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Central versus peripheral arterial cannulation and neurological outcomes after thoracic aortic surgery: meta-analysis and meta-regression of 4459 patients

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Abstract

Background: Thoracic aortic surgeries remain with high mortality rates, often associated with postoperative neurological complications. The choice of the right cannulation site is extremely important for suitable blood supply and maintenance of vital functions, especially of the central nervous system.

Objectives: To compare the influence of central versus peripheral arterial cannulation on neurological outcomes in patients undergoing thoracic aortic surgery through systematic review and meta-analysis.

Methods: MEDLINE, EMBASE, CENTRAL/CCTR, SciELO, LILACS and reference lists of relevant articles were searched for clinical studies that reported in-hospital neurological outcomes after central or peripheral arterial cannulation during thoracic aortic surgery procedures until December 2013. The principal summary measures were Odds Ratio (OR) for central compared to peripheral arterial cannulation with 95% confidence interval (CI) and p-values considered statistically significant when <0.05. The ORs were combined across studies, using the DerSimonian-Laird random effects model and fixed effects model using the Mantel-Haenszel model - both models were weighted. The meta-analysis was completed using the software Comprehensive Meta-Analysis version 2 (Biostat Inc., Englewood, NJ).

Results: Six studies were identified and included a total of 4459 patients (1180 for central and 3279 for peripheral cannulation). There was no significant difference between the central and peripheral groups regarding neurological outcomes. The meta-regression evidenced no relationship between neurological outcomes and the variables age, sex, previous coronary event, previous neurological event, urgency surgery, cardiopulmonary bypass time, activated clotting time and esophageal temperature with p>0,05.

Conclusion: When it comes to neurological outcomes in patients undergoing thoracic aortic surgery, there was no evidence that argues in favor of any choice of arterial cannulation site, which makes us reject any superiority of one approach over the other in this regard.

Keywords

thoracic aorta; stroke; cardiopulmonary bypass; outcome assessment; meta-analysis

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Introduction

Rationale

Among high complex cardiac surgeries, the most crucial ones are aortic dissecting aneurysm repairs, which are associated with elevated morbidity and mortality rates, above all, neurological complications.[1,2] This may occur due to an inadequate blood supply to the brain during cardiopulmonary bypass (CPB), especially when there is aortic arch involvement or when its reconstruction is necessary.[3,4]

Furthermore, under imminent risk of aortic disruption or in the presence of atheromatous plaques or diagnosed arteriosclerosis disease, the conventional arterial cannulation site (on the aorta) is questionable, which makes it necessary for a choice of an alternative technique for peripheral arterial cannulation, such as femoral, axillar or subclavian. However, these options are not free of complications and it is not yet clear which method is related to lesser neurological damage. This decision has varied over the last few years.[1,2,5]

Our meta-analysis attempts to verify if there is any difference regarding neurological outcomes in the postoperative period of thoracic aortic surgery, comparing the use of central arterial cannulation with peripheral arterial cannulation.

Objectives

We performed a meta-analysis of selected studies for the influence of the use of central arterial cannulation on neurological outcomes in the postoperative period of thoracic aortic surgery, comparing it with peripheral arterial cannulation, in accordance with the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).

Method

Eligibility criteria

Using the PICOS strategy (Population, Intervention, Comparison, Outcome, Study), studies were considered if: (1) the population comprised patients undergoing thoracic aortic surgery; (2) it compared efficacy between central arterial cannulation and peripheral arterial cannulation; (3) the outcomes studied included stroke or postoperative neurological events; (4) it was prospective/restrospective and/or randomized/non-randomized.

Information sources

The following databases were used (from 2000 to 2013): MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials (CENTRAL/CCTR), ClinicalTrials.gov, SciELO (Scientific Electronic Library Online), LILACS (Literatura Latino-Americana e do Caribe em Ciências da Saúde – The Latin American and Caribbean Health Sciences) and reference lists of relevant articles.

Search

We conducted the search using Medical Subject Heading (MeSH) terms: "Aortic Aneurysm, Thoracic"[Mesh] OR "Aneurysm, Dissecting"[Mesh] AND "Catheterization, Central Venous"[Mesh] OR "Catheterization, Peripheral" [Mesh] AND "Acute Disease"[Mesh] OR "Stroke"[Mesh].

Study selection

The following steps were taken: (1) identification of titles of records through database searching; (2) removal of duplicates; (3) screening and selection of abstracts; (4) assessment for eligibility through full-text articles; (5) final inclusion in the study. One reviewer followed steps 1 to 3 while two independent reviewers followed step 4 and selected studies. Inclusion or exclusion of studies was decided unanimously. When there was disagreement, a third reviewer made the final decision.

Data items

The primary endpoint was the Odds Ratio (OR) for neurological events after thoracic aortic surgery using central or peripheral arterial cannulation.

Data collection process

Two independent reviewers extracted the data. When there was disagreement about the data, a third reviewer (the first author) checked the data and made the final decision about it. From each study, we extracted patient characteristics, study design and outcomes (number of events and number of total groups).

Risk of bias in individual studies

The included studies were assessed for the following characteristics: type of randomization, multicenter enrollment (yes or no), characteristics of participants (selection bias), characteristics of personnel (performance bias), outcome assessment (detection bias) and incomplete outcome data addressed (attrition bias).

Two independent reviewers assessed the risk of bias. Agreement between the two reviewers was assessed

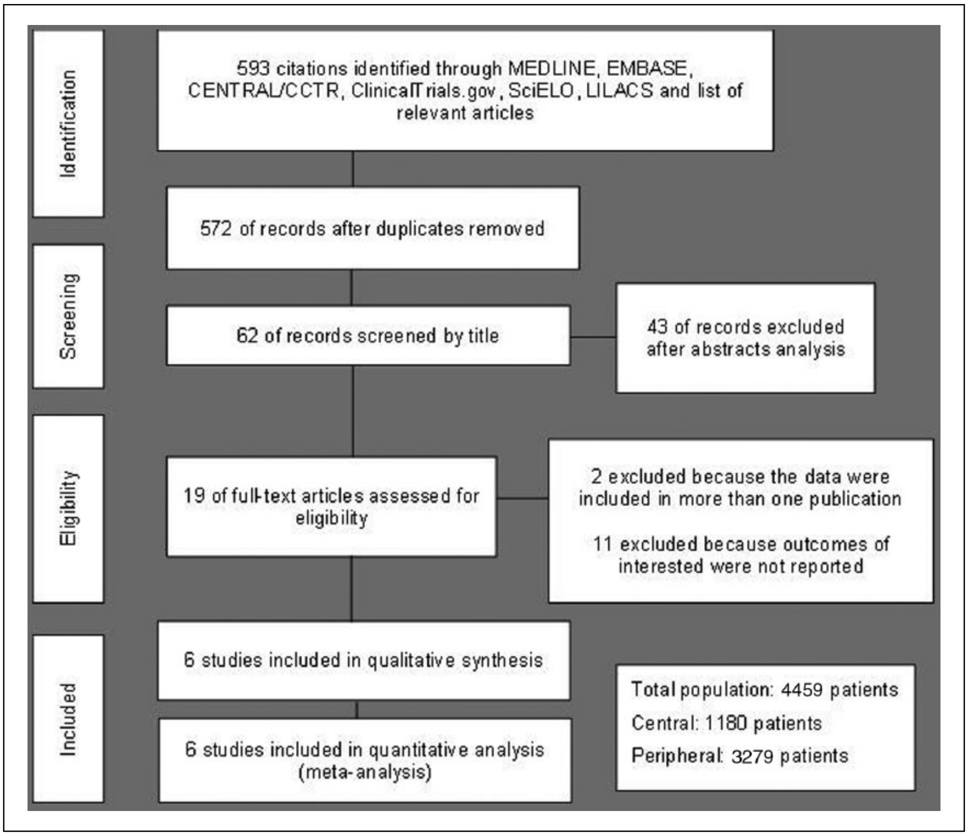

Figure 1. Flow diagram of studies included in the data search.

using Kappa statistics for full text screening and rating of relevance and risk of bias. When there was disagreement for the risk of bias, a third reviewer (the first author) checked the data and took the final decision about it.

Summary measures

The principal summary measures were ORs with 95% Confidence Interval (CI) and p-values that were considered statistically significant when <0.05. The meta-analysis was completed using the Software Comprehensive Meta-Analysis version 2 (Biostat Inc., Englewood, NJ).

Synthesis of results

Forest plots were generated for the graphical presentations of neurological outcomes and we performed the I^2 test and Chi^2 test for the assessment of heterogeneity across the studies.[6] Each study was summarized by the OR for central arterial cannulation compared to peripheral arterial cannulation. The ORs were combined across studies using the weighted DerSimonian-Laird random effects model[7] and a weighted fixed-effects model using the Mantel-Haenszel model.[8]

Risk of bias across studies

To assess publication bias, a funnel plot was generated (for each outcome), being statistically assessed by Begg and Mazumdar´s test[9] and Egger´s test.[10]

Meta-regression analysis

Meta-regression analysis was performed to determine whether the effects of the type of cannulation were modulated by pre-specified factors, such as age, sex, previous coronary event, previous neurological event, urgent surgery, cardiopulmonary bypass time, activated clotting time and esophageal temperature.

Results

Study selection

A total of 593 citations were identified, of which 19 studies were potentially relevant and retrieved as full text. Only six publications fulfilled our eligibility criteria. Inter-observer reliability of study relevance was very good (Kappa = 0.82). The agreement for decisions regarding the study validity was very good (Kappa = 0.80). The flow diagram of the search strategy can be seen in Figure 1.

Table 1.

Study	Central (n)	Peripheral (n)	Procedure	Neurological Deficit
Conzelmann et al. 2012[11]	486	1610	URGENT	PERMANENT
Suzuki et al. 2010[12]	26	51	URGENT	PERMANENT
Etz et al. 2008[13]	157	712	ELECTIVE/ URGENT	PERMANENT
Reece et al. 2007[14]	24	46	ELECTIVE/ URGENT	PERMANENT/ TEMPORARY
Morishige et al. 2006[15]	16	19	ELECTIVE/ URGENT	PERMANENT/ TEMPORARY
Svensson et al. 2004[16]	471	841	ELECTIVE/ URGENT	PERMANENT

Table 2.

Study	Randomization process	Multicenter enrollment	Selection Bias	Performance Bias	Detection Bias	Attriction Bias	Pairwise/ risk-adjusted
1- Conzelmann et al. 2012[11]	NO	YES	C	C	A	A	YES
2- Suzuki et al. 2010[12]	NO	NO	C	C	B	B	NO
3- Etz et al. 2008[13]	NO	NO	C	C	B	A	NO
4- Reece et al. 2007[14]	NO	NO	C	C	B	B	NO
5- Morishige et al. 2006[15]	NO	NO	C	B	A	A	NO
6- Svensson et al. 2004[16]	NO	NO	C	C	A	B	YES

Studies' characteristics

Characteristics of each study are shown in Table 1. A total of 4459 patients were studied, with 1180 undergoing central arterial cannulation and 3279 undergoing peripheral arterial cannulation. The overall mean age in the studies was 62±3 years and 64% were male. All the six studies included urgent surgeries and two of them involved urgent surgeries exclusively. Four studies considered only permanent neurological deficit and two also included temporary events to their outcomes. The overall internal validity was moderate, according to the analysis of risk of bias in individual studies (Table 2).

Synthesis of results

The OR for neurological outcomes in the central group compared with the peripheral group in each study is reported in Figure 2. There was no evidence for important heterogeneity of treatment effect among the studies for neurological outcomes ($Chi^2 = 4.94$ e $p = 0.423$; e $I^2 = 0.0\%$). The analysis evidenced no statistical difference for the neurological events rate (fixed model: OR = 1.111, CI 95% = 0.881 to 1.403, p = 0.374; random model: OR = 1.111, CI 95% = 0.881 to 1.403, p = 0.374).

Risk of bias across studies

A sensibility analysis was performed to assess the reliability degree of the study and revealed a funnel plot (Figure 3) that disclosed symmetry around the axis for the treatment effect in all outcomes, which means that we probably do not have publication bias related to this endpoint.

Meta-regression analysis

The meta-regression demonstrated no correlation between the neurological outcomes with the pre-specified factors age, sex, previous coronary event, previous neurological event, urgent surgery, cardiopulmonary bypass time, activated clotting time and esophageal temperature, since the coefficients were not statistically significant ($p>0.05$).

Discussion

Summary of evidence

The results of this meta-analysis demonstrate that there was no difference regarding the occurrence of neurological events, being the summary measures being free from the influence of heterogeneity of the effects or publication bias.

Meta-regression analysis reinforces these results, since it showed no statistically significant associations, demonstrating the independence of the results with respect to the analyzed covariates.

Risk of bias and limitations

Firstly, it should be noted the extensive sample size of this systematic review, with a total of 4459 patients (1180 for central and 3279 for peripheral cannulation) and 405

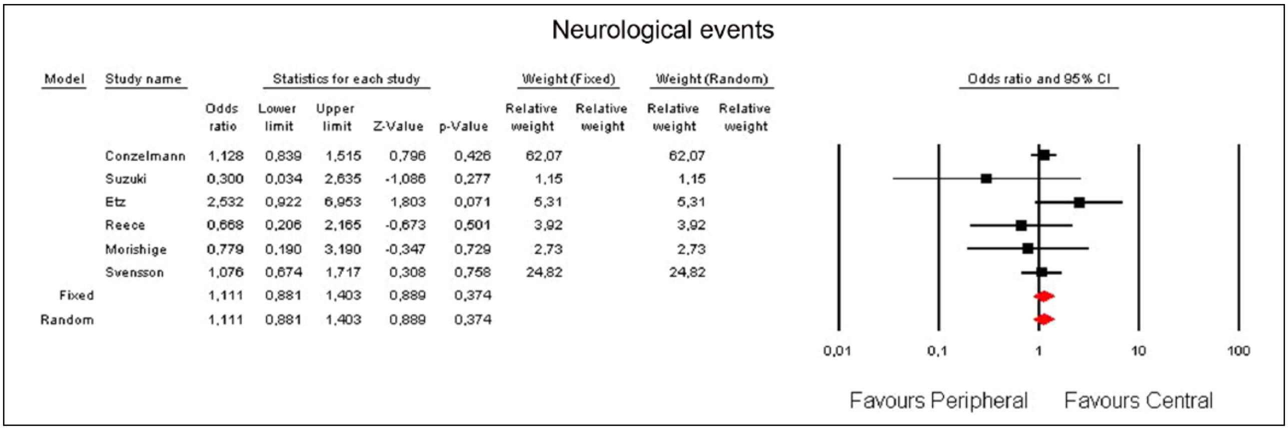

Figure 2. Risk ratio and conclusions plot of mortality associated neurological outcomes.

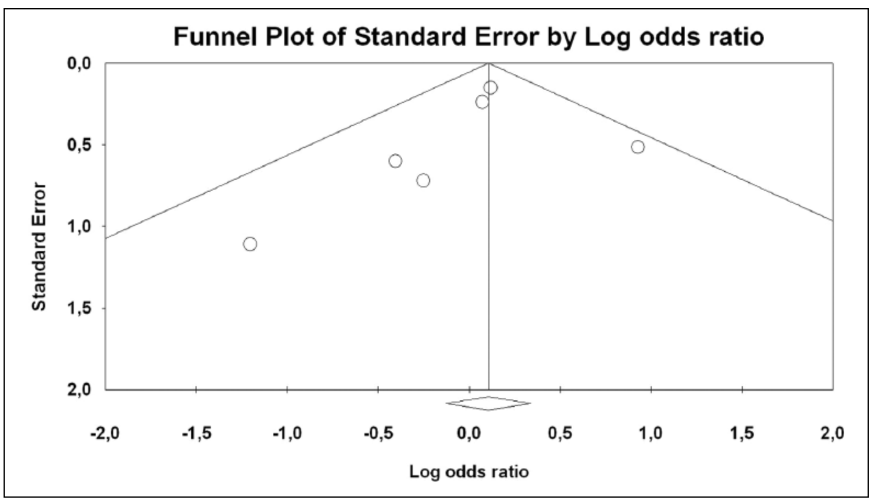

Figure 3. Publication bias analysis by funnel plot graphic for the outcomes.

events, in spite of the few papers (six) included on the meta-analysis.

On the other hand, none of these articles is a randomized trial. The studies consisted of retrospective studies with comparative analysis, except for a large case series.[11] The latter is a multicenter, prospective, web-based registry for patients suffering from acute aortic dissection type A (AADA) from 50 voluntarily participating cardiac centers in Austria, Switzerland and Germany.

This may be explained, in part, by the major characteristic of the aorta thoracic surgeries, especially AADA, when presented with an urgent or emergency need of aortic repair, which often makes it difficult to include this kind of patient in research with high methodological rigor.

Another relevant aspect to be factored in is the variation of choice of cannulation site according to the surgeon´s preference and the fact that the final decision was made mostly in the operating room after direct inspection of the vessels.[12] Additionally, various approaches were used within the institutions, providing a mixture of techniques, consequently adding a great deal of performance heterogeneity. [11-14]

No consistent pattern has been observed to guide the arterial cannulation, taking into account the severity of comorbid factors, general clinical condition or related risks. Few researchers took into consideration the atherosclerotic aneurysm diagnosis, based on previous imaging examinations and classification of the type of aneurysm in atherosclerotic, degenerative, chronic dissection and acute dissection.[13,15]

Moreover, only Morishige et al.[15] standardized the peripheral arterial cannulation and chose the right axillar artery when an atheromatous plaque or an ulceration of the ascending aorta was detected or when the ascending aorta was dissected. Otherwise central cannulation was employed.

The low prevalence of central cannulation in this present review (around 26%) may be justified in the face of the predominance of femoral catheterization in recent decades. Nowadays, in consequence of the published losses caused by retrograde flow and the possibility of echocardiography in the operating room to avoid false lumen access, its usage has been gradually decreasing.[12,14,15]

Therefore, founded on a critical evaluation, it is believed that the greatest concern associated with the arterial cannulation site is related to enhancement issues of the main thoracic aorta surgery centers, which have been improving the surgical techniques in order to reduce complications and to bring the results closer between the groups.

Secondary findings

The data from Svensson et al.,[16] even though it is the oldest of our list, suggest, but do not conclusively prove, that artery cannulation attachment of a side graft reduces stroke rates. When the propensity-based pairwise matching technique to obtain the fairest risk-adjusted comparison of neurological outcome was applied, the risk of stroke was reduced with side graft use (p=0.05). The other investigations did not consider this matter and its use was variously described.

A relevant finding from Conzelman et al.[11] is an important correlation between neurological events and mortality. In total, 16.9% of patients died within 30 days postoperatively. Among the 276 patients with a new postoperative neurological dysfunction, 30-day mortality was 22.5% (vs. 16.1% in patients without new neurological dysfunction, p = 0.0089). This finding corroborates with the value that should be given to continued search for better neurological protection and prevention of severe injury.

Conclusion

When it comes to neurological outcomes in patients undergoing thoracic aortic surgery, there was no evidence that argues in favor of any choice of arterial cannulation site, which makes us reject any superiority of one approach over the other in this regard.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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