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Cochrane Database of Systematic Reviews 1999, Issue 1. Art. No.: CD000508.

DOI: [10.1002/14651858.CD000508](https://doi.org/10.1002/14651858.CD000508).

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[Intervention Review]

Umbilical artery catheters in the newborn: effects of catheter design (end vs. side hole)

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Editorial group: Cochrane Neonatal Group

Publication status and date: New search for studies and content updated (no change to conclusions), published in Issue 1, 2010.

Citation: Barrington KJ. Umbilical artery catheters in the newborn: effects of catheter design (end vs. side hole). *Cochrane Database of Systematic Reviews* 1999, Issue 1. Art. No.: CD000508. DOI: [10.1002/14651858.CD000508](https://doi.org/10.1002/14651858.CD000508).

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ABSTRACT

Background

Umbilical arterial catheters (UACs) are among the most commonly used monitoring methodologies in neonatal intensive care. Immediately after insertion of a UAC, local vascular compromise is frequently evident, usually in the form of blue or white toes, but occasionally with more severe and extensive ischemic manifestations. Aortic thrombi and renal ischemia have also been described. Some epidemiologic and case control studies have shown that the use of umbilical artery catheterisation is statistically associated with the later development of necrotizing enterocolitis.

Objectives

To determine whether the design of an umbilical arterial catheter influences the frequency of ischemic events, aortic thrombosis, intraventricular hemorrhage, mortality or necrotising enterocolitis in newborn infants.

Search methods

Randomized and quasi-randomized controlled trials of umbilical catheterization use were obtained using the search methods of the Cochrane Neonatal Review Group. *The Cochrane Library*, MEDLINE (search via PubMed), CINAHL and EMBASE were searched from 1999 to 2009.

Selection criteria

Randomized trials in newborn infants of any birthweight or gestation.
Comparison of end hole catheters with side hole catheters.
Clinically important end points such as ischemic events or aortic thrombosis.

Data collection and analysis

There appears to be only a single trial which has addressed this issue ([Wesstrom 1979](#)).

Main results

End hole catheters are associated with a much decreased risk of aortic thrombosis compared to side hole catheters. RR = 0.27 (95% CI 0.11, 0.67)

Authors' conclusions

Side hole catheters should be avoided for umbilical arterial catheterisation in the newborn.

PLAIN LANGUAGE SUMMARY

Umbilical artery catheters in the newborn: effects of catheter design (end vs side hole)

Using umbilical artery catheters with the hole in the side instead of end leads to serious complications. The umbilical artery catheters (tubes) (UACs) commonly used in neonatal intensive care to monitor babies can sometimes cause them problems. They can be used with different accompanying doses of the drug heparin, and in different positions. The design of catheters can vary. The review found that catheters with a hole in the side instead of at the end resulted in one in three babies experiencing aortic thrombosis (a clot in the heart's major artery).

BACKGROUND

Description of the condition

Umbilical arterial catheters (UACs) are among the most commonly used monitoring methodologies in neonatal intensive care. Immediately after insertion of a UAC, local vascular compromise is frequently evident, usually in the form of blue or white toes, but occasionally with more severe and extensive ischemic manifestations. Aortic thrombi and renal ischemia have also been described. Some epidemiologic and case control studies have shown that the use of umbilical artery catheterisation is statistically associated with the later development of necrotizing enterocolitis.

Description of the intervention

One of the variations in design of the catheters has been the development of end-hole or side-hole catheters. The side hole catheters often have an integral oxygen electrode at the tip necessitating the placement of the orifice away from the tip. In the early years of neonatal intensive care, feeding tubes, which also traditionally have a side hole, may have been used as catheters for umbilical artery lines.

How the intervention might work

The position of the catheter hole could potentially lead to a difference in complication rates as the flow dynamics around the tip of the catheter will change. This may lead to a difference in the rate of clinically apparent ischemic events, or of aortic thrombosis.

Why it is important to do this review

This review updates the existing review "Umbilical artery catheters in the newborn: effects of catheter design (end vs. side hole)" published in the Cochrane Database of Systematic Reviews (Barrington 1999).

OBJECTIVES

To determine whether the design of the catheter influences morbidity with the use of umbilical artery catheters, specifically whether aortic thrombosis or clinically recognized ischemic phenomena are affected.

METHODS

Criteria for considering studies for this review

Types of studies

Randomized and quasi-randomized clinical studies were selected. Clinically relevant outcomes were collated, with survival and long-term disability being given the greatest weight. Both term and preterm infants were included.

Types of participants

Both term and preterm infants who require umbilical catheter placement were considered.

Types of interventions

Random allocation to an end hole catheter or a side hole catheter.

Types of outcome measures

1. Clinical vascular compromise, including blanching or cyanosis of the feet or toes.
2. Necrotising enterocolitis.
3. Intraventricular hemorrhage.
4. Death.
5. Aortic thrombosis.
6. Hypertension.
7. Hematuria.

Search methods for identification of studies

The standard search method of the Cochrane Neonatal Review Group was used.

Electronic searches

Randomized and quasi-randomized controlled trials of umbilical catheterization use were obtained from the following sources:

1. Medline Search using Medline Plus and the keyword headings 'Umbilic#', 'Catheter#' and subject heading 'Infant, Newborn'

The bibliography cited in each publication obtained was searched in order to identify additional relevant articles.

The original search was completed in November 1997. The search was updated in November 1998.

The search was updated in April 2009 as follows:

The Cochrane Library, MEDLINE (search via PubMed), CINAHL and EMBASE were searched from 1999 to 2009.

Search terms: umbilic* AND catheter. Limits: human, newborn infant and clinical trial. No language restrictions were applied.

Searching other resources

Randomized and quasi randomized controlled trials of umbilical catheterization use were obtained from searching the following other resources:

1. Effective Care of the Newborn Infant, edited by JC Sinclair and MB Bracken

2. Search of personal data files

Clinical trials registries were also searched for ongoing or recently completed trials (clinicaltrials.gov; controlled-trials.com; and who.int/ictpr)

Data collection and analysis

The standard methods of the Cochrane Neonatal Review Group Guidelines were employed.

Selection of studies

Reports were first reviewed to determine whether there was a concurrent control group, and discarded if not. The method of assignment to control and intervention groups was then determined and if not random or quasi random, then the trial was discarded.

Data extraction and management

The review author extracted, assessed and coded all data for each study using a form that was designed specifically for this review.

For each study, final data was entered into RevMan by the review author (KB).

Assessment of risk of bias in included studies

The standard methods of the Cochrane Neonatal Review Group were employed. Each identified trial was assessed for methodological quality with respect to a) masking of allocation b) masking of intervention c) completeness of follow-up d) masking of outcome assessment. This information is included in the Characteristics of Included Studies Table.

For the update in 2009, the risk of bias table was completed in order to address the following questions:

1. Sequence generation: Was the allocation sequence adequately generated?
2. Allocation concealment: Was allocation adequately concealed?
3. Blinding of participants, personnel and outcome assessors: Was knowledge of the allocated intervention adequately prevented during the study? At study entry? At the time of outcome assessment?
4. Incomplete outcome data: Were incomplete outcome data adequately addressed?
5. Selective outcome reporting: Are reports of the study free of suggestion of selective outcome reporting?
6. Other sources of bias: Was the study apparently free of other problems that could put it at a high risk of bias?

Measures of treatment effect

Statistical analyses was performed using Review Manager software. For categorical outcomes, estimates for relative risk and risk difference were calculated. For outcomes measured on a continuous scale, estimates for weighted mean difference were calculated. 95% confidence intervals were used.

Assessment of heterogeneity

Heterogeneity between trials was evaluated by inspecting the forest plots and quantifying the impact of heterogeneity using the I^2 statistic. A fixed effects model for meta-analysis.

Data synthesis

If multiple trials were found and meta-analysis was judged to be appropriate, the analysis would be done using Review Manager software (RevMan 5). All meta-analyses were to be done using the fixed effect model.

Subgroup analysis and investigation of heterogeneity

If data was available, subgroup analysis based on gestational age or birth weight were planned.

RESULTS

Description of studies

The original search strategy retrieved 849 articles. These were further reduced by restricting the search by use of the terms prospective, random#, control#, comparative or clinical. When

studies of animal subjects and of epidural catheterisation were also removed, 233 reports remained. The abstract of each was read individually to determine if there was a possibility that the papers were reporting randomized prospective controlled trials. No new trials comparing end hole and side hole catheters were discovered at the time of the November 1998 and April 2009 update to this review.

The search revealed only one trial investigating catheter design ([Wesstrom 1979](#)). The study was designed to randomly assign infants requiring umbilical catheter placement to one of four groups, high end hole, high side hole, low end hole or low side hole catheter. Infants were either preterm or term, requiring umbilical catheterisation for numerous different reasons. After the first 15 months of the study the side hole groups were dropped, presumably because of the high incidence of aortic thrombosis, and for the final four months randomization was to high or low placement of end hole catheters only. The end hole catheter used was an 'Argyle' umbilical catheter; the side hole catheter was an Argyle feeding tube. Most catheters were 5 Fr size.

The major outcome variable was aortic thrombosis. This was determined either by single shot angiography at the time of removal of the catheter or at autopsy. Clinically apparent sequelae were said to be recorded, but are not clearly described.

Unfortunately the designs of the two largest prospective trials of umbilical artery catheter use, [UACTSG 1992](#) and [Kempley 1993](#), did not specify catheter type. Kempley's trial included both end and side hole catheters, of 3.5, 4.0 and 5.0 French sizes, but does not give results by catheter design, whereas [UACTSG 1992](#) did not mention catheter design at all, but restricted the size to 3.5 Fr.

Risk of bias in included studies

[Wesstrom 1979](#)

Masking of allocation: Insufficient information presented to ascertain allocation masking.

Masking of intervention: Masking does not appear to have been attempted.

Completeness of follow-up: All infants appear to have been accounted for; there were nine infants among the 71 subjects for whom autopsy or angiography were not available.

Masking of outcome assessment: This was not attempted.

Other Comments: The reason for dropping the side hole groups was not clearly described. No details of the randomization process are given. There is no hypothesis described and no sample size calculations are given.

Effects of interventions

End hole compared to side hole catheters (COMPARISON 1)

Side hole catheters appear to have a much higher incidence of thromboses than end-hole catheters from this single study ([Wesstrom 1979](#)). The relative risk for the occurrence of aortic thrombosis with end hole catheters compared to side hole catheters is 0.27 (95% CI 0.11, 0.67). The risk difference is -0.35 (95% CI -0.58, -0.12); this indicates that we can expect to prevent one case of aortic thrombosis in every three infants (95% CI 2, 8) who receive an end hold rather than a side hole catheter.

No other outcomes are well enough described to determine their relative frequency with end hole compared to side hole catheters.

DISCUSSION

Given the significant increase in aortic thrombosis rates when using side hole catheters, catheters of such a design could not be recommended for routine use in newborn infants for umbilical arterial lines. It must be remembered that the catheter used in the one evaluable study was a feeding tube, which would not be utilised today by many centers, and are not likely to be approved for such use by their manufacturers. The oxygen electrode tipped catheter (which also usually has a side hole) has not been tested in any similar study, and may have a different frequency of thrombosis. Other catheters with designs which incorporate a side hole should be shown to be safe in prospective comparative trials before being introduced for clinical use.

AUTHORS' CONCLUSIONS

Implications for practice

Currently, catheters designed with a side hole should not be used routinely for umbilical artery catheterisation in the newborn.

Implications for research

Further studies to determine safety of catheters with non-standard designs should be performed. In particular the safety of the oxygen electrode tipped catheter which are used by some centers should be investigated.

ACKNOWLEDGEMENTS

The Cochrane Neonatal Review Group has been funded in part 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.

REFERENCES

References to studies included in this review

Wesstrom 1979 {published data only}

Wesstrom G, Finnstrom O, Stenport G. Umbilical artery catheterization in newborns. I Thrombosis in relation to catheter type and position. *Acta Paediatrica Scandinavica* 1979;**68**:575-81.

Additional references

Kempley 1993

Kempley ST, Bennett S, Loftus BG, Cooper D, Gamsu HR. Randomized trial of umbilical arterial catheter position: Clinical outcome. *Acta Paediatrica* 1993;**82**:173-6.

UACTSG 1992

Umbilical Artery Catheter Trial Study Group. Relationship of intraventricular hemorrhage or death with the level of umbilical

artery catheter placement: A multicenter randomized clinical trial. *Pediatrics* 1992;**90**:881-7.

References to other published versions of this review

Barrington 1997

Barrington KJ. Umbilical artery catheters in the newborn: effects of catheter design (end vs side hole). *Cochrane Database of Systematic Reviews* 1997, Issue 4. [DOI: [10.1002/14651858.CD000508](https://doi.org/10.1002/14651858.CD000508)]

Barrington 1999

Barrington KJ. Umbilical artery catheters in the newborn: effects of catheter design (end vs side hole). *Cochrane Database of Systematic Reviews* 1999, Issue 1. [DOI: [10.1002/14651858.CD000508](https://doi.org/10.1002/14651858.CD000508)]

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Wesstrom 1979

Methods	Random assignment to one of 4 groups initially, high end hole, high side hole, low end hole or low side hole catheter. After the first 15 months the side hole groups were dropped and the final 4 months randomization was to high or low placement of end hole catheters only.	
Participants	62 term and preterm infants, requiring umbilical arterial catheterisation for medical care.	
Interventions	39 infants had end hole catheters, 23 had side hole catheters.	
Outcomes	Thrombosis on angiography performed at removal was the primary outcome variable. Necrotising enterocolitis not determined; clinical vascular compromise not stated.	
Notes		
Risk of bias		
Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Insufficient information presented to ascertain allocation masking.
Allocation concealment?	High risk	Masking does not appear to have been attempted. Random assignment to one of 4 groups initially, high end hole, high side hole, low end hole or low side hole catheter. After the first 15 months the side hole groups were dropped and the final 4 months randomization was to high or low placement of end hole catheters only.
Blinding? All outcomes	High risk	Masking of outcome assessment was not attempted.
Incomplete outcome data addressed?	Unclear risk	All infants appear to have been accounted for; there were nine infants among the 71 subjects for whom autopsy or angiography were not available.

Umbilical artery catheters in the newborn: effects of catheter design (end vs. side hole) (Review)

Wesstrom 1979 (Continued)

All outcomes

Free of selective reporting?	Low risk	
Free of other bias?	Unclear risk	Random assignment to one of 4 groups initially, high end hole, high side hole, low end hole or low side hole catheter. After the first 15 months the side hole groups were dropped and the final 4 months randomization was to high or low placement of end hole catheters only

DATA AND ANALYSES

Comparison 1. End hole compared to side hole catheters

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Incidence of aortic thrombosis	1	62	Risk Ratio (M-H, Fixed, 95% CI)	0.27 [0.11, 0.67]

Analysis 1.1. Comparison 1 End hole compared to side hole catheters, Outcome 1 Incidence of aortic thrombosis.

WHAT'S NEW

Date	Event	Description
4 August 2009	New search has been performed	<p>This review updates the existing review "Umbilical artery catheters in the newborn: effects of catheter design (end vs side hole)" published in the Cochrane Database of Systematic Reviews, Issue 1, 1999 (Barrington 1999).</p> <p>Updated search found no new trials.</p> <p>No changes to conclusions.</p>

HISTORY

Protocol first published: Issue 1, 1999

Review first published: Issue 1, 1999

Date	Event	Description
22 October 2008	Amended	Converted to new review format.

CONTRIBUTIONS OF AUTHORS

Keith Barrington (KB) wrote the original review and updated the review in 1999.

The 2009 update was conducted centrally by the Cochrane Neonatal Review Group staff (Yolanda Montagne, Roger Soll, Diane Haughton) and reviewed and approved by KB.

DECLARATIONS OF INTEREST

None

INDEX TERMS

Medical Subject Headings (MeSH)

*Umbilical Arteries; Catheterization [*instrumentation]; Equipment Design

MeSH check words

Humans; Infant, Newborn