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Tracheal suctioning without disconnection in intubated ventilated neonates (Review)

Taylor JE, Hawley G, Flenady V, Woodgate PG

Taylor JE, Hawley G, Flenady V, Woodgate PG.
Tracheal suctioning without disconnection in intubated ventilated neonates.
Cochrane Database of Systematic Reviews 2011, Issue 12. Art. No.: CD003065.
DOI: 10.1002/14651858.CD003065.pub2.

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[Intervention Review]

Tracheal suctioning without disconnection in intubated ventilated neonates

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Editorial group: Cochrane Neonatal Group.
Publication status and date: Edited (no change to conclusions), published in Issue 5, 2012.
Review content assessed as up-to-date: 19 July 2011.

Citation: Taylor JE, Hawley G, Flenady V, Woodgate PG. Tracheal suctioning without disconnection in intubated ventilated neonates. *Cochrane Database of Systematic Reviews* 2011, Issue 12. Art. No.: CD003065. DOI: 10.1002/14651858.CD003065.pub2.

ABSTRACT

Background

Assisted mechanical ventilation is a necessity in the neonatal population for a variety of respiratory and surgical conditions. However, there are a number of potential hazards associated with this life saving intervention. New suctioning techniques have been introduced into clinical practice which aim to prevent or reduce these untoward effects.

Objectives

To assess the effects of endotracheal suctioning without disconnection in intubated ventilated neonates.

Search methods

The review has drawn on the search strategy for the Cochrane Neonatal Review Group. A comprehensive search of Cochrane databases, MEDLINE and CINAHL, and the Society for Pediatric Research abstracts was undertaken by the review authors (July 2011).

Selection criteria

All trials that utilised random or quasi-random patient allocation and in which suctioning with or without disconnection from the ventilator was compared.

Data collection and analysis

Standard methods of the Cochrane Neonatal Group were used. Each review author separately reviewed trials for eligibility and quality and extracted data; they then compared and resolved differences. Analysis was performed using the fixed-effect model and outcomes were reported using relative risk (RR) for categorical data and mean difference (MD) for outcomes measured on a continuous scale.

Main results

Four trials (252 infants) were included in this review. The trials employed a cross-over design in which suctioning with or without disconnection was compared. Suctioning without disconnection resulted in a reduction in episodes of hypoxia (typical RR 0.48, CI 95% 0.31 to 0.74; 3 studies; 241 participants). There were also fewer infants who experienced episodes where the transcutaneous partial pressure of oxygen ($TcPO_2$) decreased by > 10% (typical RR 0.39, 95% CI 0.19 to 0.82; 1 study; 11 participants). Suctioning without disconnection resulted in a smaller percentage change in heart rate (weighted mean difference (WMD) 6.77, 95% CI 4.01 to 9.52; 4 studies; 239 participants) and a reduction in the number of infants experiencing a decrease in heart rate by > 10% (typical RR 0.61, CI 0.40 to 0.93; 3 studies; 52 participants).The number of infants having bradycardic episodes was also reduced during closed suctioning (typical RR 0.38, CI 95% 0.15 to 0.92; 3 studies; 241 participants).

Authors' conclusions

There is some evidence to suggest suctioning without disconnection from the ventilator improves the short term outcomes; however the evidence is not strong enough to recommend this practice as the only method of endotracheal suctioning. Future research utilising larger trials needs to address the implications of the different techniques on ventilator associated pneumonia, pulmonary morbidities and neurodevelopment. Infants less than 28 weeks also need to be included in the trials.

PLAIN LANGUAGE SUMMARY

Tracheal suctioning without disconnection in intubated, ventilated neonates

Sometimes newborn babies have trouble breathing and need mechanical help. Air can be supplied through a tube inserted into their nose, mouth or trachea (windpipe). There are some potential problems with the tube. Soft tissue can be damaged increasing secretion of fluids that can block the tube, raise blood pressure or cause damage and infections. Using suction to clear the tubes can be done either with or without disconnection from the ventilator. The review of trials found there was some evidence that suctioning without disconnection improves stability. These improvements were small so this can not be recommended as the only way to suction the babies. More research is needed.

BACKGROUND

Assisted mechanical ventilation is a necessity in the neonatal population for a variety of respiratory and surgical conditions. However, mechanical ventilation requires the infant to be intubated with an endotracheal tube (ETT). When an infant is intubated there is an increase in the production of secretions, which the infant is unable to clear. It is imperative these secretions are removed otherwise the ETT may block (Morrow 2004). Moreover if the secretions remain, ventilation will be impaired causing a decrease in tidal volume, an increase in partial pressure of carbon dioxide (PCO_2) and poor oxygenation (Clifton-Koeppel 2006). The aim of ETT suctioning is to remove the secretions with minimal complications (Argent 2009).

Description of the condition

Complications are well documented in the literature. Infants are at risk of atelectasis (Boothroyd 1996), hypoxia (Simbruner 1981; Danford 1983), tissue trauma, pneumothorax (Kuzenski 1978; Bailey 1988) and decreases in lung compliance and functional residual capacity (Morrow 2004). Hypo or hypertension (Kaiser 2008), cardiac dysrhythmias (Simbruner 1981), changes to the cerebral blood flow and volume (Shah 1992; Skov 1992; Kaiser 2008), increased cranial pressure (Shah 1992; Skov 1992) and microbial colonisation of the lower airways (Brodsky 1987) are also implications

Description of the intervention

One method used to minimise these complications is suctioning without disconnection from the ventilator by the use of specifically designed closed suction circuits or the use of adaptors which allow ventilation to continue during suction.

How the intervention might work

The continuation of ventilation during suction may potentially maintain positive end expiratory pressure and maintain the fraction of inspired oxygen (FiO_2).

Why it is important to do this review

This is an update of the Cochrane review first published in 2001, which found that although there are advantages to suctioning using a closed technique, the evidence was insufficient to make recommendations for clinical practice. Recently, two evidence-based guidelines on endotracheal suctioning (Gardner 2009; AARC 2010) have been published. Both of these recommend the use of closed suctioning in infants and neonates. The aim of this update is to determine if there is any new evidence that may impact on the original review's conclusion.

OBJECTIVES

To assess the effects of endotracheal suctioning without disconnection in ventilated neonates.

METHODS

Criteria for considering studies for this review

Types of studies

All trials utilising random or quasi-random patient allocation and in which suctioning with and without disconnection from the ventilator were compared.

Types of participants

All infants receiving ventilatory support via an endotracheal tube who underwent regular endotracheal suctioning.

Types of interventions

Any methods used to enable endotracheal suctioning without disconnection from the ventilator compared to suctioning with disconnection.

Types of outcome measures

Primary outcomes

- Bradycardia (HR < 100 bpm)
- Heart rate decrease > 10%
- Hypoxia (oxygen saturation (SaO_2) < 90%)
- Change in heart rate (%)
- Transcutaneous partial pressure of oxygen ($TcPO_2$) decrease > 10%
- Hypoxaemia
- Hypertension
- Hypotension
- Dislodgment of the endotracheal tube
- Blockage of the endotracheal tube
- Intraventricular haemorrhage
- Pneumothorax

Secondary outcomes

A priori subgroup analysis.

- Birth weight: < 1000 g; 1000 to 2000 g; > 2000 g
- Ventilation mode (synchronised intermittent mandatory ventilation (SIMV) or high-frequency oscillatory ventilation (HFOV))
- Gestational age (< 28 weeks)
- Acute versus chronic respiratory failure
- With or without preoxygenation
- With or without increased mechanical ventilation

Search methods for identification of studies

Electronic searches

The review has drawn on the search strategy for the Cochrane Neonatal Review Group. See: Cochrane Neonatal Group search strategy for specialised register. A comprehensive search was also undertaken by the review authors including *The Cochrane Library* (Issue 7, 2011), MEDLINE (1966 to July 2011) and CINAHL (1982 to July 2011) databases (search terms included infant-newborn, suction*, endotracheal, ETT, adaptor, adapter, closed, controlled clinical trial, randomised controlled trial) and cross referencing.

Searching other resources

The abstracts of the Society for Pediatric Research (from 2000 to 2011) were searched electronically through the Pediatric Academic Societies (PAS) website (abstractsonline). Clinical trials registries were also searched for ongoing or recently completed trials (clinicaltrials.gov; controlled-trials.com; and who.int/ictrp).

Data collection and analysis

Selection of studies

We used the standard methods of The Cochrane Collaboration and its Neonatal Review Group. The methodological quality of each trial was reviewed by the review authors independently. There were no unresolved differences and a referee (Australasian Regional Co-coordinator for the Neonatal Review Group) was not needed.

Data extraction and management

We assessed the methodological quality of each trial and data were extracted independently by two review authors. Each review author used the same specifically designed data sheet. We compared results and differences were resolved by discussion.

Assessment of risk of bias in included studies

For this update, two review authors independently assessed risk of bias for each study using the criteria outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2009).

Measures of treatment effect

The standard methods of the Cochrane Neonatal Review Group were used to synthesise the data. For individual trials, mean differences (MD) and 95% confidence intervals (CI) were reported for continuous variables. For categorical outcomes, the risk ratio (RR) and 95% CIs were reported. The meta-analysis also utilised the methods outlined above.

Unit of analysis issues

In most cases, the number of observations should match the number randomised. All the studies in this review utilised a cross-over design (Gunderson 1986; Mosca 1997; Kalyn 2003; Hoellering 2008). The suitability of this methodology was assessed using the *Cochrane Handbook for Systematic Reviews of Interventions* (Chapter 16.4) and the advantages of using this design were weighed against the disadvantages. Long term effects cannot be assessed using this methodology, however, the short term physiological effects as described in this review were suitable to be assessed with a cross-over design. Cross-over designs have the potential to cause bias by a carry-over effect and a period effect. A carry-over effect (a type of period-by-intervention interaction) was not thought to be a problem with this intervention as open or closed suctioning have a temporary effect on the neonate and wash out periods were described, between 60 minutes (Mosca 1997; Kalyn 2003) and 90 minutes (Hoellering 2008). This was thought to be ample time to ensure a carry-over effect did not occur. A possible period effect was also not thought to be of concern as the cross-over was conducted within a fairly narrow time interval; the longest time frame reported was within the same day. Other possible issues described in the Handbook were also thought to be covered in this review. The order in which treatments were given were randomised in each study and it was clear from the trials how many interventions occurred: one in two trials (Kalyn 2003; Hoellering 2008) and three in two trials (Gunderson 1986; Mosca 1997). In all the trials, first and second exposure to intervention data were used in this review. From this assessment, cross-over trials were considered suitable for evaluating the transient effects of endotracheal suctioning with or without disconnection from the ventilator.

Dealing with missing data

Additional information was requested from the authors of trials (Spence 1992; Tan 1992; Mosca 1997; Kalyn 2003; Hoellering 2008; Candida S. de Paula 2010) to clarify methodology and seek further data regarding outcomes. Additional information was obtained for four of these studies (Spence 1992, Mosca 1997; Kalyn 2003; Hoellering 2008).

Assessment of heterogeneity

Heterogeneity among the trials in each analysis was measured using the I^2 statistic. Heterogeneity is graded as 0% to 30% (might not be important), 31% to 50% (moderate heterogeneity), 51% to 75% (substantial heterogeneity), 76% to 100% (considerable heterogeneity). A fixed-effect model was used for the meta-analysis unless heterogeneity was evident (exceeding 50%).

Assessment of reporting biases

Reporting biases were investigated by determining the degree of symmetry seen in the funnel plot. Where potential biases were suspected, we attempted to contact authors to provide missing data.

Data synthesis

Statistical analysis was performed by using the Review Manager software (RevMan 2010). A fixed-inverse variance meta-analysis was used to combine data where trials with similar populations and methods were examining the same intervention.

Subgroup analysis and investigation of heterogeneity

Subgroup analysis of birthweight was performed by Kalyn 2003 and Hoellering 2008 by mode of ventilation (synchronised intermittent mandatory ventilation (SIMV) or high frequency oscillatory ventilation (HFOV)).
Any evidence of heterogeneity was explored by conducting a random-effects model analysis.

Sensitivity analysis

The need for a sensitivity analysis was determined by examining individual peculiarities of the studies and following them up. This included identifying missing data or particular decisions relating to the studies. As cross-over design trials were included, it was important to know the interval time between interventions, to prevent any possible carry-over treatment effect occurring. An adequate time interval between interventions was utilised and missing data reported on in all included trials. Funnel plots were inspected visually and no further sensitivity analysis was done.

RESULTS

Description of studies

Using the above search strategy, 10 studies were identified. See: Characteristics of included studies; Characteristics of excluded studies

Included studies

Four studies were included in this review (Gunderson 1986; Mosca 1997; Kalyn 2003; Hoellering 2008). Participants in the included studies were similar. The birth weight (BW) range was 570 to 5680 g. The gestational age (GA) range was 24 to 42 weeks. All infants were receiving mechanical ventilation for respiratory distress, and receiving routine endotracheal suctioning. The studies used similar techniques and methodology. A suction procedure employing a special adapter which permitted endotracheal suction without disconnection from the ventilator was used. Preoxygenation was performed in one study (Kalyn 2003). A cross-over design was employed in all the included studies. In two studies (Gunderson 1986; Mosca 1997), each infant underwent three paired suctioning procedures. The data used in these reviews were averages of the three measurements for each condition, with or without disconnection. In the other two studies (Kalyn 2003; Hoellering 2008), the participants were studied during one suctioning procedure. Both used two passes of the suction catheter.

The effects of the suctioning methods on heart rate and oxygenation status were recorded. Extra data were received from Hoellering 2008 and Kalyn 2003, which enabled meta-analysis to occur for four outcomes: heart rate decrease > 10% (Gunderson 1986; Mosca 1997; Hoellering 2008), percentage change in heart rate (Gunderson 1986; Mosca 1997; Kalyn 2003), bradycardia (Mosca 1997; Kalyn 2003; Hoellering 2008) and hypoxia ($SaO_2 < 90\%$) (Mosca 1997; Kalyn 2003; Hoellering 2008). Due to differences in reporting, data for per cent change in $TcPO_2$ and $TcPO_2$ decrease > 10% were from one trial (Gunderson 1986). Kalyn 2003 reported the mean $TcPO_2$. Hoellering 2008 also reported loss of lung volume and time to recover lung volume. Mosca 1997 also reported cerebral blood volume and intracellular cerebral oxygenation using near-infrared spectroscopy.

Excluded studies

Seven studies were identified but excluded. Four of these were excluded as neither random nor quasi-random allocation to suction method was used (Cabal 1979; Zmora 1980; Graff 1987; Spence 1992). These studies used a cross-over design with alternation of suction method but did not randomly or quasi-randomly allocate the initial treatment method. Candida S. de Paula 2010 and Tan 1992 were excluded due to insufficient data. These studies were published in abstract form and further data has been requested. Tan 2004 was excluded as it compared two methods of closed suction, closed versus partially ventilated suction.

Risk of bias in included studies

The overall quality of the included studies was good and confirmation from authors was obtained where necessary.

Allocation

In Gunderson 1986, blinding of allocation was performed by randomising the participants using a non-replaceable sealed card system. Mosca 1997 employed a quasi-randomised method of treatment allocation, that is the order of allocation to the first treatment exposure was alternated (personal communication from author). Hoellering 2008 randomised participants to the first procedure using a sealed opaque envelope and outcome assessment was made blinded to the intervention. Kalyn 2003 randomised participants using block randomisation, factor of four, according to birth weight. A sealed envelope system was used.

Blinding

Gunderson 1986 and Hoellering 2008 both ensured outcome assessment was made blind to the intervention. In Kalyn 2003 the investigation team performed the suction, therefore blinding to the intervention was not possible. It is not clear from Mosca 1997 if the investigators were blind to the intervention.

Incomplete outcome data

In Gunderson 1986, one study (out of three planned studies for each infant), one neonate was dropped from the analysis because during this period the fraction of inspired oxygen (FiO_2) dropped to below 0.3 (thus meeting an exclusion criterion). However, data from the other two study periods for this neonate were included in the analysis. In Kalyn 2003, nine infants did not complete the study, two due to family concerns, six infants were extubated and one was transferred before the study was completed. Outcomes were available for all infants enrolled in Mosca 1997 and Hoellering 2008.

Selective reporting

Gunderson 1986; Hoellering 2008 and Mosca 1997 reported all the data in the results. In Kalyn 2003, data from the included 200 participants were presented as the entire group of neonates and according to birthweight. Not more than 20% of data were found to be missing from the analysis.

Other potential sources of bias

Gunderson 1986; Kalyn 2003 and Hoellering 2008 reported on the randomisation technique well. Mosca 1997 did not specify if the allocation technique was adequate, but no evidence of bias was found in the text. Hoellering 2008 did have a small number in the high frequency oscillation ventilation group but this did not produce significant results. The addition of the large number of participants from the Kalyn 2003 study did not cause a significant change in the final results.

Effects of interventions

There were a total of 252 infants included in this review.

Suctioning without disconnection versus with disconnection (Comparison 1)

Heart rate decrease > 10% (Outcome 1.1)

Fewer infants experienced heart rate decreases > 10% when suctioning was performed without disconnection (typical RR 0.61, 95% CI 0.40 to 0.93; three studies; 52 participants) (Gunderson 1986; Mosca 1997; Hoellering 2008) (Figure 1; Figure 2).

Figure 1. Funnel plot of comparison: 1 Suctioning without disconnection versus with disconnection, Outcome: 1.1 Heart rate decrease > 10%.

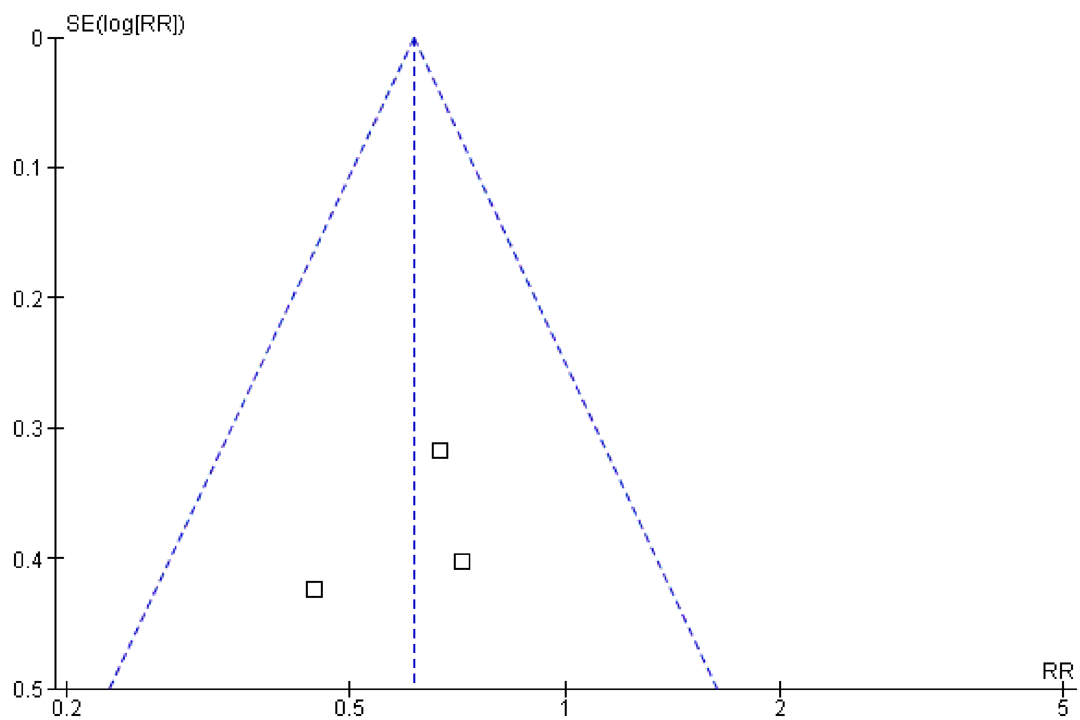
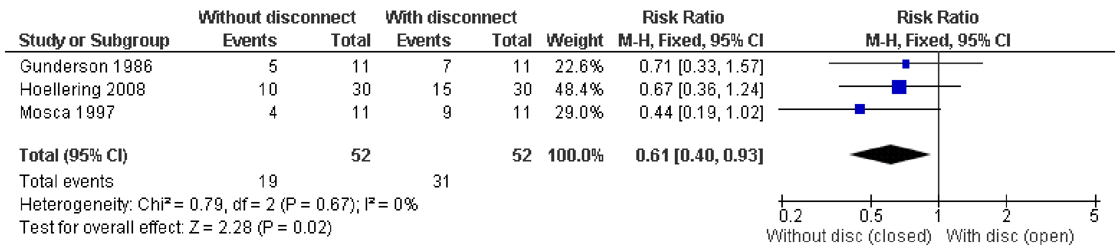


Figure 2. Forest plot of comparison: 1 Suctioning without disconnection versus with disconnection, outcome: 1.1 Heart rate decrease > 10%.



Change in heart rate (HR) (%) - by weight (Outcome 1.2)

Four trials assessed percentage change in heart rate. Gunderson 1986 and Hoellering 2008 found no evidence of effect whereas Mosca 1997 and Kalyn 2003 found a percentage decrease in heart rate when suctioning without disconnection from the ventilator. In a meta-analysis, the four trials collectively found a statistically significant result (weighted mean difference (WMD) 6.77, 95% CI 4.01 to 9.52; four studies; 239 participants) (Figure 3; Figure 4).

Figure 3. Funnel plot of comparison: 1 Suctioning without disconnection versus with disconnection, Outcome: 1.2 Change in heart rate (HR) (%) - by weight.

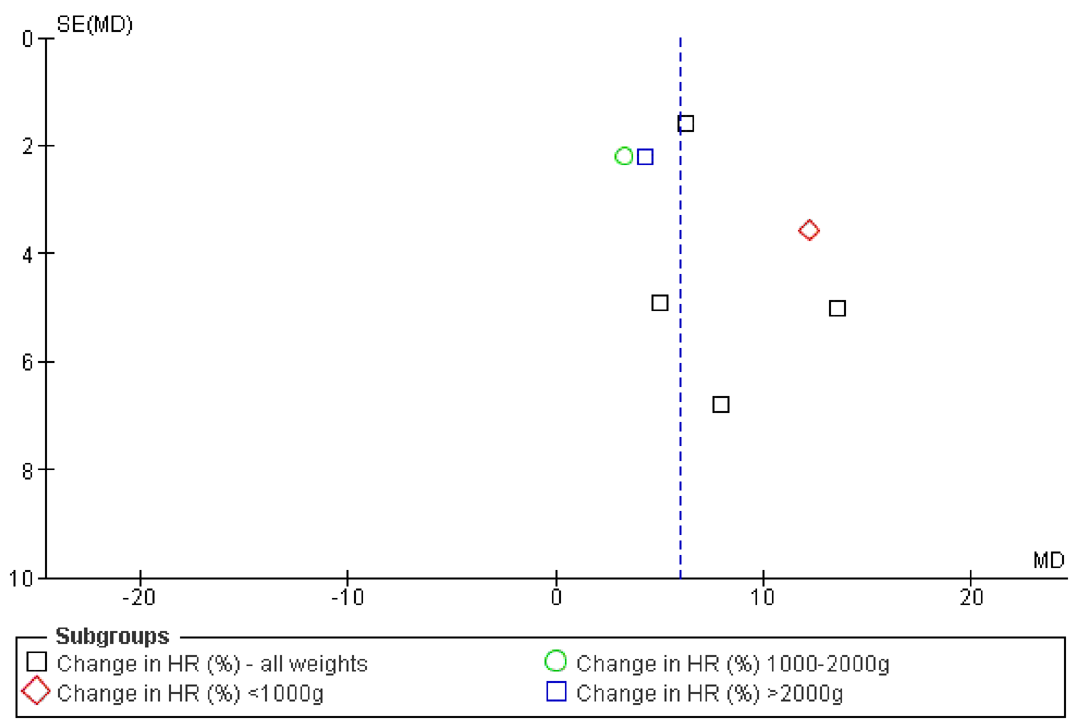
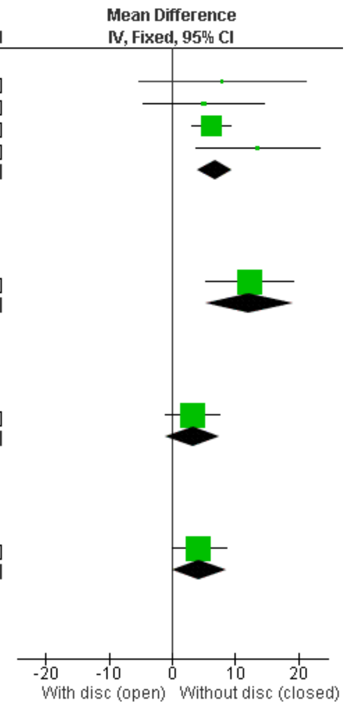


Figure 4. Forest plot of comparison: 1 Suctioning without disconnection versus with disconnection, outcome: 1.2 Change in heart rate (HR) (%) - by weight.

Study or Subgroup	Without disconnect Mean	SD	Total	With disconnect Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
1.2.1 Change in HR (%) - all weights								
Gunderson 1986	-3.4	11.4	11	-11.3	19.4	11	4.3%	7.90 [-5.40, 21.20]
Hoellering 2008	-12.7	19.42	30	-17.7	18.37	30	8.3%	5.00 [-4.57, 14.57]
Kalyn 2003	-2.99	11.43	187	-9.21	18.29	187	79.5%	6.22 [3.13, 9.31]
Mosca 1997	-5.93	6.07	11	-19.44	15.45	11	7.9%	13.51 [3.70, 23.32]
Subtotal (95% CI)			**239**			**239**	**100.0%**	**6.77 [4.01, 9.52]**
Heterogeneity: Chi² = 2.09, df = 3 (P = 0.55); I² = 0%								
Test for overall effect: Z = 4.81 (P < 0.00001)								
1.2.2 Change in HR (%) <1000g								
Kalyn 2003	-6.16	14.25	55	-18.34	22.27	55	100.0%	12.18 [5.19, 19.17]
Subtotal (95% CI)			**55**			**55**	**100.0%**	**12.18 [5.19, 19.17]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 3.42 (P = 0.0006)								
1.2.3 Change in HR (%) 1000-2000g								
Kalyn 2003	-1.9	9.41	68	-5.15	15.5	68	100.0%	3.25 [-1.06, 7.56]
Subtotal (95% CI)			**68**			**68**	**100.0%**	**3.25 [-1.06, 7.56]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.48 (P = 0.14)								
1.2.4 Change in HR (%) >2000g								
Kalyn 2003	-1.44	10.26	64	-5.68	14.26	64	100.0%	4.24 [-0.06, 8.54]
Subtotal (95% CI)			**64**			**64**	**100.0%**	**4.24 [-0.06, 8.54]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.93 (P = 0.05)								



Bradycardia (HR < 100 bpm) - by weight (Outcome 1.3)

Mosca 1997; Kalyn 2003; Hoellering 2008 reported on bradycardia and found less evidence with closed suctioning come (typical RR 0.38, 95% CI 0.15 to 0.92; three studies; 241 participants).

Hypoxia ($Sa0_2$ < 90%) - by weight (Outcome 1.4)

Three studies assessed hypoxia (Mosca 1997; Kalyn 2003; Hoellering 2008). Kalyn 2003 and Mosca 1997 found fewer infants experienced episodes of hypoxia when suctioning was performed without disconnection. Hoellering 2008 found no evidence of effect. The meta-analysis supported fewer episodes of hypoxia when using a closed technique (typical RR 0.48, 95% CI 0.31 to 0.74; three studies; 241 participants).

Change in $TcP0_2$ (%) (Outcome 1.5)

There was a smaller percentage decrease in $TcP0_2$ when suctioning was performed without disconnection (MD 18.50%, 95% CI 8.11 to 28.89; one study; 11 participants) (Gunderson 1986). The percentage decrease in $TcP0_2$ when suctioning was performed without disconnection was only 2.9%, versus 21.4% with disconnection.

$TcP0_2$ decrease > 10% (Outcome 1.6)

One trial assessed a $TcP0_2$ decrease > 10% (Gunderson 1986). When suctioning was performed without disconnection, there was a statistically significant reduction (RR 0.39, 95% CI 0.19 to 0.82; one study; 11 participants).

A subgroup analysis by weight was performed, with data from one trial (Kalyn 2003). Also a subgroup analysis of ventilation modes was performed, from one trial (Hoellering 2008). Due to insufficient data no other pre-specified subgroup analyses (gestational age, acute versus chronic respiratory failure, with or without pre-oxygenation, and with or without increased mechanical ventilation) could be conducted.

Subgroup analysis

Weight (Figure 2; Figure 4)

Infants < 1000 g had a smaller decrease in heart rate when suctioning was performed without disconnection (MD 12.18, 95% CI 5.19 to 19.17; one study; 55 participants) (Outcome 1.2.2). There was no evidence of effect for bradycardia (RR 0.33, 95% CI 0.04 to 3.12; one study; 61 participants) (Outcome 1.3.2) or hypoxia (RR 0.60, 95% CI 0.15 to 2.40; one study; 61 participants) (Outcome 1.4.2).

No effect in infants in the 1000 g to 2000 g group was seen on the per cent change in heart rate (MD 3.25, 95% CI -1.06 to 7.56;

one study; 68 participants), bradycardia (RR 0.33, 95% CI 0.01 to 8.05; one study; 72 participants) or hypoxia (RR 0.33, 95% CI 0.04 to 3.13; one study; 72 participants).

No effect on the per cent change in heart rate (MD 4.24, 95% CI -0.06 to 8.54; one study; 64 participants) (Outcome 1.2.4), bradycardia (RR 0.5, 95% CI 0.05 to 5.38; one study; 67 participants) (Outcome 1.3.4) or hypoxia (RR 0.33, 95% CI 0.09 to 1.18; one study; 67 participants) (Outcome 1.4.4) was apparent in infants > 2000 g.

Mode of ventilation - synchronised intermittent mechanical ventilation (SIMV) versus high frequency oscillatory ventilation (HFOV)

No effect was seen in infants receiving SIMV on hypoxia (RR 0.63, 95% CI 0.25 to 1.58; one study; 20 participants) (Outcome 2.4.1), bradycardia (RR 0.67, 95% CI 0.12 to 3.57; one study; 20 participants) (Outcome 2.3.1), heart rate > 10% (RR 0.70, 95% CI 0.33 to 1.47; one study; 20 participants) (Outcome 2.1.1) or the per cent change in heart rate (MD 4.98, 95% CI -5.88 to 15.84; one study; 20 participants) (Outcome 2.2.1).

No effect was seen in infants receiving HFOV on hypoxia (RR 0.67, 95% CI 0.39 to 1.15; one study; 10 participants) (Outcome 2.4.2), bradycardia (RR 0.33, 95% CI 0.04 to 2.69; one study; 10 participants) (Outcome 2.3.2), heart rate > 10% (RR 0.60, 95% CI 0.19 to 1.86; one study; 10 participants) (Outcome 2.1.2) or the per cent change in heart rate (MD 5.04, 95% CI -14.37 to 24.45; one study; 10 participants) (Outcome 2.2.2).

DISCUSSION

Summary of main results

A total of 252 infants were enrolled into the four included trials. All of the trials used a cross-over design, which enables assessment of the immediate effects of the intervention only.

The results of this review demonstrate that endotracheal suctioning without disconnection from the ventilator is beneficial in terms of reducing immediate adverse effects. This technique produces less variability in heart rate and slightly less bradycardia. Hypoxic episodes were reduced as measured by SaO_2 < 90% and change in $TcPO_2$. The strength of evidence, although statistically significant, is not sufficiently clinically significant to recommend this practice for all infants all of the time. Suctioning practices need to be individualised, based on the infant's cardiorespiratory response to suctioning.

The a priori subgroup analysis of the different weight categories included the results from one trial (Kalyn 2003). Although the infants < 1000 g demonstrated a significantly lower percentage change in heart rate, this did not effect oxygenation. There were also no increased episodes of bradycardia. The other weight categories showed no benefits when suctioning using a closed technique.

The a priori subgroup analysis for the difference in modes of ventilation includes the results from one trial (Hoellering 2008). There was no evidence that suctioning without disconnection maintains stability in heart rate or oxygen saturation for infants receiving high frequency oscillatory ventilation, however the confidence intervals were wide suggesting the trial may be too small to show any statistical significance.

Overall completeness and applicability of evidence

There were insufficient data available to assess the other clinically important outcomes which were identified a priori. For example, none of the identified studies reported outcomes such as endotracheal tube dislodgment, incidence of tube blockage, infection, or major morbidities such as intraventricular haemorrhage and pneumothorax. Long term outcomes cannot be assessed due to the cross-over methodology of the studies. A priori subgroup analysis (gestational age, acute versus chronic respiratory failure, with or without preoxygenation) to detect differential effects were also unable to be performed.

Potential biases in the review process

A limitation to this review was the definition of hypoxia, SaO_2 < 90%. Many neonatal units accept lower saturation limits for preterm infants and in one trial (Hoellering 2008) the author communicated that some infants had a SaO2 < 90% prior to suctioning. The per cent change in SaO_2 < 10% may have provided more valuable information, but these data were unavailable. Furthermore, the trials used different suctioning techniques, different sized suctioning catheters and different suction pressure, which may have impacted on the results.

Agreements and disagreements with other studies or reviews

The infants included in these studies were similar to the current population of patients in neonatal intensive care units.

The benefits of suction without disconnection on immediate complications of suctioning are consistent with other reports with similar findings. These include the identified studies which were not included in this review (Cabal 1979; Zmora 1980; Graff 1987; Spence 1992; Tan 1992).

The role of preoxygenation with endotracheal suctioning is reported in the Cochrane review 'Preoxygenation for tracheal suctioning in intubated, ventilated newborn infants' (Pritchard 2001).

AUTHORS' CONCLUSIONS

Implications for practice

There is some evidence to suggest suctioning without disconnection from the ventilator improves the immediate outcomes of oxygenation, however, the evidence is not strong enough to recommend this practice as the only method of suctioning. There is insufficient evidence to determine if all infants < 1000 g should receive suctioning without disconnection. Also it appears that infants receiving HFOV do not benefit from using a closed technique however, due to the small sample size, this can not become a recommendation. The method of suctioning used needs to be determined on an individual patient basis and the mode the clinicians feel confident with.

Implications for research

Future trials are needed to clarify the safety and efficacy of endotracheal suction. Such trials need to address the implications of the different techniques on ventilated associated pneumonia, pulmonary morbidities and neurodevelopment. Larger trials are required to determine the role of suctioning without disconnection for infants receiving HFOV and other modes of ventilation, such as volume guarantee. Future trials also need to assess suctioning without disconnection for infants less than 28 weeks gestation. The Tan 2004 study demonstrated extremely premature infants suctioned with a fully closed technique to be more physiologically stable than with partially closed suctioning. It is recommended that similar studies on extremely premature infants be performed to study long term neurodevelopmental outcomes in this population.

ACKNOWLEDGEMENTS

We would like to acknowledge Dr Fabio Mosca, Kaye Spence, Angela Kalyn and Dr David Tingay for providing additional information on their trials, and also David Henderson-Smart for assistance with this review.

Editorial support of the Cochrane Neonatal Review Group has been funded with Federal funds from the Eunice Kennedy Shriver National Institute of Child Health and Human Development National Institutes of Health, Department of Health and Human Services, USA, under Contract No. HHSN267200603418C.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

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

Gunderson 1986

Methods	Blinding of randomisation: yes. Blinding of intervention: no. Complete follow-up: yes. Blind outcome assessment: yes. Cross-over design, random allocation
Participants	11 newborns with RDS. GA range 29-33 weeks , Birth weight range 840-2125 g. Age at time of study 24-75 hours. Negative blood cultures. Fio2 > 0.3 and receiving mechanical ventilation (including CPAP), ETT > 3.0mm (internal diameter)
Interventions	Experimental group: Endotracheal tube suction using end hole endotracheal tube adaptor (Isothermal 3165). Control group received ETT suction using disconnection from ventilator. Single operator technique. Studied at beginning and end of three separate 2 hour study periods
Outcomes	Heart rate: number of occasions >10% decrease, per cent change, episodes of bradycardia (<100bpm). TcPO2: episodes of >10% decrease, decrease to <50mmHg and percent change
Notes	Preoxygenation not performed. Studied during a two hour study period. No two study periods were consecutive i.e. the second part of the study period did not constitute the first part of another

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Stated intervention chosen randomly from card system.
Allocation concealment (selection bias)	Low risk	Sealed envelope.
Blinding (performance bias and detection bias) All outcomes	High risk	Unable to blind intervention.
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data accounted for. In third cross-over period, one neonate was excluded from analysis because the neonate was weaned to an Fio2 of less than 0.3 during study period
Selective reporting (reporting bias)	Low risk	All data reported accounted for in results.

Gunderson 1986 (*Continued)*

Other bias	Unclear risk	Not clear if deviations from protocol were made.

Hoellering 2008

Methods	Cross-over trial, random allocation. Investigators blind to procedure using a screen. Infants were grouped by the mode of ventilation, 20 SIMV and 10 HFOV
Participants	30 infants admitted to NICU < 10 weeks old, ventilated and intubated receiving suction at least twice a day. Infants stratified into mode of ventilation; SIMV and HFOV FiO2 <90%, suction pressure -19KPa, variable ETT size 2.5-3.5mm, catheter size 6FG
Interventions	Experimental group: Closed suctioning using TrachCare neonatal closed tracheal suction system attached 60 minutes prior to procedure Control group: Open suction by transiently disconnecting the ventilator. Two passes of the suction catheter performed Studied two minutes prior, during and post suction for 5 minutes
Outcomes	Heartrate: number of occasions >10% decrease, per cent change, episodes of bradycardia (<100bpm) Oxygen saturation: Number of occasion fell below 90%. Loss of lung volume and time to recover lung volume.
Notes	There was a 60 minute washout period between interventions and no longer than 4 hours Preoxygenation not performed. Oxygen saturation < 90% was requested from author and it must be noted that some of the infants had Sao2 < 90% prior to suctioning

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Order of intervention by block randomisation.
Allocation concealment (selection bias)	Low risk	Sealed, opaque envelopes for determining the procedure sequence
Blinding (performance bias and detection bias) All outcomes	Low risk	Intervention was blinded to the investigators by a screen placed between them and the patient
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data requested supplied by author with no discrepancies.

Selective reporting (reporting bias)	Low risk	No discrepancies found in reporting, when further data received from author
Other bias	Unclear risk	Sample size small in HFOV group.

Kalyn 2003

Methods	Cross-over trial comparing 2 different suctioning techniques Block randomisation, factor of 4, according to birth wt .
Participants	200 preterm infants admitted to NICU requiring ventilation/intubation, stratified by birth weight: <1000g, 1000-2000g, >2000g
Interventions	Experimental Group: Closed suctioning technique using 'Neo-LINK' adaptor on the end of the ETT 15-30 minutes prior to commencement of baseline data collection Control Group: Open suctioning performed by transiently disconnecting ETT tube. Single operator technique from a research team of seven. Two passes of the suction catheter was performed Studied 2 minutes prior to suction, during and post suction until recovery of TcPO2 to base or 30mins post suction, whichever came first
Outcomes	Heart rate, respiratory rate, blood pressure, oxygen saturation, transcutaneous partial pressure of oxygen, transcutaneous partial pressure of carbon dioxide
Notes	Extra data received from author. Demographic data not reported on. Preoxygenation in 40% of sample - 5-10% (performed for both arms) Wash-out period of 90 minutes between interventions.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Block randomisation.
Allocation concealment (selection bias)	Low risk	Sealed envelopes, for determining first procedural sequence.
Blinding (performance bias and detection bias) All outcomes	High risk	Unable to blind interventions.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Any missing data accounted for in results. If more than 20% of the physiological data were missing for a variable, it was included in the analysis. This is reflected in the re-

		sults with the varying sample size. Extra data requested and supplied
Selective reporting (reporting bias)	Low risk	No conflicts with extra data supplied.
Other bias	Unclear risk	Unable to completely determine if bias evident from text.

Mosca 1997

Methods	Blinding of allocation: No (quasi-random). Blinding of intervention: no. Complete follow-up: yes. Blinded outcome assessment: can't tell. Quasi-randomised crossover design.
Participants	11 preterm infants receiving mechanical ventilation for RDS or BPD. Median GA 29 weeks (range 25-36), median BW 1170 gm (range 760-2700 gm)
Interventions	Experimental group: Suction without disconnection using an adapter (Trach care, Ballard). Control group: ETT suction group with disconnection from the ventilator. Each infant underwent one suction by each method 60 minutes apart. This was repeated three times on the same day at intervals of several hours alternating the order in which the suction method was performed
Outcomes	Mean arterial blood pressure, cerebral blood volume, intracellular cerebral oxygenation, heart rate change, bradycardia (HR<100bpm), PCO2, arterial oxygen saturation
Notes	Preoxygenation not performed. Individual patient data provided by Dr Mosca. 60 minute wash-out period between interventions.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Employed a quasi-random method of treatment allocation, i.e. the order of allocation to the first treatment exposure was alternated (personal communication from author)
Allocation concealment (selection bias)	Unclear risk	Not mentioned in text.
Blinding (performance bias and detection bias) All outcomes	High risk	Unable to blind intervention.

Mosca 1997 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Low risk	All data from participants studied, reported on.
Selective reporting (reporting bias)	Low risk	Extra data supplied with no conflicting evidence.
Other bias	Unclear risk	Unable to determine fully from text if discrepancy between outcomes specified and data presented

Abbreviations
RDS - respiratory distress syndrome
GA - gestational age
CPAP - continuous positive airway pressure
FiO2 - fraction of inspired oxygen
ETT - endotracheal tube
BPD - bronchopulmonary dysplasia
NICU - neonatal intensive care unit
TcPO2 - transcutaneous arterial partial pressure (tension) of oxygen.
SaO2 - arterial oxygenation saturation

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

Study	Reason for exclusion
Cabal 1979	Unable to verify random or quasi-random allocation.
Candida S. de Paula 2010	Insufficient data (abstract only).
Graff 1987	Unable to verify random or quasi-random allocation.
Spence 1992	Random or quasi-random allocation not used.
Tan 1992	Insufficient data (abstract only).
Tan 2004	Used partially ventilated modes of closed suctioning and cohort were all < 1000 grams
Zmora 1980	Unable to verify random or quasi-random allocation.

DATA AND ANALYSES

Comparison 1. Suctioning without disconnection versus with disconnection

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Heart rate decrease >10%	3	104	Risk Ratio (M-H, Fixed, 95% CI)	0.61 [0.40, 0.93]
2 Change in heart rate (HR)(%) - by weight	4		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
2.1 Change in HR (%) - all weights	4	478	Mean Difference (IV, Fixed, 95% CI)	6.77 [4.01, 9.52]
2.2 Change in HR (%) <1000g	1	110	Mean Difference (IV, Fixed, 95% CI)	12.18 [5.19, 19.17]
2.3 Change in HR (%) 1000-2000g	1	136	Mean Difference (IV, Fixed, 95% CI)	3.25 [-1.06, 7.56]
2.4 Change in HR (%) >2000g	1	128	Mean Difference (IV, Fixed, 95% CI)	4.24 [-0.06, 8.54]
3 Bradycardia (HR < 100 bpm) - by weight	3		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
3.1 Bradycardia (HR < 100 bpm) - all weights	3	482	Risk Ratio (M-H, Fixed, 95% CI)	0.38 [0.15, 0.92]
3.2 Bradycardia (HR < 100 bpm) <1000g	1	122	Risk Ratio (M-H, Fixed, 95% CI)	0.33 [0.04, 3.12]
3.3 Bradycardia (HR < 100 bpm) 1000-2000g	1	144	Risk Ratio (M-H, Fixed, 95% CI)	0.33 [0.01, 8.05]
3.4 Bradycardia (HR < 100 bpm) > 2000g	1	134	Risk Ratio (M-H, Fixed, 95% CI)	0.5 [0.05, 5.38]
4 Hypoxia (SaO2 < 90%) - by weight	3		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
4.1 Hypoxia (SaO2 < 90%) - all weights	3	482	Risk Ratio (M-H, Fixed, 95% CI)	0.48 [0.31, 0.74]
4.2 Hypoxia (SaO2 < 90%) < 1000g	1	122	Risk Ratio (M-H, Fixed, 95% CI)	0.6 [0.15, 2.40]
4.3 Hypoxia (SaO2 < 90%) 1000-2000g	1	144	Risk Ratio (M-H, Fixed, 95% CI)	0.33 [0.04, 3.13]
4.4 Hypoxia (SaO2 < 90%) > 2000g	1	134	Risk Ratio (M-H, Fixed, 95% CI)	0.33 [0.09, 1.18]
5 Change in TcPO2 (%)	1	22	Mean Difference (IV, Fixed, 95% CI)	18.5 [8.11, 28.89]
6 TcPO2 decrease>10%	1	22	Risk Ratio (M-H, Fixed, 95% CI)	0.39 [0.19, 0.82]

Comparison 2. Suctioning without disconnect versus with disconnect - by ventilation mode

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Heart rate decrease > 10%	1		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
1.1 SIMV - synchronised intermittent mandatory ventilation	1	40	Risk Ratio (M-H, Fixed, 95% CI)	0.7 [0.33, 1.47]
1.2 HFOV - high frequency oscillatory ventilation	1	20	Risk Ratio (M-H, Fixed, 95% CI)	0.6 [0.19, 1.86]
2 Change in heart rate (HR) (%)	1		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
2.1 SIMV - synchronised intermittent mandatory ventilation	1	40	Mean Difference (IV, Fixed, 95% CI)	4.98 [-5.88, 15.84]
2.2 HFOV - high frequency oscillatory ventilation	1	20	Mean Difference (IV, Fixed, 95% CI)	5.04 [-14.37, 24.45]
3 Bradycardia (HR <100 bpm)	1		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
3.1 SIMV - synchronised intermittent mandatory ventilation	1	40	Risk Ratio (M-H, Fixed, 95% CI)	0.67 [0.12, 3.57]
3.2 HFOV - high frequency oscillatory ventilation	1	20	Risk Ratio (M-H, Fixed, 95% CI)	0.33 [0.04, 2.69]
4 Hypoxia (Sao2 < 90%)	1		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
4.1 SIMV - synchronised intermittent mandatory ventilation	1	40	Risk Ratio (M-H, Fixed, 95% CI)	0.63 [0.25, 1.58]
4.2 HFOV - high frequency oscillatory ventilation	1	20	Risk Ratio (M-H, Fixed, 95% CI)	0.67 [0.39, 1.15]

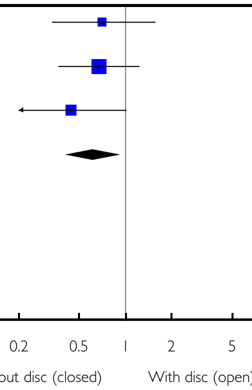
Analysis 1.1. Comparison 1 Suctioning without disconnection versus with disconnection, Outcome 1 Heart rate decrease >10%.

Review: Tracheal suctioning without disconnection in intubated ventilated neonates

Comparison: 1 Suctioning without disconnection versus with disconnection

Outcome: 1 Heart rate decrease >10%

Study or subgroup	Without disconnect n/N	With disconnect n/N	Risk Ratio M-H,Fixed,95% CI	Weight	Risk Ratio M-H,Fixed,95% CI
Gunderson 1986	5/11	7/11		22.6 %	0.71 [0.33, 1.57]
Hoellering 2008	10/30	15/30		48.4 %	0.67 [0.36, 1.24]
Mosca 1997	4/11	9/11		29.0 %	0.44 [0.19, 1.02]
Total (95% CI)	**52**	**52**		**100.0 %**	**0.61 [0.40, 0.93]**



Total events: 19 (Without disconnect), 31 (With disconnect)

Heterogeneity: $Chi^2 = 0.79$, df = 2 (P = 0.67); $I^2 = 0.0\%$

Test for overall effect: Z = 2.28 (P = 0.022)

Test for subgroup differences: Not applicable

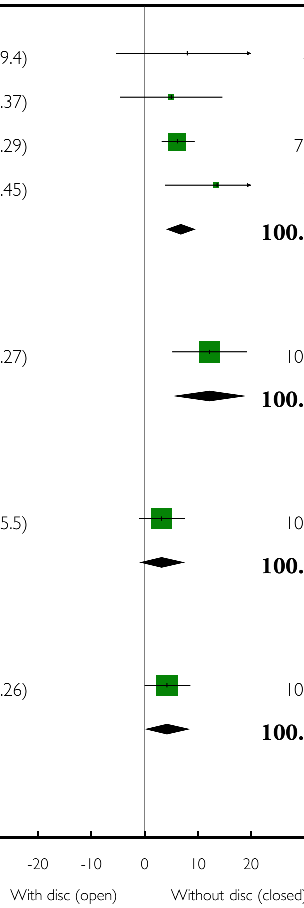
Analysis 1.2. Comparison 1 Suctioning without disconnection versus with disconnection, Outcome 2 Change in heart rate (HR)(%) - by weight.

Review: Tracheal suctioning without disconnection in intubated ventilated neonates

Comparison: 1 Suctioning without disconnection versus with disconnection

Outcome: 2 Change in heart rate (HR)(%) - by weight

Study or subgroup	Without disconnect N	Without disconnect Mean(SD)	With disconnect N	With disconnect Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 Change in HR (%) - all weights							
Gunderson 1986	11	-3.4 (11.4)	11	-11.3 (19.4)		4.3 %	7.90 [-5.40, 21.20]
Hoellering 2008	30	-12.7 (19.42)	30	-17.7 (18.37)		8.3 %	5.00 [-4.57, 14.57]
Kalyn 2003	187	-2.99 (11.43)	187	-9.21 (18.29)		79.5 %	6.22 [3.13, 9.31]
Mosca 1997	11	-5.93 (6.07)	11	-19.44 (15.45)		7.9 %	13.51 [3.70, 23.32]
Subtotal (95% CI)	**239**		**239**			**100.0 %**	**6.77 [4.01, 9.52]**
Heterogeneity: Chi^2 = 2.09, df = 3 (P = 0.55); I^2 =0.0%							
Test for overall effect: Z = 4.81 (P < 0.00001)							
2 Change in HR (%) <1000g							
Kalyn 2003	55	-6.16 (14.25)	55	-18.34 (22.27)		100.0 %	12.18 [5.19, 19.17]
Subtotal (95% CI)	**55**		**55**			**100.0 %**	**12.18 [5.19, 19.17]**
Heterogeneity: not applicable							
Test for overall effect: Z = 3.42 (P = 0.00063)							
3 Change in HR (%) 1000-2000g							
Kalyn 2003	68	-1.9 (9.41)	68	-5.15 (15.5)		100.0 %	3.25 [-1.06, 7.56]
Subtotal (95% CI)	**68**		**68**			**100.0 %**	**3.25 [-1.06, 7.56]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.48 (P = 0.14)							
4 Change in HR (%) >2000g							
Kalyn 2003	64	-1.44 (10.26)	64	-5.68 (14.26)		100.0 %	4.24 [-0.06, 8.54]
Subtotal (95% CI)	**64**		**64**			**100.0 %**	**4.24 [-0.06, 8.54]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.93 (P = 0.054)							



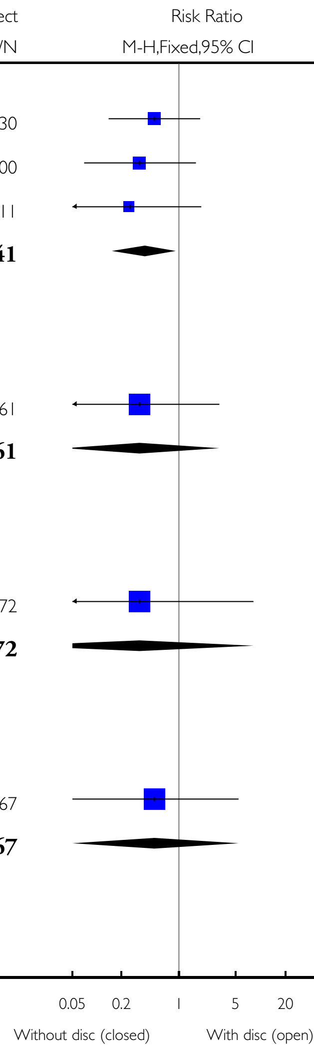
Analysis 1.3. Comparison 1 Suctioning without disconnection versus with disconnection, Outcome 3 Bradycardia (HR < 100 bpm) - by weight.

Review: Tracheal suctioning without disconnection in intubated ventilated neonates

Comparison: 1 Suctioning without disconnection versus with disconnection

Outcome: 3 Bradycardia (HR < 100 bpm) - by weight

Study or subgroup	Without disconnect n/N	With disconnect n/N	Weight	Risk Ratio M-H,Fixed,95% CI
1 Bradycardia (HR < 100 bpm) - all weights				
Hoellering 2008	3/30	6/30	37.5 %	0.50 [0.14, 1.82]
Kalyn 2003	2/200	6/200	37.5 %	0.33 [0.07, 1.63]
Mosca 1997	1/11	4/11	25.0 %	0.25 [0.03, 1.90]
Subtotal (95% CI)	**241**	**241**	**100.0 %**	**0.38 [0.15, 0.92]**
Total events: 6 (Without disconnect), 16 (With disconnect)				
Heterogeneity: $Chi^2 = 0.37$, df = 2 (P = 0.83); I^2 =0.0%				
Test for overall effect: Z = 2.15 (P = 0.031)				
2 Bradycardia (HR < 100 bpm) <1000g				
Kalyn 2003	1/61	3/61	100.0 %	0.33 [0.04, 3.12]
Subtotal (95% CI)	**61**	**61**	**100.0 %**	**0.33 [0.04, 3.12]**
Total events: 1 (Without disconnect), 3 (With disconnect)				
Heterogeneity: not applicable				
Test for overall effect: Z = 0.96 (P = 0.34)				
3 Bradycardia (HR < 100 bpm) 1000-2000g				
Kalyn 2003	0/72	1/72	100.0 %	0.33 [0.01, 8.05]
Subtotal (95% CI)	**72**	**72**	**100.0 %**	**0.33 [0.01, 8.05]**
Total events: 0 (Without disconnect), 1 (With disconnect)				
Heterogeneity: not applicable				
Test for overall effect: Z = 0.68 (P = 0.50)				
4 Bradycardia (HR < 100 bpm) > 2000g				
Kalyn 2003	1/67	2/67	100.0 %	0.50 [0.05, 5.38]
Subtotal (95% CI)	**67**	**67**	**100.0 %**	**0.50 [0.05, 5.38]**
Total events: 1 (Without disconnect), 2 (With disconnect)				
Heterogeneity: not applicable				
Test for overall effect: Z = 0.57 (P = 0.57)				



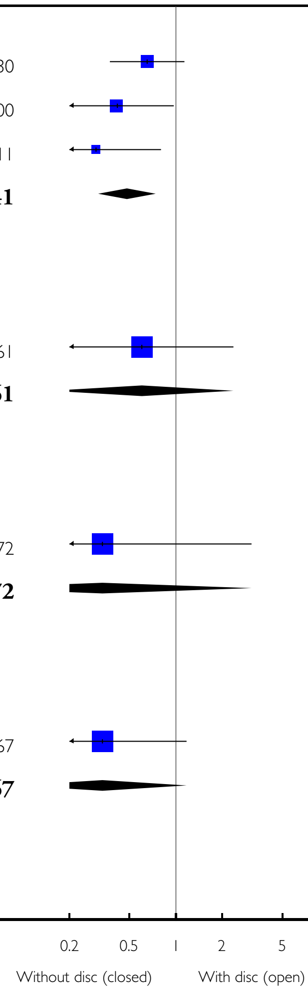
Analysis 1.4. Comparison 1 Suctioning without disconnection versus with disconnection, Outcome 4 Hypoxia (SaO2 < 90%) - by weight.

Review: Tracheal suctioning without disconnection in intubated ventilated neonates

Comparison: 1 Suctioning without disconnection versus with disconnection

Outcome: 4 Hypoxia (SaO2 < 90%) - by weight

Study or subgroup	Without disconnect n/N	With disconnect n/N	Risk Ratio M-H,Fixed,95% CI	Weight	Risk Ratio M-H,Fixed,95% CI
1 Hypoxia (SaO2 < 90%) - all weights					
Hoellering 2008	11/30	17/30		38.6 %	0.65 [0.37, 1.14]
Kalyn 2003	7/200	17/200		38.6 %	0.41 [0.17, 0.97]
Mosca 1997	3/11	10/11		22.7 %	0.30 [0.11, 0.80]
Subtotal (95% CI)	**241**	**241**		**100.0 %**	**0.48 [0.31, 0.74]**
Total events: 21 (Without disconnect), 44 (With disconnect)					
Heterogeneity: $Chi^2 = 2.09$, df = 2 (P = 0.35); $I^2 = 4\%$					
Test for overall effect: Z = 3.32 (P = 0.00090)					
2 Hypoxia (SaO2 < 90%) < 1000g					
Kalyn 2003	3/61	5/61		100.0 %	0.60 [0.15, 2.40]
Subtotal (95% CI)	**61**	**61**		**100.0 %**	**0.60 [0.15, 2.40]**
Total events: 3 (Without disconnect), 5 (With disconnect)					
Heterogeneity: not applicable					
Test for overall effect: Z = 0.72 (P = 0.47)					
3 Hypoxia (SaO2 < 90%) 1000-2000g					
Kalyn 2003	1/72	3/72		100.0 %	0.33 [0.04, 3.13]
Subtotal (95% CI)	**72**	**72**		**100.0 %**	**0.33 [0.04, 3.13]**
Total events: 1 (Without disconnect), 3 (With disconnect)					
Heterogeneity: not applicable					
Test for overall effect: Z = 0.96 (P = 0.34)					
4 Hypoxia (SaO2 < 90%) > 2000g					
Kalyn 2003	3/67	9/67		100.0 %	0.33 [0.09, 1.18]
Subtotal (95% CI)	**67**	**67**		**100.0 %**	**0.33 [0.09, 1.18]**
Total events: 3 (Without disconnect), 9 (With disconnect)					
Heterogeneity: not applicable					
Test for overall effect: Z = 1.71 (P = 0.088)					



Analysis 1.5. Comparison 1 Suctioning without disconnection versus with disconnection, Outcome 5 Change in TcPO2 (%).

Review: Tracheal suctioning without disconnection in intubated ventilated neonates

Comparison: 1 Suctioning without disconnection versus with disconnection

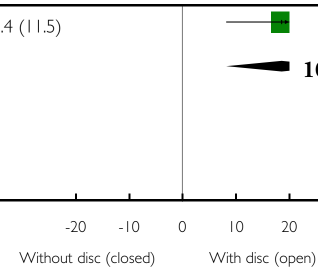
Outcome: 5 Change in TcPO2 (%)

Study or subgroup	Without disconnect		With disconnect		Mean Difference	Weight	Mean Difference
	N	Mean(SD)	N	Mean(SD)	IV,Fixed,95% CI		IV,Fixed,95% CI
Gunderson 1986	11	-2.9 (13.3)	11	-21.4 (11.5)		100.0 %	18.50 [8.11, 28.89]
Total (95% CI)	**11**		**11**			**100.0 %**	**18.50 [8.11, 28.89]**

Heterogeneity: not applicable

Test for overall effect: Z = 3.49 (P = 0.00048)

Test for subgroup differences: Not applicable



Analysis 1.6. Comparison 1 Suctioning without disconnection versus with disconnection, Outcome 6 TcPO2 decrease>10%.

Review: Tracheal suctioning without disconnection in intubated ventilated neonates

Comparison: 1 Suctioning without disconnection versus with disconnection

Outcome: 6 TcPO2 decrease>10%

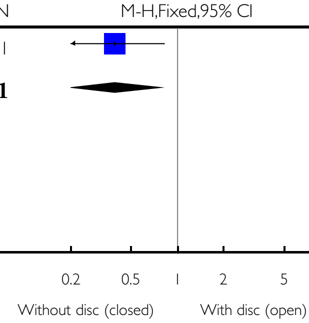
Study or subgroup	Without disconnect	With disconnect	Risk Ratio	Weight	Risk Ratio
	n/N	n/N	M-H,Fixed,95% CI		M-H,Fixed,95% CI
Gunderson 1986	4/11	11/11		100.0 %	0.39 [0.19, 0.82]
Total (95% CI)	**11**	**11**		**100.0 %**	**0.39 [0.19, 0.82]**

Total events: 4 (Without disconnect), 11 (With disconnect)

Heterogeneity: not applicable

Test for overall effect: Z = 2.49 (P = 0.013)

Test for subgroup differences: Not applicable



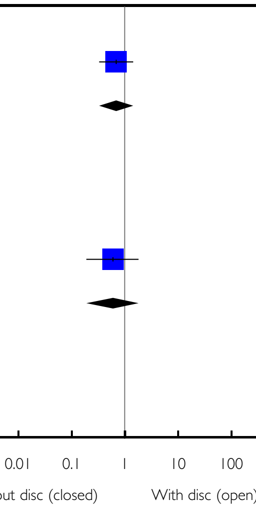
Analysis 2.1. Comparison 2 Suctioning without disconnect versus with disconnect - by ventilation mode, Outcome 1 Heart rate decrease > 10%.

Review: Tracheal suctioning without disconnection in intubated ventilated neonates

Comparison: 2 Suctioning without disconnect versus with disconnect - by ventilation mode

Outcome: 1 Heart rate decrease > 10%

Study or subgroup	without disconnetion n/N	with disconnection n/N	Risk Ratio M-H,Fixed,95% CI	Weight	Risk Ratio M-H,Fixed,95% CI
1 SIMV - synchronised intermittent mandatory ventilation					
Hoellering 2008	7/20	10/20		100.0 %	0.70 [0.33, 1.47]
Subtotal (95% CI)	**20**	**20**		**100.0 %**	**0.70 [0.33, 1.47]**
Total events: 7 (without disconnetion), 10 (with disconnection)					
Heterogeneity: not applicable					
Test for overall effect: Z = 0.94 (P = 0.35)					
2 HFOV - high frequency oscillatory ventilation					
Hoellering 2008	3/10	5/10		100.0 %	0.60 [0.19, 1.86]
Subtotal (95% CI)	**10**	**10**		**100.0 %**	**0.60 [0.19, 1.86]**
Total events: 3 (without disconnetion), 5 (with disconnection)					
Heterogeneity: not applicable					
Test for overall effect: Z = 0.88 (P = 0.38)					



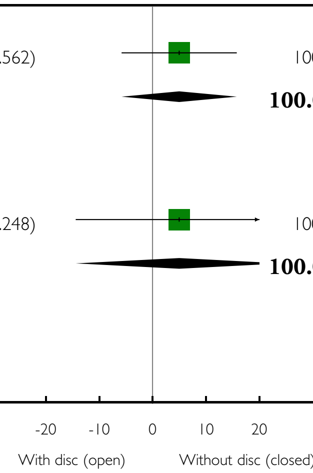
Analysis 2.2. Comparison 2 Suctioning without disconnect versus with disconnect - by ventilation mode, Outcome 2 Change in heart rate (HR) (%).

Review: Tracheal suctioning without disconnection in intubated ventilated neonates

Comparison: 2 Suctioning without disconnect versus with disconnect - by ventilation mode

Outcome: 2 Change in heart rate (HR) (%)

Study or subgroup	without disconnection N	Mean(SD)	with disconnection N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 SIMV - synchronised intermittent mandatory ventilation							
Hoellering 2008	20	-11.259 (18.4273)	20	-16.24 (16.562)		100.0 %	4.98 [-5.88, 15.84]
Subtotal (95% CI)	**20**		**20**			**100.0 %**	**4.98 [-5.88, 15.84]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.90 (P = 0.37)							
2 HFOV - high frequency oscillatory ventilation							
Hoellering 2008	10	-15.58 (22.03)	10	-20.62 (22.248)		100.0 %	5.04 [-14.37, 24.45]
Subtotal (95% CI)	**10**		**10**			**100.0 %**	**5.04 [-14.37, 24.45]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.51 (P = 0.61)							
Test for subgroup differences: Chi^2 = 0.00, df = 1 (P = 1.00), I^2 =0.0%							



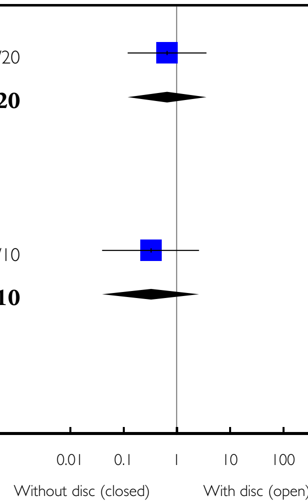
Analysis 2.3. Comparison 2 Suctioning without disconnect versus with disconnect - by ventilation mode, Outcome 3 Bradycardia (HR <100 bpm).

Review: Tracheal suctioning without disconnection in intubated ventilated neonates

Comparison: 2 Suctioning without disconnect versus with disconnect - by ventilation mode

Outcome: 3 Bradycardia (HR <100 bpm)

Study or subgroup	without disconnetion n/N	with disconnection n/N	Risk Ratio M-H,Fixed,95% CI	Weight	Risk Ratio M-H,Fixed,95% CI
1 SIMV - synchronised intermittent mandatory ventilation					
Hoellering 2008	2/20	3/20		100.0 %	0.67 [0.12, 3.57]
Subtotal (95% CI)	**20**	**20**		**100.0 %**	**0.67 [0.12, 3.57]**
Total events: 2 (without disconnetion), 3 (with disconnection)					
Heterogeneity: not applicable					
Test for overall effect: Z = 0.47 (P = 0.64)					
2 HFOV - high frequency oscillatory ventilation					
Hoellering 2008	1/10	3/10		100.0 %	0.33 [0.04, 2.69]
Subtotal (95% CI)	**10**	**10**		**100.0 %**	**0.33 [0.04, 2.69]**
Total events: 1 (without disconnetion), 3 (with disconnection)					
Heterogeneity: not applicable					
Test for overall effect: Z = 1.03 (P = 0.30)					



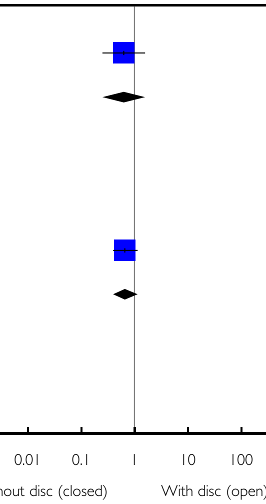
Analysis 2.4. Comparison 2 Suctioning without disconnect versus with disconnect - by ventilation mode, Outcome 4 Hypoxia (Sao2 < 90%).

Review: Tracheal suctioning without disconnection in intubated ventilated neonates

Comparison: 2 Suctioning without disconnect versus with disconnect - by ventilation mode

Outcome: 4 Hypoxia (Sao2 < 90%)

Study or subgroup	without disconnetion n/N	with disconnection n/N	Risk Ratio M-H,Fixed,95% CI	Weight	Risk Ratio M-H,Fixed,95% CI
1 SIMV - synchronised intermittent mandatory ventilation					
Hoellering 2008	5/20	8/20		100.0 %	0.63 [0.25, 1.58]
Subtotal (95% CI)	**20**	**20**		**100.0 %**	**0.63 [0.25, 1.58]**
Total events: 5 (without disconnetion), 8 (with disconnection)					
Heterogeneity: not applicable					
Test for overall effect: Z = 0.99 (P = 0.32)					
2 HFOV - high frequency oscillatory ventilation					
Hoellering 2008	6/10	9/10		100.0 %	0.67 [0.39, 1.15]
Subtotal (95% CI)	**10**	**10**		**100.0 %**	**0.67 [0.39, 1.15]**
Total events: 6 (without disconnetion), 9 (with disconnection)					
Heterogeneity: not applicable					
Test for overall effect: Z = 1.45 (P = 0.15)					



WHAT'S NEW

Last assessed as up-to-date: 19 July 2011.

Date	Event	Description
17 April 2012	Amended	Assessed as Up-to-date and Next Stage Expected dates corrected

HISTORY

Protocol first published: Issue 1, 1997

Review first published: Issue 2, 2001

Date	Event	Description
7 February 2011	New citation required and conclusions have changed	Conclusions changed. New authorship.
19 October 2010	New search has been performed	Converted to new format.
2 August 2010	New search has been performed	New search conducted
7 February 2010	New search has been performed	This updates the review "Tracheal suctioning without disconnection in intubated ventilated neonates" published in the Cochrane Database of Systematic Reviews (Woodgate 2001). Updated search in July 2011 identified two new studies for inclusion in this review update, as well as the addition of new subgroups: 1. by neonatal weight, 2. by ventilation mode.
5 February 2001	New citation required and conclusions have changed	Substantive amendment

CONTRIBUTIONS OF AUTHORS

Original review: P Woodgate, V Flenady - searched for studies, assessed studies for inclusion and wrote the review.

Review update: J Taylor, G Hawley - searched for studies, assessed studies for inclusion and wrote the review update.

P Woodgate and V Flenady - revised the review.

DECLARATIONS OF INTEREST

None

SOURCES OF SUPPORT

Internal sources

- Perinatal Epidemiology Unit, Mater Hospital, South Brisbane, Queensland, Australia.
- Mater Mothers Hospital, South Brisbane, Queensland, Australia.

External sources

- No sources of support supplied

INDEX TERMS

Medical Subject Headings (MeSH)

*Intubation, Intratracheal; Cross-Over Studies; Heart Rate; Randomized Controlled Trials as Topic; Respiration; Respiration, Artificial [*adverse effects]; Suction [*methods]; Ventilator Weaning

MeSH check words

Humans; Infant, Newborn