 ml/kg/min, 95% CI -27.69 to 23.84; Analysis 9.4).

Subgroup analysis by age

SaO₂

Levene 1990 was the only study that compared SaO₂ in the prone and supine positions in infants older than one month. Unlike the pooled estimate of neonatal studies (MD 2.19%, 95% CI 1.35 to 3.04; Analysis 10.1) or the overall estimate (MD 2.06%, 95% CI 1.27 to 2.85; Analysis 10.1) which favoured the prone position, there was no significant difference between prone and supine groups in the Levene 1990 study (MD 0.81%, 95% CI -0.91 to 2.53; Analysis 10.1).

Sensitivity analysis

We had planned to conduct a sensitivity analysis based on quality criteria. However, this was not possible due to inadequate data.

DISCUSSION

Summary of main results

The data from cross-over studies provides evidence that short and medium-term prone positioning is beneficial in improving ventilation, oxygenation and chest wall stability in ventilated preterm infants with acutely respiratory distress. No adverse effects were identified.

We observed no other statistically significant effects of any of the other positions.

Overall completeness and applicability of evidence

While there was evidence for a positive effect of prone positioning, the clinical significance is not clear as the effect size tended to be small and the outcomes were relatively transient. There were no data reporting more clinically meaningful outcomes such as mortality, morbidity and recovery variables. In addition, the majority of the included studies compared prone and supine positioning in preterm ventilated neonates. Only three studies reported data for children older than one year of age. Therefore, it was not clear to what extent we can generalise these data in the treatment of other infants and children with acute respiratory distress.

Apart from the prone versus supine comparison, there was simply not enough evidence to draw any conclusions about the effects of other positions in acute respiratory distress.

There were insufficient data to determine if there are any adverse outcomes related to prone or other positioning. None of the studies measured outcomes that may have predisposed participants to adverse outcomes in relation to specific positioning. These might include accidental removal of the endotracheal tube, pressure areas, facial oedema or joint contractures.

The subgroup analysis based on ventilation status showed a significant difference between ventilated and non-ventilated subgroups although the SaO₂ was significantly higher for both subgroups in the prone position. However, these differences between subgroups should not be over-interpreted because these analyses were based on relatively few data. Similarly, the lack of a significant difference between the prone and supine position in infants and children aged at least one month may have been due to the low number of these children for whom data were available.

Because the pathophysiology of acute respiratory distress varies substantially, we proposed to undertake a subgroup analysis based on the reported cause and related pathophysiology of respiratory distress. However, the only data for subgroups other than preterm neonates came from the one small study by [Levene 1990](#) who reported data from infants with upper and lower respiratory tract infections in the prone and supine positions.

Quality of the evidence

Small participant numbers and short study times are major limitations to the conclusions that we can draw from this review. The majority of studies reported data from fewer than 50 infants or children, with the number of participants ranging in age from four ([Bjornson 1992](#)) to 55 ([McEvoy 1997](#)). As most of the studies included in this review were of a short duration it is not possible to establish whether any beneficial or adverse effects of positioning become significant over longer periods. Only five studies collected data for more than three hours. Three reported outcomes from 12 to 24 hours ([Jenni 1997](#); [Keene 2000](#); [Kornecki 2001](#)) and only two reported data for more than 24 hours ([Antunes 2003](#); [Bjornson 1992](#)). The study by [Kornecki 2001](#) highlights the importance of collecting data for longer periods, in that while there was no difference between the prone and supine positions until the sixth hour, oxygenation appears to have steadily increased up to 12 hours.

We observed no other statistically significant effects of any of the other positions. However, this may be due to the low number of identified studies and small participant numbers. Therefore, data from studies with much higher participant numbers are required to draw any conclusions about the effects or lack of effects of the other positions.

Potential biases in the review process

While there were few studies we considered to have a high risk of bias in selection, detection or attrition bias, the majority of studies did not describe how these potential selection or detection biases were addressed. Therefore, there may still be risk of bias in these studies.

Agreements and disagreements with other studies or reviews

The finding from this review that short and medium-term prone positioning is beneficial in improving ventilation, oxygenation and

chest wall stability in acutely respiratory-distressed ventilated preterm infants was supported by the review of [Balaguer 2006](#), which concluded that the prone position in ventilated preterm neonates resulted in improved oxygenation in the short term. Similarly, reviews of positioning for respiratory-distressed, ventilated adult participants have also concluded that prone positioning was beneficial in improving oxygenation in the short term ([Ball 1999](#); [Curley 1999](#); [Wong 1999](#)).

AUTHORS' CONCLUSIONS

Implications for practice

We concluded that prone positioning was significantly more beneficial than other positions in terms of improving ventilation, oxygenation and chest wall stability for ventilated preterm infants hospitalised with acute respiratory distress in the identified cross-over studies. Whether the benefits of prone positioning may be extrapolated to non-ventilated infants and children hospitalised with acute respiratory distress is uncertain. At present there are insufficient data in these patient groups to resolve this issue. However, due to the association of the prone position with sudden infant death syndrome (SIDS), all hospitalised infants placed in the prone position must have continuous cardio-respiratory and SaO₂ monitoring.

Implications for research

Large, international, multicentre, randomised controlled trials are required to better assess the effect of positioning respiratory-distressed infants and children in the prone position. Any future studies should also collect clinically meaningful data such as mortality, morbidity, recovery variables and adverse effects. Trials also need to determine the optimal frequency and timing of the prone position to gain maximal sustained benefits. As most identified studies reported data from neonates, future studies are needed to determine whether the prone position is also effective for older infants and children. In addition, to investigate whether findings are consistent across a range of participants, future trials should report separate data for subgroups of infants and children based on the age group, the causes of acute respiratory distress, and whether or not they are mechanically ventilated. Further research on the effectiveness of other positions for infants and children with acute respiratory distress is also needed.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Antunes 2003

Methods	Parallel RCT of prone and supine positions
Participants	<p>Included: 43 ventilated preterm infants with a gestational age < 37 weeks and birth weight < 2000 grams and required ventilation for more than 48 hours in the first week of life</p> <p>Excluded: infants with congenital abnormalities or clinical/surgical reasons which made prone positioning impossible</p> <p>Median gestational age: 29 weeks; median birth weight: 1207 g; median age at study: prone group 11 days, supine group 4 days; median FiO₂: 0.34</p> <p>Setting: NICU, Brazil</p>
Interventions	<p>Infants in the prone group were placed in the supine position from 7 to 10 am each day of the study for washes, physical examination, lab tests and X-rays; infants in both groups were in the supine position at all other times</p> <p>Median time in study: 2 days for both groups (range: 1 to 10 days)</p>
Outcomes	<p> SaO₂ < 90%, SaO₂, respiratory rate, positive inspiratory pressure, heart rate </p>

Antunes 2003 (Continued)

Notes Median values reported for continuous outcomes

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Low risk	Sealed envelopes used for randomisation
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Data from one infant were excluded as the study protocol was not completed

Bhat 2003

Methods	Cross-over RCT of prone and supine positions
Participants	Included: 20 preterm infants who had respiratory distress syndrome Excluded: not stated Median gestational age: 30 weeks; median birth weight: 1312 g; median age: 4 weeks; oxygen-dependent: 10 Setting: NICU, children's hospital, UK
Interventions	Infants were studied on 2 successive days, on each day the study position was maintained for 3 hours
Outcomes	SaO ₂
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Bjornson 1992

Methods	Cross-over RCT of prone, supine and lateral positions
Participants	<p>Included: 4 preterm infants with a gestational age of 24 to 30 weeks and birth weight of 500 to 1500 grams requiring continuing ventilatory assistance after 7 days of life for respiratory distress syndrome</p> <p>Median gestational age: 26.5 weeks; median birth weight: 1003 g; age: 9 to 24 days</p> <p>Excluded: infants with documented infections, congenital defects, cardiac anomalies other than PDA, intraventricular haemorrhage grade III & IV and maternal history of substance abuse</p> <p>Setting: medical centre and general hospital, Washington, US</p>
Interventions	Infants were placed in each of the positions for 20 minutes each over a 60-minute session; infants underwent 6 to 9 sessions over 8 to 14 days
Outcomes	<p>SaO₂</p> <p>Data collection began immediately after position change at 1-minute intervals for 20 minutes each position; data were reported for 6 to 9 sessions</p>
Notes	One infant completed 7/9 sessions and one completed 6 sessions due to intolerance of handling

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated but decision made by the primary investigator
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Bozynski 1988

Methods	Cross-over RCT of supine, left lateral and right lateral positions
Participants	<p>Included: 18 ventilated very low birth weight (birth weight 1500 grams or less) of at least 14 days post-natal age with chronic lung disease (characteristic findings on chest radiograph) who had been stable in the preceding 24 hours and normal blood pressure without pharmacologic support</p> <p>Excluded: infants with thoracostomy tubes, asymmetric lung disease, clinically significant PDA</p> <p>Median gestational age: 27.5 weeks; median birth weight: 970 g; median age: 31 days; median FiO₂: 0.32</p> <p>Setting: US</p>

Bozynski 1988 (Continued)

Interventions	Infants were settled in position for 15 minutes then measurements recorded every 30 seconds for 5 minutes	
Outcomes	tcO ₂ ; tcCO ₂	
Notes		
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Chang 2002

Methods	Cross-over RCT of prone and supine positions	
Participants	<p>Included: 28 preterm infants, gestational age of 25 to 36 weeks, postnatal age of 7 days or less, mechanically ventilated with intermittent mandatory ventilation and in a stable condition</p> <p>Excluded: infants treated with sedatives or with known congenital abnormalities</p> <p>Mean gestational age: 30 weeks; mean birth weight: 1378 g; mean age: 30 hours; mean weight: 1335 g; mean FiO₂: 0.35</p> <p>20 had signs of respiratory distress syndrome, 8 did not</p> <p>Setting: 2 tertiary care centres in Taiwan</p>	
Interventions	Infants were settled for 10 minutes in each position and data were to be recorded for 2 hours. However, 10 infants did not complete the 2 hours in both positions therefore the mean time in each position was 104 minutes	
Outcomes	<p>SaO₂; episodes of low SaO₂ (< 90% for > 20 s; duration and frequency)</p> <p>The length of data collection was matched for the shorter position duration</p>	
Notes	Some infants in one position longer than others and later period of data used for comparison in these infants	
Risk of bias		
Bias	Authors' judgement	Support for judgement

Chang 2002 (Continued)

Random sequence generation (selection bias)	Low risk	Block randomised by a third person
Allocation concealment (selection bias)	Low risk	Block randomised by a third person
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	An investigator was present by each bedside so there may have been some bias in data collection, however, outcomes were not subjective
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Crane 1990

Methods	Cross-over RCT of prone, supine and right lateral positions
Participants	Included: 19 premature infants mechanically ventilated with intermittent mandatory ventilation and PEEP for clinical hyaline membrane disease Excluded: not stated Mean gestational age: 31 weeks; mean birth weight: 1485 g; age: 20 to 72 hours; mean FiO ₂ : 0.43 Setting: regional NICU, USA
Interventions	Infants remained in study position from 10 to 85 minutes
Outcomes	tcCO ₂ ; PaCO ₂ Measurements were stabilised for 1 to 4 minutes before data were collected
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	High risk	Loss to follow-up 5/19; data were discarded due to excessive drift or inaccurate or inappropriate calibration of equipment

Curley 2005

Methods	Parallel RCT of prone and supine positions
Participants	<p>Included: 102 Intubated and ventilated paediatric participants (2 weeks to 18 years) with a $\text{PaO}_2/\text{FiO}_2$ of less than or equal to 300, bilateral pulmonary infiltrates and no clinical evidence of left atrial hypertension</p> <p>Excluded: less than 42 weeks postconceptual age, unable to tolerate a position change, respiratory failure due to cardiac disease, hypoxaemia without bilateral infiltrates, bone marrow or lung transplant, receiving extracorporeal membrane oxygenation, a non-pulmonary condition that was exacerbated by the prone position, participated in another trial within previous 30 days, decision to limit life support</p> <p>Median age: 2 years; median FiO_2: 0.60; diagnosis: pneumonia 28, bronchiolitis with pneumonia 8, sepsis 7, aspiration 6, other 2</p> <p>Setting: 7 paediatric ICUs, US</p>
Interventions	Patients were placed in the prone position 20 hours/day while in the acute phase of their illness up to a maximum of 7 days; the median time in each position (acute phase) was 4 days in the prone group and 5 days in the supine group
Outcomes	OI; PaO_2 ; PaCO_2 ; tidal volume; minute ventilation; FiO_2 ; $\text{PaO}_2/\text{FiO}_2$; PEEP; extubations; obstructed ETT; pressure ulcers; hypercapnia
Notes	Mortality was also reported at 28 days, however, as the intervention continued only up to a maximum of 7 days, we did not include these data in this review

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomisation performed using a permuted block design
Allocation concealment (selection bias)	Low risk	Serial numbered opaque sealed envelopes were used
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Data collection was not blinded but outcomes were not subjective
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Loss to follow-up 1/102 because consent was withdrawn

Ennis 1978

Methods	Cross-over RCT of supine, left lateral and right lateral positions
Participants	<p>Included: 9 infants with hyaline membrane disease, all receiving assisted ventilation</p> <p>Excluded: not stated</p> <p>Setting: US</p>
Interventions	Infants were placed in each position semi-erect and also lying flat

Ennis 1978 (Continued)

Outcomes	PaO ₂	
	Measurements commenced 5 to 10 minutes after position change or if intervention required, the mean value was calculated from 4 points, i.e. the start and end of recording and 2 equidistant points between	
Notes		
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Loss to follow-up 1/9 because one infant could not be nursed flat at physicians request

Fox 1990

Methods	Cross-over RCT of prone and supine positions	
Participants	<p>Included: 25 preterm infants with a gestational age of 36 weeks or less, who were receiving intermittent mandatory ventilation and/or CPAP and supplemental oxygen for respiratory distress syndrome, and had an umbilical artery oxygen tension catheter in situ</p> <p>Excluded: infants receiving paralysing drugs Mean gestational age: 31 weeks; mean age: 58 hours; mean weight: 1633 g</p> <p>Setting: level III NICU, US</p>	
Interventions	<p>All in incubators, on water mattress with head elevated 30 degrees, infants were allowed to settle to sleep after positioning before data collection commenced</p> <p>Ventilatory parameters and FiO2 remained unchanged</p>	
Outcomes	<p>PaO₂</p> <p>Sampling occurred every 30 seconds for 15 minutes in each position; all data collected within a 1-hour period</p>	
Notes		
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	First position randomly assigned by coin toss

Fox 1990 (Continued)

Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Heaf 1983

Methods	Cross-over RCT of supine and lateral good-lung dependent, or lateral good-lung uppermost positions	
Participants	<p>Included: 10 infants with unilateral lung disease Excluded: not stated</p> <p>Mean age: 45 days; mean weight: 3240 g; mean FiO₂: 0.33; ventilation: intubated 5, mechanically ventilated 3; diagnosis: post-diaphragmatic hernia repair 8, hypoplastic right lung 1, atelectasis of the right lung 1</p> <p>Setting: UK</p>	
Interventions	Only the order of the lateral positions were randomly allocated; both lateral positions were preceded by supine positioning; infants remained in each position for 10 minutes	
Outcomes	<p>tcO₂; tcCO₂</p> <p>Recorded over the 10 minutes in each position</p>	
Notes		

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Ibrahim 2007

Methods	Parallel RCT of prone and supine positions
Participants	Included: 34 children aged 8 weeks to 10 years on mechanical ventilation for acute respiratory failure Excluded: participants with cardiac or neurological disease, chest or abdominal trauma, neurological surgery, unstable circulatory system or receiving extracorporeal membrane oxygenation Median age: 12 months; FiO ₂ : 0.5; diagnosis: sepsis 13, pneumonia 12, inhalation injury 5, drowning 2 Setting: paediatric ICU, Saudi Arabia
Interventions	Prone and supine for 20 hours, both groups also received inhaled nitric oxide
Outcomes	OI; PaO ₂ /FiO ₂ at 1 hour and 20 hours
Notes	Outcome data were also collected at 24 hours, however, as children in the prone group were changed to the supine position at 20 hours, these data were not included

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment was not blinded but outcomes were not subjective
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Loss to follow-up 2/34; one because PaO ₂ improved and the other because of clinical deterioration

Jenni 1997

Methods	Cross-over RCT of horizontal prone position and prone position with the head elevated
Participants	Included: 12 spontaneously breathing preterm infants with a history of idiopathic recurrent apnoea Excluded: underlying disease such as anaemia, intracranial haemorrhage, heart disease or infection Mean gestational age: 28 weeks; mean birth weight: 1145 g; mean age: 18 days; mean FiO ₂ : 0.26; other: 8 infants required supplemental oxygen Age: 6 to 38 days Setting: University Children's Hospital, Switzerland
Interventions	In the elevated position, the infants head was elevated to 15 degrees from the horizontal; each infant spent a total of 24 hours in each position (6 hours each day); all were nursed in an incubator with constantly maintained FiO ₂ and temperature during the study
Outcomes	SaO ₂ ; hypoxaemia (SaO ₂ < 80%); bradycardia (< 90 beats per minute); thoracic impedance; FiO ₂

Jenni 1997 (Continued)

Notes

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Keene 2000

Methods	Cross-over RCT of prone and supine positions
Participants	Included: 22 infants of less than 34 weeks gestation with symptomatic apnoea or bradycardia at least 24 hours following extubation or discontinuation of CPAP Excluded: infants with any condition precluding them from being placed prone or supine Mean gestational age: 26.9 weeks; mean birth weight: 865 g; mean postconceptual age: 31.9 weeks; mean weight: 1204 g; diagnosis: respiratory distress syndrome 16, bronchopulmonary dysplasia 7; oxygenated: 13 Setting: USA
Interventions	Each infant was studied for 24 hours with the position changed every 6 hours
Outcomes	SaO ₂ ; hypoxaemia (SaO ₂ < 80%); apnoea (> 10 secs); bradycardia (< 100 bpm) Most extreme value in each individual and mean duration recorded

Notes

Risk of bias

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

Keene 2000 (Continued)

Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up
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Kornecki 2001

Methods	Cross-over RCT of prone and supine positions
Participants	Included: 10 children aged 8 weeks to 16 years who required mechanical ventilation for moderate to severe acute respiratory failure Excluded: not stated Mean age: 5 years; mean weight: 22.5 kg; diagnosis: sepsis/acute respiratory distress syndrome 4, pneumonia 3, other 3 Setting: 36-bed paediatric critical care unit in a tertiary care university-based children's hospital in the US
Interventions	Supine first, then random order of first study position; 12 hours in each position
Outcomes	Oxygenation index Data collected at 2, 4, 6, 8, 12 hours for each position
Notes	Heart rate, PaCO ₂ and arterial BP were not reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Loss to follow-up 2/12 enrolled, because they could not be placed in prone position due to physical restrictions

Levene 1990

Methods	Cross-over RCT of prone and supine positions
Participants	Included: 13 infants aged 2 to 11 months with upper respiratory tract infection and nasal discharge and 17 infants with lower respiratory tract infection, or bronchiolitis (as determined clinically by tachypnoea, fever, wheeze, crackles on auscultation) Excluded: infants with SaO ₂ < 85% in air

Levene 1990 (Continued)

Setting: UK

Interventions	After settling in each position for 10 minutes, infants remained in each position for 20 minutes All participants studied during quiet sleep
Outcomes	SaO ₂ continuously measured over 20 minutes
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	High risk	Loss to follow-up 9/39 infants as they did not go to sleep or woke when moved

McEvoy 1997

Methods	Alternately allocated cross-over trial of prone and supine positions
Participants	Included: 55 infants with a birth weight less than 1000 g, a diagnosis of respiratory distress syndrome, a FiO ₂ of more than 0.21 at 28 days or older, and a chest radiograph consistent with chronic lung disease Excluded: infants with multiple congenital anomalies, congenital heart disease, culture proven sepsis, evidence of seizure activity, or grade IV intra-ventricular haemorrhage Mean gestational age: 26.0; mean birth weight: 775 g; mean age: 42.0 days; mean weight: 1147 g; mean FiO ₂ : 0.30; ventilated: 17 Setting: NICUs, hospital and medical centre, USA
Interventions	1 hour in each position; alternatively and consecutively monitored after a 10-minute stabilisation period in each position before monitoring was commenced; all were quietly asleep
Outcomes	SaO ₂ ; heart rate; respiratory rate; hypoxaemia (SaO ₂ < 80% at 0 to 45 s)
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Alternate allocation was used

McEvoy 1997 (Continued)

Allocation concealment (selection bias)	High risk	Alternate allocation was used
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Mendoza 1991

Methods	Cross-over RCT of prone and supine positions
Participants	Included: 33 infants with respiratory distress syndrome and continuing intubation at 2 or more weeks of age; all were ventilated Excluded: not stated Median gestational age: 27 weeks; median birth weight: 820 g; median age: 28 days; median weight: 1000 g; median FiO ₂ : 0.30 Setting: USA
Interventions	Study time not stated; feedings stopped at least 30 minutes before study and stomach contents aspirated before pulmonary function testing
Outcomes	SaO ₂ ; respiratory rate; heart rate; tidal volume; minute ventilation; compliance; pulmonary resistance; work of breathing
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	High risk	Loss to follow-up 7/33 for spontaneous breaths as these infants did not have any spontaneous breaths in one or both positions and 5/33 for computer-selected breaths as these infants did not have any

Mizuno 1995

Methods	Cross-over RCT of prone and supine positions
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Mizuno 1995 (Continued)

Participants	<p>Included: 6 preterm infants with a birthweight of less than 1000 g with radiographic and clinical evidence of chronic lung disease requiring ventilatory support and a feeding volume of more than 100 ml a day</p> <p>Excluded: not stated</p> <p>Mean gestational age: 24.9 weeks; mean birth weight: 722.7 g; mean age: 47.5 days; mean weight: 957 g; mean FiO₂: 0.33; diagnosis: respiratory distress syndrome 5, dry lung 1</p> <p>Setting: not stated</p>
Interventions	The infant was settled into position for at least 1 hour before being fed nasogastrically over 1 hour
Outcomes	<p>SaO₂; tcPO₂; tidal volume; minute ventilation; heart rate; respiratory rate</p> <p>Measured 10 minutes before and after feeding when infants were quiet and awake</p>
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Mizuno 1999

Methods	Cross-over RCT of prone and supine positions
Participants	<p>Included: 7 very low birthweight infants with radiographic and clinical evidence of chronic lung disease, requiring ventilatory support and a feeding volume of more than 100 ml a day</p> <p>Excluded: not stated</p> <p>Mean gestational age: 26.6 weeks; mean birth weight: 845 g; mean age: 57.4 days; mean weight: 1018 g; mean FiO₂: 0.24</p> <p>Setting: not stated</p>
Interventions	The infant was settled into position for at least 1 hour before being fed nasogastrically over 1 hour
Outcomes	<p>SaO₂; tcPCO₂; tidal volume; minute ventilation; spontaneous respiratory rate; pulmonary resistance</p> <p>Measured 10 minutes before and during feeding (20 minutes, 40 minutes and end of feeding) when infants were quiet and awake</p>

Mizuno 1999 (Continued)

Notes

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Oliveira 2009

Methods	Cross-over RCT of prone and supine positions
Participants	<p>Included: 12 preterm newborn infants recovering from respiratory distress syndrome with a gestational age of between 28 and 36 weeks; free from congenital malformations; free from clinical or surgical conditions that would prevent positioning from being studied; clinically stable, defined as spontaneous breathing, on room air or oxygen therapy with a FiO_2 under 0.40 for more than 72 hours; recovering from respiratory distress syndrome, defined by radiological and clinical criteria; and weight above 1000 g at the time of enrolment</p> <p>Excluded: any factors preventing the infant being put in either the prone or supine position</p> <p>Mean gestational age: 30.8 weeks; mean birth weight: 1316 g; mean postconceptional age: 32.8 weeks; mean weight: 1446 g</p> <p>Setting: NICU, University Hospital, Brazil</p>
Interventions	After 5 minutes of instrument calibration, infants remained in the study position for 30 minutes while data were recorded
Outcomes	<p>SaO_2; tidal volume; minute ventilation; spontaneous respiratory rate; thoracoabdominal asynchrony; laboured breathing index</p> <p>Measured for 30 minutes</p>

Notes

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated

Oliveira 2009 (Continued)

Allocation concealment (selection bias)	Low risk	Randomly allocated using sealed envelopes
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Polacek 1992

Methods	Cross-over RCT of supine, lateral atelectatic lung dependent; and lateral atelectatic lung non-dependent positions	
Participants	<p>Included: 25 children, aged from birth to 17 years, and unilateral atelectasis who had undergone heart surgery within the previous 2 weeks, and had an indwelling arterial catheter</p> <p>Excluded: children with previous underlying disease, presence of pulmonary hypertension, presence of cardiac lesions with persistent intracardiac shunting</p> <p>Median age: 20 months; ventilation: mechanical ventilation 10, supplemental oxygen 9, spontaneously breathing room air 6</p> <p>Setting: PICU in a tertiary paediatric hospital, USA</p>	
Interventions	<p>All children were placed in the supine position first; only the order of the lateral position were randomised</p> <p>Children were positioned for 15 minutes in each position over a total of 45 minutes</p>	
Outcomes	<p>PaO₂</p> <p>Arterial blood gas sampled 15 minutes after position change</p>	
Notes		

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Schlessel 1993

Methods	Cross-over RCT of supine, left lateral and right lateral positions
Participants	<p>Included: 16 intubated infants of less than 36 weeks gestational age, clinical and radiological findings of respiratory distress syndrome, and decreasing ventilator and oxygen requirements for at least 24 hours prior to the study</p> <p>Excluded: infants with clinically significant patent ductus arteriosus, asymmetric lung disease, pulmonary interstitial emphysema, pneumothorax</p> <p>Mean gestational age: 33.4 weeks; mean birth weight: 2060 g; mean age: 5 days; FiO₂: 0.21 to 0.29 (settings not changed through the study)</p> <p>Setting: USA</p>
Interventions	Each infant was placed in supine, followed by lateral positioning, then supine again, followed by the other lateral position; only the order of lateral positioning was randomised; each infant was placed for 15 minutes in each position over a total of 1 hour
Outcomes	<p>PaO₂; PaCO₂; respiratory rate; heart rate; blood pressure; dynamic lung compliance; total pulmonary resistance; inspiratory resistance; expiratory resistance; tidal volume</p> <p>Pulmonary mechanics were measured at 5 and 15 minutes in each position and arterial blood gases at 15 minutes</p>
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	The order of the supine position was not randomised, only the lateral positions were randomised
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Sconyers 1987

Methods	Cross-over RCT of supine flat, supine elevated, prone flat and prone elevated positions
Participants	<p>Included: 17 infants with tachypnoea of pulmonary aetiology</p> <p>Patients required to be stable enough not to require respiratory intervention for the 2-hour study period</p> <p>Excluded: infants with apnoea, bradycardia, multiple chest tubes or significant metabolic acidosis</p> <p>Diagnosis: transient tachypnoea of newborn 6, respiratory distress syndrome 6, bronchopulmonary dysplasia 5</p> <p>Setting: US</p>

Sconyers 1987 (Continued)

Interventions	Both supine and prone positions were done while flat and while elevated (20 to 30 degrees above the horizontal) Each infant was placed for 30 minutes in each position
Outcomes	Respiratory rate; heart rate Measured before each position change
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated
Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	High risk	There was a high potential for bias because the bedside nurse 'counted' the respiratory and heart rates
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to be no loss to follow-up

Wolfson 1992

Methods	Cross-over RCT of prone and supine positions
Participants	Included: 24 preterm infants recovering from respiratory distress who had received mechanical ventilation and supplemental oxygen for a minimum of 2 days and who were spontaneously breathing room air or had an FiO ₂ of less than 0.40 at the time of study Excluded: those with cardiac involvement or surgical intervention Mean gestational age: 28 weeks; mean birth weight: 1020 g; mean postconceptual age: 33 weeks; mean weight: 1450 g Setting: 2 NICUs in the USA
Interventions	Study time unclear; minimum 10 minutes in each position and no longer than 3 minutes at a time. Chest wall synchrony was taken over 10 breaths
Outcomes	Tidal volume; peak to peak oesophageal pressure; respiratory rate; minute ventilation; pulmonary resistance; pulmonary compliance; thoracoabdominal synchrony
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not stated

Wolfson 1992 (Continued)

Allocation concealment (selection bias)	Unclear risk	Not stated
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not stated
Incomplete outcome data (attrition bias) All outcomes	High risk	Loss to follow-up 4/24, reasons not given

BP - blood pressure
 bpm - beats per minute
 CPAP - continuous positive airways pressure
 ETT - endotracheal tube
 FiO₂ - inspired oxygen
 ICU - intensive care unit
 NICU - neonatal intensive care unit
 O₂ - oxygen
 OI - oxygenation index = (mean airway pressure X FiO₂% / PaO₂)
 PaCO₂ - arterial carbon dioxide tension
 PaO₂ - arterial oxygen tension
 PDA - patent ductus arteriosus
 PEEP - positive expiratory end pressure
 PICU - paediatric intensive care unit
 RCT - randomised controlled trial
 SaO₂ - oxygen saturation of haemoglobin
 tcO₂ - transcutaneous oxygen level
 tcCO₂ - transcutaneous carbon dioxide level

Characteristics of excluded studies [ordered by study ID]

Study	Reason for exclusion
Anonymous 2005	Comment on Curley 2005
Avery 1962	Healthy infants
Baird 1991	Not randomised
Brackbill 1973	Healthy infants
Branco 2005	Comment on Curley 2005
Carlo 1989	Not currently hospitalised respiratory-distressed participants, follow-up study
Dahl 1972	Healthy infants
Heimler 1992	Healthy preterm infants with apnoea not requiring respiratory support or supplemental oxygen, no evidence of respiratory distress
Hutchison 1979	Healthy infants
Itakura 1998	Not randomised

Study	Reason for exclusion
Kavanagh 2005	Comment on Curley 2005
Kishan 1981	Does not appear to be randomised, infants do not have respiratory distress
Kravitz 1958	Not randomised, no evidence of respiratory distress
Kurlac 1994	Healthy preterm infants with apnoea, no evidence of respiratory distress, those who required assisted ventilation were excluded
Liroy 1988	Not randomised, no evidence of respiratory distress
Lopez-Herce Cid 2003	Not randomised
Main 2006	Comment on Curley 2005
Martin 1979	Not randomised, no evidence of respiratory distress in 11 of 16 infants
Maynard 2000	No evidence of respiratory distress in 7 of 10 infants
McKinley 2000	Comparison side/side turns versus prone/supine turns
Murai 1994	Patients were weaned from oxygen and ventilator during study hence measures/interventions were not consistent
Murdoch 1994	Not randomised
Numa 1997	Not randomised
Sahni 1999	Study of healthy infants
Sawhney 2005	Only 24% of participants had acute respiratory distress
Schrod 1993	Not randomised
Schwartz 1975	Study of healthy babies, no evidence of respiratory distress
Vanderghem 1983	No evidence of respiratory distress
Wagaman 1979	Not randomised

DATA AND ANALYSES

Comparison 1. Prone versus supine: parallel trials

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Patients with SaO₂ < 90%	1		Odds Ratio (M-H, Fixed, 95% CI)	Totals not selected
1.1 Day 1	1		Odds Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.2 Day 2	1		Odds Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
2 PaO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 PaCO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 PaO ₂ /FiO ₂	2	121	Mean Difference (IV, Random, 95% CI)	28.16 [-9.92, 66.24]
5 Oxygenation Index	2	121	Mean Difference (IV, Fixed, 95% CI)	-2.42 [-3.60, -1.25]
6 Tidal volume	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
7 Adverse events	2		Odds Ratio (M-H, Fixed, 95% CI)	Totals not selected
7.1 Extubations	1		Odds Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.2 Obstructed endotracheal tube	1		Odds Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.3 Pressure ulcers	1		Odds Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.4 Hypercapnea	1		Odds Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.5 Reintubations	1		Odds Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.6 Atelectasis	1		Odds Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

Analysis 1.1. Comparison 1 Prone versus supine: parallel trials, Outcome 1 Patients with SaO₂ < 90%.

Analysis 1.2. Comparison 1 Prone versus supine: parallel trials, Outcome 2 PaO₂.

Analysis 1.3. Comparison 1 Prone versus supine: parallel trials, Outcome 3 PaCO₂.

Study or subgroup	Prone		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Curley 2005	50	56 (13)	49	53 (12)		3[-1.93,7.93]

Analysis 1.4. Comparison 1 Prone versus supine: parallel trials, Outcome 4 PaO₂/FiO₂.

Study or subgroup	Prone		Supine		Mean Difference	Weight	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Random, 95% CI		Random, 95% CI
Curley 2005	50	183 (69)	49	176 (62)		45.75%	7[-18.83,32.83]
Ibrahim 2007	11	199 (17)	11	153 (14.1)		54.25%	46[32.95,59.05]
Total ***	61		60			100%	28.16[-9.92,66.24]
Heterogeneity: Tau ² =651.49; Chi ² =6.98, df=1(P=0.01); I ² =85.67%							
Test for overall effect: Z=1.45(P=0.15)							

Analysis 1.5. Comparison 1 Prone versus supine: parallel trials, Outcome 5 Oxygenation Index.

Study or subgroup	Prone		Supine		Mean Difference	Weight	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI		Fixed, 95% CI
Curley 2005	50	11 (9)	49	12 (9)		11%	-1[-4.55,2.55]
Ibrahim 2007	11	9.5 (2.1)	11	12.1 (0.2)		89%	-2.6[-3.85,-1.35]
Total ***	61		60			100%	-2.42[-3.6,-1.25]
Heterogeneity: Tau ² =0; Chi ² =0.7, df=1(P=0.4); I ² =0%							
Test for overall effect: Z=4.04(P<0.0001)							

Analysis 1.6. Comparison 1 Prone versus supine: parallel trials, Outcome 6 Tidal volume.

Study or subgroup	Prone		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Curley 2005	42	6.2 (1.1)	42	6.8 (1)		-0.6[-1.05,-0.15]

Analysis 1.7. Comparison 1 Prone versus supine: parallel trials, Outcome 7 Adverse events.

Study or subgroup	Prone		Supine		Odds Ratio	Odds Ratio
	n/N		n/N		M-H, Fixed, 95% CI	M-H, Fixed, 95% CI
1.7.1 Extubations

Comparison 2. Prone versus supine: cross-over trials

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 SaO ₂	9	390	Mean Difference (IV, Random, 95% CI)	1.97 [1.18, 2.77]
1.1 All	8	330	Mean Difference (IV, Random, 95% CI)	2.19 [1.35, 3.04]
1.2 URTI	1	26	Mean Difference (IV, Random, 95% CI)	-0.5 [-2.58, 1.58]
1.3 LRTI	1	34	Mean Difference (IV, Random, 95% CI)	1.80 [-0.78, 4.38]
2 PaO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 tcPCO ₂	3	54	Mean Difference (IV, Fixed, 95% CI)	-2.53 [-6.06, 0.99]
4 Oxygenation Index	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4.1 30 minutes	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4.2 2 hours	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4.3 4 hours	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4.4 6 hours	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4.5 8 hours	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4.6 12 hours	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
5 Number of episodes SaO ₂ < 80%	2	154	Mean Difference (IV, Fixed, 95% CI)	-3.46 [-4.60, -2.33]
6 Respiratory rate	6	222	Mean Difference (IV, Fixed, 95% CI)	-3.84 [-5.93, -1.75]
7 Tidal volume	5	196	Mean Difference (IV, Fixed, 95% CI)	0.35 [-0.12, 0.82]
7.1 Spontaneous breaths	5	140	Mean Difference (IV, Fixed, 95% CI)	0.33 [-0.20, 0.87]
7.2 Mechanical breaths	1	56	Mean Difference (IV, Fixed, 95% CI)	0.40 [-0.58, 1.38]
8 Minute volume	5	196	Mean Difference (IV, Fixed, 95% CI)	4.82 [-18.01, 27.65]
8.1 Spontaneous breaths	5	140	Mean Difference (IV, Fixed, 95% CI)	-1.93 [-27.69, 23.84]
8.2 Mechanical breaths	1	56	Mean Difference (IV, Fixed, 95% CI)	29.5 [-19.78, 78.78]
9 Work of breathing	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
9.1 Spontaneous breaths	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
9.2 Mechanical breaths	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
10 Dynamic lung compliance	2	148	Mean Difference (IV, Fixed, 95% CI)	0.01 [-0.11, 0.13]
10.1 Spontaneous breaths	2	92	Mean Difference (IV, Fixed, 95% CI)	0.07 [-0.18, 0.33]
10.2 Mechanical breaths	1	56	Mean Difference (IV, Fixed, 95% CI)	-0.01 [-0.15, 0.13]
11 Total pulmonary resistance	3	162	Mean Difference (IV, Fixed, 95% CI)	-24.72 [-41.61, -7.82]
11.1 Spontaneous breaths	3	106	Mean Difference (IV, Fixed, 95% CI)	-17.09 [-36.20, 2.02]
11.2 Mechanical breaths	1	56	Mean Difference (IV, Fixed, 95% CI)	-52.1 [-88.31, -15.89]
12 Inspiratory resistance	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
12.1 Spontaneous breaths	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
12.2 Mechanical breaths	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
13 Expiratory resistance	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
13.1 Spontaneous breaths	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
13.2 Mechanical breaths	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
14 Thoracoabdominal synchrony	2	64	Mean Difference (IV, Fixed, 95% CI)	-30.76 [-41.39, -20.14]
15 Laboured Breathing Index	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
16 Heart rate	3	113	Mean Difference (IV, Random, 95% CI)	-7.05 [-13.99, -0.10]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
17 Number of episodes of heart rate < 90 bpm	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
18 Oesophageal pressure	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Analysis 2.1. Comparison 2 Prone versus supine: cross-over trials, Outcome 1 SaO₂.

Analysis 2.2. Comparison 2 Prone versus supine: cross-over trials, Outcome 2 PaO₂.

Analysis 2.3. Comparison 2 Prone versus supine: cross-over trials, Outcome 3 tcPCO₂.

Analysis 2.4. Comparison 2 Prone versus supine: cross-over trials, Outcome 4 Oxygenation Index.

Analysis 2.5. Comparison 2 Prone versus supine: cross-over trials, Outcome 5 Number of episodes SaO₂ < 80%.

Analysis 2.6. Comparison 2 Prone versus supine: cross-over trials, Outcome 6 Respiratory rate.

Analysis 2.7. Comparison 2 Prone versus supine: cross-over trials, Outcome 7 Tidal volume.

Analysis 2.8. Comparison 2 Prone versus supine: cross-over trials, Outcome 8 Minute volume.

Analysis 2.9. Comparison 2 Prone versus supine: cross-over trials, Outcome 9 Work of breathing.

Analysis 2.10. Comparison 2 Prone versus supine: cross-over trials, Outcome 10 Dynamic lung compliance.

Analysis 2.11. Comparison 2 Prone versus supine: cross-over trials, Outcome 11 Total pulmonary resistance.

Analysis 2.12. Comparison 2 Prone versus supine: cross-over trials, Outcome 12 Inspiratory resistance.

Analysis 2.13. Comparison 2 Prone versus supine: cross-over trials, Outcome 13 Expiratory resistance.

Analysis 2.14. Comparison 2 Prone versus supine: cross-over trials, Outcome 14 Thoracoabdominal synchrony.

Analysis 2.15. Comparison 2 Prone versus supine: cross-over trials, Outcome 15 Laboured Breathing Index.

Analysis 2.16. Comparison 2 Prone versus supine: cross-over trials, Outcome 16 Heart rate.

Analysis 2.17. Comparison 2 Prone versus supine: cross-over trials, Outcome 17 Number of episodes of heart rate < 90 bpm.

Study or subgroup	Prone		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Keene 2000	22	9 (8.8)	22	9.7 (12)		-0.7 [-6.92, 5.52]
					Favours prone -10 -5 0 5 10 Favours supine	

Analysis 2.18. Comparison 2 Prone versus supine: cross-over trials, Outcome 18 Oesophageal pressure.

Study or subgroup	Prone		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Wolfson 1992	20	9.4 (6.3)	20	8.9 (5.6)		0.51 [-3.17, 4.19]
					Favours prone -4 -2 0 2 4 Favours supine	

Comparison 3. Lateral versus supine: cross-over trials

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 SaO ₂	1	8	Mean Difference (IV, Fixed, 95% CI)	1.42 [-0.82, 3.66]
1.1 Right or left	1	8	Mean Difference (IV, Fixed, 95% CI)	1.42 [-0.82, 3.66]
2 PaO ₂	2		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
2.1 Right lateral	2	48	Mean Difference (IV, Fixed, 95% CI)	-2.41 [-11.77, 6.95]
2.2 Left lateral	2	48	Mean Difference (IV, Fixed, 95% CI)	-3.60 [-13.57, 6.37]
3 PaCO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3.1 Right lateral	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.2 Left lateral	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4 tcPO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4.1 Right lateral	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4.2 Left lateral	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
5 tcPCO ₂	2		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
5.1 Right lateral	2	64	Mean Difference (IV, Fixed, 95% CI)	-0.63 [-4.66, 3.41]
5.2 Left lateral	1	36	Mean Difference (IV, Fixed, 95% CI)	-0.95 [-5.07, 3.17]
6 Tidal volume	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
6.1 Right lateral	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
6.2 Left lateral	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
7 Dynamic lung compliance	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
7.1 Right lateral	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.2 Left lateral	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
8 Total pulmonary resistance	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.1 Right lateral	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
8.2 Left lateral	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

Analysis 3.1. Comparison 3 Lateral versus supine: cross-over trials, Outcome 1 SaO₂.

Analysis 3.2. Comparison 3 Lateral versus supine: cross-over trials, Outcome 2 PaO₂.

Analysis 3.3. Comparison 3 Lateral versus supine: cross-over trials, Outcome 3 PaCO₂.

Analysis 3.4. Comparison 3 Lateral versus supine: cross-over trials, Outcome 4 tcPO₂.

Analysis 3.5. Comparison 3 Lateral versus supine: cross-over trials, Outcome 5 tcPCO₂.

Analysis 3.6. Comparison 3 Lateral versus supine: cross-over trials, Outcome 6 Tidal volume.

Analysis 3.7. Comparison 3 Lateral versus supine: cross-over trials, Outcome 7 Dynamic lung compliance.

Analysis 3.8. Comparison 3 Lateral versus supine: cross-over trials, Outcome 8 Total pulmonary resistance.

Comparison 4. Right lateral versus left lateral: cross-over trials

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 PaO ₂	2	48	Mean Difference (IV, Fixed, 95% CI)	1.72 [-7.89, 11.33]
2 PaCO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 tcPO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 tcPCO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 Tidal volume	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
6 Dynamic lung compliance	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
7 Total pulmonary resistance	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Analysis 4.1. Comparison 4 Right lateral versus left lateral: cross-over trials, Outcome 1 PaO₂.

Analysis 4.2. Comparison 4 Right lateral versus left lateral: cross-over trials, Outcome 2 PaCO₂.

Analysis 4.3. Comparison 4 Right lateral versus left lateral: cross-over trials, Outcome 3 tcPO₂.

Analysis 4.4. Comparison 4 Right lateral versus left lateral: cross-over trials, Outcome 4 tcPCO₂.

Study or subgroup	Right lateral		Left lateral		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Bozynski 1988	18	45.4 (7.5)	18	44.6 (5.9)		0.77 [-3.64, 5.18]
					Favours right	Favours left

Analysis 4.5. Comparison 4 Right lateral versus left lateral: cross-over trials, Outcome 5 Tidal volume.

Study or subgroup	Right lateral		Left lateral		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Schlessel 1993	16	4.8 (0.9)	16	5.6 (2)		-0.8 [-1.87, 0.27]
					Favours left	Favours right

Analysis 4.6. Comparison 4 Right lateral versus left lateral: cross-over trials, Outcome 6 Dynamic lung compliance.

Study or subgroup	Right lateral		Left lateral		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Schlessel 1993	16	1.9 (1.1)	16	1.8 (1.2)		0.07 [-0.71, 0.85]
					Favours left	Favours right

Analysis 4.7. Comparison 4 Right lateral versus left lateral: cross-over trials, Outcome 7 Total pulmonary resistance.

Study or subgroup	Right lateral		Left lateral		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Schlessel 1993	16	37 (35)	16	50 (45)		-13 [-40.93, 14.93]
					Favours right	Favours left

Comparison 5. Elevated versus flat: cross-over trials

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 SaO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
1.1 Prone	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2 PaO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.1 Supine	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2.2 All	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
3 Number of episodes of SaO ₂ < 80%	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3.1 Prone	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4 Respiratory rate	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4.1 Prone	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4.2 Supine	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
5 Heart rate	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5.1 Prone	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
5.2 Supine	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
6 Number of episodes heart rate < 90 bpm	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
6.1 Prone	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

Analysis 5.1. Comparison 5 Elevated versus flat: cross-over trials, Outcome 1 SaO₂.

Study or subgroup	Elevated		Flat		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
5.1.1 Prone						
Jenni 1997	12	93.5 (3.2)	12	93.2 (3.2)		0.31[-2.23,2.85]

Analysis 5.2. Comparison 5 Elevated versus flat: cross-over trials, Outcome 2 PaO₂.

Study or subgroup	Elevated		Flat		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
5.2.1 Supine						
Ennis 1978	9	70 (21)	8	71 (15)		-1[-18.21,16.21]
5.2.2 All						
Ennis 1978	8	74.4 (18.3)	8	73.5 (15.9)		0.96[-15.81,17.73]

Analysis 5.3. Comparison 5 Elevated versus flat: cross-over trials, Outcome 3 Number of episodes of SaO₂ < 80%.

Study or subgroup	Elevated		Flat		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
5.3.1 Prone						
Jenni 1997	12	12.5 (16.5)	12	24.2 (22.4)		-11.75[-27.46,3.96]

Analysis 5.4. Comparison 5 Elevated versus flat: cross-over trials, Outcome 4 Respiratory rate.

Study or subgroup	Elevated		Flat		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
5.4.1 Prone						
Sconyers 1987	17	61 (17)	17	73 (20)		-12[-24.48,0.48]
5.4.2 Supine						
Sconyers 1987	17	66 (19)	17	76 (21)		-10[-23.46,3.46]

Analysis 5.5. Comparison 5 Elevated versus flat: cross-over trials, Outcome 5 Heart rate.

Study or subgroup	Elevated		Flat		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
5.5.1 Prone						
Sconyers 1987	17	147 (14)	17	151 (13)		-4[-13.08,5.08]
5.5.2 Supine						
Sconyers 1987	17	151 (15)	17	152.5 (16)		-1.5[-11.93,8.93]

Analysis 5.6. Comparison 5 Elevated versus flat: cross-over trials, Outcome 6 Number of episodes heart rate < 90 bpm.

Study or subgroup	Elevated		Flat		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
5.6.1 Prone						
Jenni 1997	12	12.1 (11.3)	12	14.4 (12.6)		-2.27[-11.81,7.27]

Comparison 6. Supine versus good-lung dependent: cross-over trials

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 PaO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 TcPO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 TcPCO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Tidal volume	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 Dynamic lung compliance	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Analysis 6.1. Comparison 6 Supine versus good-lung dependent: cross-over trials, Outcome 1 PaO₂.

Study or subgroup	Good lung dependent		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Polacek 1992	25	111.9 (50.4)	25	115.4 (45.3)		-3.44[-30,23.12]
					Favours supine	Favours dependent

Analysis 6.2. Comparison 6 Supine versus good-lung dependent: cross-over trials, Outcome 2 TcPO₂.

Study or subgroup	Good lung dependent		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	10	73 (22.1)	10	78 (22.1)		-5[-24.41,14.41]
					Favours supine	Favours dependent

Analysis 6.3. Comparison 6 Supine versus good-lung dependent: cross-over trials, Outcome 3 TcPCO₂.

Study or subgroup	Good lung dependent		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	10	38 (7.3)	10	38 (7.6)		0[-6.51,6.51]
					Favours dependent	Favours supine

Analysis 6.4. Comparison 6 Supine versus good-lung dependent: cross-over trials, Outcome 4 Tidal volume.

Study or subgroup	Good lung dependent		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	4	6.5 (4)	4	6.4 (4)		0.1[-5.44,5.64]
					Favours supine	Favours dependent

Analysis 6.5. Comparison 6 Supine versus good-lung dependent: cross-over trials, Outcome 5 Dynamic lung compliance.

Study or subgroup	Good lung dependent		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	4	2.6 (1.4)	4	2.6 (1.4)		0 [-1.94,1.94]

Comparison 7. Supine versus good-lung independent: cross-over trials

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 PaO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 tcPO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 tcPCO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Tidal volume	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 Dynamic lung compliance	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Analysis 7.1. Comparison 7 Supine versus good-lung independent: cross-over trials, Outcome 1 PaO₂.

Study or subgroup	Good lung independent		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Polacek 1992	25	118.1 (48.7)	25	115.4 (45.3)		2.78 [-23.28,28.84]

Analysis 7.2. Comparison 7 Supine versus good-lung independent: cross-over trials, Outcome 2 tcPO₂.

Study or subgroup	Good lung independent		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	10	82 (22.1)	10	78 (22.1)		4 [-15.41,23.41]

Analysis 7.3. Comparison 7 Supine versus good-lung independent: cross-over trials, Outcome 3 tcPCO₂.

Study or subgroup	Good Lung Independen		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	10	38 (7.9)	10	38 (7.6)		0[-6.79,6.79]
					Favours Independent	Favours Supine

Analysis 7.4. Comparison 7 Supine versus good-lung independent: cross-over trials, Outcome 4 Tidal volume.

Study or subgroup	Good lung independent		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	4	7 (6)	4	6.5 (4)		0.5[-6.57,7.57]
					Favours supine	Favours independent

Analysis 7.5. Comparison 7 Supine versus good-lung independent: cross-over trials, Outcome 5 Dynamic lung compliance.

Study or subgroup	Good lung independent		Supine		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	4	3 (2)	4	2.6 (1.4)		0.41[-1.98,2.8]
					Favours supine	Favours independent

Comparison 8. Good-lung dependent versus good lung-independent: cross-over trials

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 PaO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 tcPO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 tcPCO ₂	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Tidal volume	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 Dynamic lung compliance	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Analysis 8.1. Comparison 8 Good-lung dependent versus good lung-independent: cross-over trials, Outcome 1 PaO₂.

Study or subgroup	Good lung independent		Good lung dependent		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Polacek 1992	25	118.1 (48.7)	25	111.9 (50.4)		6.22[-21.25,33.69]
					Favours dependent	Favours independent

Analysis 8.2. Comparison 8 Good-lung dependent versus good lung-independent: cross-over trials, Outcome 2 tcPO₂.

Study or subgroup	Good lung independent		Good lung dependent		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	10	82 (22.1)	10	73 (22.1)		9[-10.41,28.41]
					Favours dependent	Favours independent

Analysis 8.3. Comparison 8 Good-lung dependent versus good lung-independent: cross-over trials, Outcome 3 tcPCO₂.

Study or subgroup	Good lung independent		Good lung dependent		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	10	38 (7.9)	10	38 (7.3)		0[-6.66,6.66]
					Favours independent	Favours dependent

Analysis 8.4. Comparison 8 Good-lung dependent versus good lung-independent: cross-over trials, Outcome 4 Tidal volume.

Study or subgroup	Good lung independent		Good lung dependent		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	4	7 (6)	4	6.5 (4)		0.5[-6.57,7.57]
					Favours dependent	Favours independent

Analysis 8.5. Comparison 8 Good-lung dependent versus good lung-independent: cross-over trials, Outcome 5 Dynamic lung compliance.

Study or subgroup	Good lung independent		Good lung dependent		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Heaf 1983	4	3 (2)	4	2.6 (1.4)		0.41[-1.98,2.8]
					Favours dependent	Favours independent

Comparison 9. Subgroup analysis by ventilation status: cross-over trials

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 SaO₂	9	390	Mean Difference (IV, Random, 95% CI)	2.06 [1.27, 2.85]
1.1 Ventilated	6	266	Mean Difference (IV, Random, 95% CI)	2.68 [1.53, 3.83]
1.2 Non-ventilated	3	124	Mean Difference (IV, Random, 95% CI)	1.23 [0.60, 1.87]
2 Respiratory rate	6	222	Mean Difference (IV, Fixed, 95% CI)	-3.84 [-5.93, -1.75]
2.1 Ventilated	3	92	Mean Difference (IV, Fixed, 95% CI)	-4.01 [-6.21, -1.80]
2.2 Non-ventilated	3	130	Mean Difference (IV, Fixed, 95% CI)	-2.39 [-8.98, 4.19]
3 Tidal volume	5	140	Mean Difference (IV, Fixed, 95% CI)	0.33 [-0.20, 0.87]
3.1 Ventilated	3	78	Mean Difference (IV, Fixed, 95% CI)	0.16 [-0.48, 0.80]
3.2 Non-ventilated	2	62	Mean Difference (IV, Fixed, 95% CI)	0.74 [-0.25, 1.73]
4 Minute volume	5	140	Mean Difference (IV, Fixed, 95% CI)	-1.93 [-27.69, 23.84]
4.1 Ventilated	3	78	Mean Difference (IV, Fixed, 95% CI)	-8.48 [-36.07, 19.11]
4.2 Non-ventilated	2	62	Mean Difference (IV, Fixed, 95% CI)	42.74 [-29.30, 114.78]

Analysis 9.1. Comparison 9 Subgroup analysis by ventilation status: cross-over trials, Outcome 1 SaO₂.

Analysis 9.2. Comparison 9 Subgroup analysis by ventilation status: cross-over trials, Outcome 2 Respiratory rate.

Analysis 9.3. Comparison 9 Subgroup analysis by ventilation status: cross-over trials, Outcome 3 Tidal volume.

Analysis 9.4. Comparison 9 Subgroup analysis by ventilation status: cross-over trials, Outcome 4 Minute volume.

Comparison 10. Subgroup analysis by age: cross-over trials

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 SaO ₂	9	390	Mean Difference (IV, Random, 95% CI)	2.06 [1.27, 2.85]
1.1 Neonates	8	330	Mean Difference (IV, Random, 95% CI)	2.19 [1.35, 3.04]
1.2 > One month	1	60	Mean Difference (IV, Random, 95% CI)	0.81 [-0.91, 2.53]

Analysis 10.1. Comparison 10 Subgroup analysis by age: cross-over trials, Outcome 1 SaO₂.

ADDITIONAL TABLES

Table 1. Median and range data

Study	Outcome	Supine n	Supine (median)	Supine (range)	Prone n	Prone (median)	Prone (median)
Antunes 2003	Respiratory rate day 1	21	25	20 to 33	21	20	20 to 24
Antunes 2003	Respiratory rate day 2	20	20	18 to 29	20	20	20 to 22
Curley 2005	Minute ventilation	42	1.6	* 1.0 to 3.2	42	1.6	0.6 to 2.8

* Interquartile range

APPENDICES

Appendix 1. Previous search strategy

For this first update we searched the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2008, Issue 3) which contains the Acute Respiratory Infections Group's Specialised Register; MEDLINE (January 1966 to August Week 1, 2008); EMBASE (January 2004 to Week 33, 2008) and CINAHL (January 2004 to August Week 3, 2008).

We combined the MEDLINE search terms with a search strategy used to identify relevant trials ([Dickersin 1994](#)). We adapted the search terms to search EMBASE and CINAHL.

TERMS FOR ACUTE RESPIRATORY DISTRESS

- 1 Exp Bronchiolitis/
- 2 Bronchiolitis.tw
- 3 Exp respiratory syncytial virus infections/
- 4 Respiratory syncytial virus.tw
- 5 RSV.tw
- 6 Bronchopneumonia.tw
- 7 Exp bronchial diseases/ [incorporates asthma, bronchopneumonia]
- 8 Exp respiratory distress syndrome, adult/
- 9 ARDS.tw
- 10 (Acute respiratory distress).tw
- 11 Acute lung injury.tw
- 12 ALI.tw
- 13 Exp respiratory tract infections/
- 14 Respiratory distress.tw
- 15 (Resp\$ adj25 distress).tw
- 16 (Bronch\$ adj25 distress).tw
- 17 Respiratory infection.tw
- 18 Exp respiratory insufficiency/ [Used for respiratory failure]
- 19 Respiratory insufficiency.tw
- 20 Respiratory failure.tw
- 21 Exp respiratory distress syndrome/
- 22 Respiratory distress syndrome.tw
- 23 Exp pneumonia/
- 24 Pneumonia.tw
- 25 Exp lung diseases/ [incorporates pneumonia, RDS]
- 26 Exp hyaline membrane disease/
- 27 Hyaline membrane disease.tw
- 28 Exp Bronchopulmonary dysplasia/
- 29 Bronchopulmonary dysplasia.tw
- 30 Chronic neonatal lung disease.tw
- 31 Or/1-30

POSITIONING TERMS

- 32 Exp posture/ [This will capture (exp supine position/) and (exp prone position/)]
- 33 Postur\$.tw
- 34 Supine.tw
- 35 Prone.tw
- 36 Face adj5 down.tw
- 37 Side adj5 lying.tw
- 38 Lateral\$.tw
- 39 Kinetic adj5 position\$.tw
- 40 Continuous body position\$.tw
- 41 Upright.tw
- 42 High adj5 sitting.tw
- 43 Semirecumbent.tw
- 44 Position\$.tw
- 45 Or/32-44
- 46 31 and 45

Appendix 2. Embase.com search strategy

#28 #24 AND #27 116416 Jan 2011
 #27 #25 OR #26 83206316 Jan 2011
 #26 random*:ab,ti OR placebo*:ab,ti OR factorial*:ab,ti OR crossover*:ab,ti OR 'cross-over':ab,ti OR 'cross over':ab,ti OR assign*:ab,ti OR allocat*:ab,ti OR volunteer*:ab,ti OR ((singl* OR doubl*) NEAR/2 (blind* OR mask*)):ab,ti AND [embase]/lim79319116 Jan 2011
 #25 'randomized controlled trial'/exp OR 'single blind procedure'/exp OR 'double blind procedure'/exp OR 'crossover procedure'/exp AND [embase]/lim 23497116 Jan 2011
 #24 #20 AND #23 1301916 Jan 2011
 #23 #21 OR #22 52233216 Jan 2011
 #22 postur*:ab,ti OR supine:ab,ti OR prone:ab,ti OR (face NEAR/5 down*):ab,ti OR (side NEAR/5 (lay OR laying OR laid OR lying OR lies OR lays)):ab,ti OR lateral*:ab,ti OR (kinetic NEAR/5 position*):ab,ti OR 'continuous body position':ab,ti OR 'continuous body positions':ab,ti OR upright:ab,ti OR (high NEAR/5 sitting):ab,ti OR 'semi-recumbent':ab,ti OR semirecumbent:ab,ti OR 'semi-recline':ab,ti OR semirecline:ab,ti OR position*:ab,ti AND [embase]/lim51802216 Jan 2011
 #21 'body posture'/de AND [embase]/lim21003 16 Jan 2011
 #20 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 679544 16 Jan 2011
 #19 'chronic neonatal lung disease':ab,ti OR 'chronic neonatal lung diseases':ab,ti AND [embase]/lim29 16 Jan 2011
 #18 'hyaline membrane disease':ab,ti AND [embase]/lim1319 16 Jan 2011
 #17 'hyaline membrane disease'/de AND [embase]/lim2972 16 Jan 2011
 #16 ards:ab,ti OR rds:ab,ti AND [embase]/lim9686 16 Jan 2011
 #15 (distress* NEAR/2 (respir* OR bronch*)):ab,ti AND [embase]/lim22691 16 Jan 2011
 #14 pneumon*:ab,ti AND [embase]/lim99195 16 Jan 2011
 #13 'lung disease'/exp AND [embase]/lim513379 16 Jan 2011
 #12 (respir* NEAR/3 (insufficien* OR fail*)):ab,ti AND [embase]/lim22834 16 Jan 2011
 #11 (respir* NEAR/5 infect*):ab,ti AND [embase]/lim32004 16 Jan 2011
 #10 'respiratory tract infection'/exp AND [embase]/lim147424 16 Jan 2011
 #9 'acute lung injury':ab,ti OR 'acute lung injuries':ab,ti OR ali:ab,ti AND [embase]/lim 7550 16 Jan 2011
 #8 'acute lung injury'/de AND [embase]/lim 3542 16 Jan 2011
 #7 bronchopneumon*:ab,ti AND [embase]/lim 2178 16 Jan 2011
 #6 'bronchopneumonia'/de AND [embase]/lim 3002 16 Jan 2011
 #5 'bronchus disease'/exp AND [embase]/lim 6865616 Jan 2011
 #4 'respiratory syncytial virus':ab,ti OR 'respiratory syncytial viruses':ab,ti OR rsv:ab,ti AND [embase]/lim 904616 Jan 2011
 #3 'respiratory syncytial virus infection'/de OR 'respiratory syncytial pneumovirus'/de AND [embase]/lim 877916 Jan 2011
 #2 bronchiolit*:ab,ti AND [embase]/lim 644716 Jan 2011
 #1 'bronchiolitis'/exp AND [embase]/lim 876316 Jan 2011

Appendix 3. CINAHL search strategy

S49 S38 and S48
 S48 s39 or S40 or S41 or S42 or S43 or S44 or S45 or S46 or S47
 S47 (MH "Quantitative Studies")
 S46 (MH "Random Assignment")
 S45 (MH "Placebos")
 S44 TI placebo* or AB placebo*
 S43 TI random* or AB random*
 S42 TI (singl* blind* or doubl* blind* or trebl* blind* or tripl* blind* or singl* mask* or doubl* mask* or trebl* mask* or tripl* mask*) or AB (singl* blind* or doubl* blind* or trebl* blind* or tripl* blind* or singl* mask* or doubl* mask* or trebl* mask* or tripl* mask*)
 S41 TI clinic* trial* or AB clinic* trial*
 S40 PT clinical trial
 S39 (MH "Clinical Trials+")
 S38 S22 and S37
 S37 S23 or S24 or S25 or S26 or S27 or S28 or S29 or S30 or S31 or S32 or S33 or S34 or S35 or S36
 S36 TI position* or AB position*
 S35 TI (semi-recumbent or semirecumbent or semi-reclin* or semireclin*) or AB (semi-recumbent or semirecumbent or semi-reclin* or semireclin*)
 S34 TI high N5 sitting or AB high N5 sitting
 S33 TI upright or AB upright
 S32 TI continuous body position* or AB continuous body position*
 S31 TI kinetic N5 position* or AB kinetic N5 position*
 S30 TI lateral* or AB lateral*
 S29 TI side N5 laid or AB side N5 laid
 S28 TI side N5 lying or AB side N5 lying

S27 TI side N5 lies or AB side N5 lies
 S26 TI side N5 lay* or AB side N5 lay*
 S25 TI face N5 down* or AB face N5 down*
 S24 TI (supine or prone or postur*) or AB (supine or prone or postur*)
 S23 (MH "Posture+")
 S22 S1 or S2 or S3 or S4 or S5 or S7 or S8 or S9 or S10 or S11 or S12 or S13 or S14 or S15 or S16 or S17 or S18 or S19 or S20 or S21
 S21 TI chronic neonatal lung disease* or AB chronic neonatal lung disease*
 S20 TI hyaline membrane disease* or AB hyaline membrane disease*
 S19 TI (ards or rds) or AB (ards or rds)
 S18 TI bronch* N25 distress* or AB bronch* N25 distress*
 S17 TI respir* N25 distress* or AB respir* N25 distress*
 S16 TI pneumon* or AB pneumon*
 S15 TI respir* N3 fail* or AB respir* N3 fail*
 S14 (MH "Bronchial Diseases+")
 S13 TI respir* N3 insufficien* or AB respir* N3 insufficien*
 S12 (MH "Lung Diseases+")
 S11 "respiratory insufficiency"
 S10 TI respir* N5 infect* or AB respir* N5 infect*
 S9 (MH "Respiratory Tract Infections+")
 S8 TI (acute lung injury or ali) or AB (acute lung injury or ali)
 S7 TI bronchopneumon* or AB bronchopneumon*
 S6 (MH "Bronchial Diseases")
 S5 TI (respiratory syncytial virus* or rsv) or AB (respiratory syncytial virus* or rsv)
 S4 (MH "Respiratory Syncytial Virus Infections")
 S3 (MH "Respiratory Syncytial Viruses")
 S2 TI bronchiolit* or AB bronchiolit*
 S1 (MH "Bronchiolitis+")

WHAT'S NEW

Date	Event	Description
12 April 2012	New search has been performed	Searches conducted. One new study was identified (Oliveira 2009) but our conclusions remain unchanged. Additional details were added to the Methods and the 'Risk of bias' tables.
26 August 2011	New citation required but conclusions have not changed	A new author joined the team to update this review.

HISTORY

Protocol first published: Issue 2, 2002

Review first published: Issue 2, 2005

Date	Event	Description
7 August 2008	New search has been performed	Searches conducted. Two new studies have been included in this updated review.
14 February 2008	Amended	Converted to new review format.
13 July 2006	Amended	Plain language summary re-written.
24 October 2004	New search has been performed	Searches conducted.

CONTRIBUTIONS OF AUTHORS

Donna Gillies: protocol development, data extraction, analysis, drafting and finalisation of original and updated reviews.

Deborah Wells: protocol development, data extraction, analysis, drafting and finalisation of original review and the 2008 update.

Abhishta P Bhandari: data extraction and drafting of the 2011 update.

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- The Children's Hospital Westmead, Sydney, Australia.

External sources

- No sources of support supplied

INDEX TERMS

Medical Subject Headings (MeSH)

Acute Disease; Bronchopulmonary Dysplasia [therapy]; Infant, Premature; Patient Positioning [*methods]; Posture [*physiology]; Randomized Controlled Trials as Topic; Respiration, Artificial; Respiratory Distress Syndrome, Newborn [*therapy]; Respiratory Insufficiency [*therapy]; Respiratory Tract Infections [therapy]; Treatment Outcome

MeSH check words

Adolescent; Child; Child, Preschool; Humans; Infant; Infant, Newborn