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Review

Effects of four major brain protection strategies during proximal aortic surgery: A systematic review and network meta-analysis

Shulei Fan[a,c], Hongbo Li[a,b,d,e], Daoxin Wang[a,c], Chun Wu[b], Zhengxia Pan[b], Yonggang Li[b], Yong An[b], Gang Wang[b], Jiangtao Dai[b], Quan Wang[a,b,d,e,*]

[a] Chongqing Medical University, Chongqing, China
[b] Department of Cardiothoracic Surgery, Children's Hospital of Chongqing Medical University, Ministry of Education Key Laboratory of Child Development and Disorders, Chongqing, China
[c] Department of Respiratory Medicine, Second Affiliated Hospital of Chongqing Medical University, Chongqing, China
[d] China International Science and Technology Cooperation Base of Child Development and Critical Disorders, Chongqing, China
[e] Chongqing Key Laboratory of Pediatrics, Chongqing Medical University, Chongqing, China

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ABSTRACT

Background: Reliable brain protection during proximal aortic surgery remains a formidable surgical challenge. Various cerebral protection techniques have been used in the clinic; however, there is no consensus regarding which strategy is best. In this network meta-analysis (NMA), we focused on permanent neurological deficits (PND) and perioperative mortality associated with four major brain protection strategies used during proximal aortic surgery.
Methods: We performed a literature search of the MEDLINE, Embase, Cochrane Library and PubMed databases. The primary outcomes of this analysis were PND and perioperative mortality. Network rank and surface under the cumulative ranking curve (SUCRA) analyses were performed to evaluate and identify the superiority of different brain protection techniques.
Results: Thirty-two studies involving 6772 participants were included in this review. The number of studies that involved DHCA, DHCA + ACP, DHCA + RCP and MHCA + ACP were 16, 19, 23 and 15, respectively. Based on SUCRA analyses, moderate hypothermic circulatory arrest with antegrade cerebral perfusion (MHCA + ACP) was the best choice in terms of PND (predictive probabilities: 77.5), and deep hypothermic circulatory arrest with retrograde cerebral perfusion (DHCA + RCP) was the best choice in terms of mortality (predictive probabilities: 65.4). Deep hypothermic circulatory arrest (DHCA) alone was inferior to the other techniques in terms of both PND and mortality.
Conclusions: Effective cerebral perfusion should be actively considered. Retrograde perfusion (RCP) can reduce mortality and will not increase risks of PND compared with antegrade perfusion (ACP) when performing DHCA. Moderate hypothermia should be recommended when performing ACP. DHCA + RCP and MHCA + ACP seem to be appropriate brain protection strategies during proximal aortic surgery and more clinical studies involving pairwise comparisons between them are needed.

1. Introduction

Since Griepp and his colleagues first shared their 14-year experience on using hypothermic circulatory arrest (HCA) during aortic arch replacement in 1975 [1], various techniques, such as antegrade cerebral perfusion (ACP) [2] and retrograde cerebral perfusion (RCP) [3], have been performed to provide better cerebral protection during proximal aortic surgery. However, permanent neurological deficits (PND) and perioperative death are still not rare [4]. Deep hypothermic circulatory arrest (DHCA) alone, DHCA with ACP (DHCA + ACP), DHCA with RCP (DHCA + RCP) and moderate hypothermic circulatory arrest (MHCA) with ACP (MHCA + ACP) are four major brain protection strategies applied in the clinic. No conclusions have been drawn about which strategy is the best for brain protection. Pairwise comparisons are common [5], however, few studies have conducted multiple comparisons of all four strategies.

* Corresponding author. Department of Cardiothoracic surgery, Children's Hospital of Chongqing Medical University, Ministry of Education Key Laboratory of Child Development and Disorders, No.136, Zhongshan 2nd Road, Yuzhong Dis Chongqing, 400014, China.
E-mail address: 1024068781@qq.com (Q. Wang).

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Network meta-analysis (NMA) is a new method that employs Bayesian or frequency statistical theory. In this NMA, we were able to perform multiple comparisons and rank their effects. NMA involving both randomized controlled trials (RCTs) and observational cohort studies (OCS) were widely used recently [6]. Hence, we performed a systematic review and NMA of randomized and observational studies to increase our understanding of brain protection strategies during proximal aortic surgery.

2. Methods

2.1. Protocol and registration

This systematic review and meta-analysis was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [7] and the PRISMA Extension Statement for Reporting of Systematic Reviews Incorporating Network Meta-analyses of Health Care Interventions [8]. The study protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO, CRD42018094824). We published the protocol before [9] and provided a PRISMA-NMA Checklist and AMSTAR 2 Checklist.

2.2. Ethical approval statement

All analyses were based on previous published studies, thus no ethical approval or patient consent was required.

2.3. Eligibility criteria

The four brain protection strategies included in the NMA were DHCA, DHCA + ACP, DHCA + RCP and MHCA + ACP. DHCA was defined as initiation of circulatory arrest coinciding with a nasopharyngeal temperature of 14.1 °C–20 °C. MHCA was defined as circulatory arrest with a temperature of 20.1 °C–28 °C [10]. Proximal aortic surgery was defined as surgery of ascending aorta, aortic arch or proximal thoracic aorta [11].

2.4. Information sources and search strategy

We searched MEDLINE, Embase, the Cochrane Library database PubMed (through Dec. 2017) with the following combined text and Medical Subject Headings (MeSH) terms: Aorta, Thoracic (MeSH), Aorta (MeSH), circulatory arrest, cerebral perfusion, antegrade, hypothermic and retrograde. We considered all potentially eligible studies without language restrictions. We also performed hand searches of the bibliographies and internet searches of unpublished studies in the form of posters or abstracts.

2.5. Study selection

Three pairs of investigators (HL, SF, GW, JD, CW and PZ) independently reviewed the eligible scientific reports, extracted the data and assessed the quality of the studies. Any discrepancies were resolved by consensus and arbitration by a panel of investigators within the review team (QW, DW, YL and YA). Studies were included in the analyses if the following criteria were met: 1) they were RCTs or OCS; 2) they involved patients undergoing open proximal aortic surgery; 3) they used at least two of the four brain protection strategies mentioned above; and 4) at least one major outcome was clearly mentioned. Infants with congenital heart diseases such as transposition of great arteries (TGA) and interrupter aortic arch (IAA) were not included. Studies involving significant different incidence of preoperative neurological deficits between groups were not considered. Duplicate reports, reviews, letters with no exact data, meta-analyses and animal studies were excluded.

2.6. Data collection process and data items

EndNote and manual entry were used to merge the retrieved citations and eliminate duplicates. The following variables were extracted: author name(s), publication year, publication journal, study type, country where the study was conducted, methods of the brain protection strategies, preoperative neurological deficits, total sample size, operative time, disease type, mortality rates, incidence of PND and surgical approaches.

PND and mortality were the primary outcomes. PND were defined as persistent focal or global neurologic dysfunction (mainly stroke or coma), often accompanied by changes in brain imaging. Mortality was defined as death that occurred intraoperatively, within the same admission postoperatively, or by 30 days postoperatively.

2.7. Geometry of the network

Data for PND and mortality were obtained from individual studies, and risk ratios (RRs), weights, 95% confidential intervals (CIs) and 95% predicted intervals (PrI) were calculated. Network geometry was performed to show the interactions among the studies included in the NMA. The contributions of direct comparisons in the network were demonstrated in a contribution plot for the network.

2.8. Risk of bias within individual studies

The quality of OCS was independently evaluated by each investigator using the Newcastle-Ottawa quality assessment scale (NOS), and a final score greater than 6 was regarded as indicative of high quality [12]. Furthermore, ROBINS-I (Risk Of Bias In Non-randomized Studies of Interventions) was used to assess risk of bias in OCS [13]. The 2009 Updated Method Guidelines for Systematic Reviews in the Cochrane Back Review Group were used for quality assessment of RCTs, and studies were rated as having a “low risk of bias” when at least 6 of the 12 criteria were met [14].

2.9. Data synthesis and analysis

Inconsistencies in the NMA were evaluated with global and local approaches. The global approach via the Wald test was used to measure overall inconsistency. Loop and pairwise comparisons were used as local approaches to assess for inconsistency. A consistency model was used in the NMA only when inconsistency was not found by both global and local tests.

The pairwise treatment effect of NMA is shown in a network interval plot. Network rank and surface under the cumulative ranking curve (SUCRA) analyses were performed to evaluate and determine the superiority of different brain protection techniques.

2.10. Risk of bias across studies and quality of evidence for primary outcomes

A network funnel plot was created to check for publication bias in the NMA. The quality of evidence for the primary outcomes was assessed by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) for NMA [15].

2.11. Statistics

All analyses were performed with Stata (version 14.0, Stata Corp, College Station, TX, USA). A difference of $p < .05$ was considered to be statistically significant. The raw data and code are provided in the *Supplementary material.*

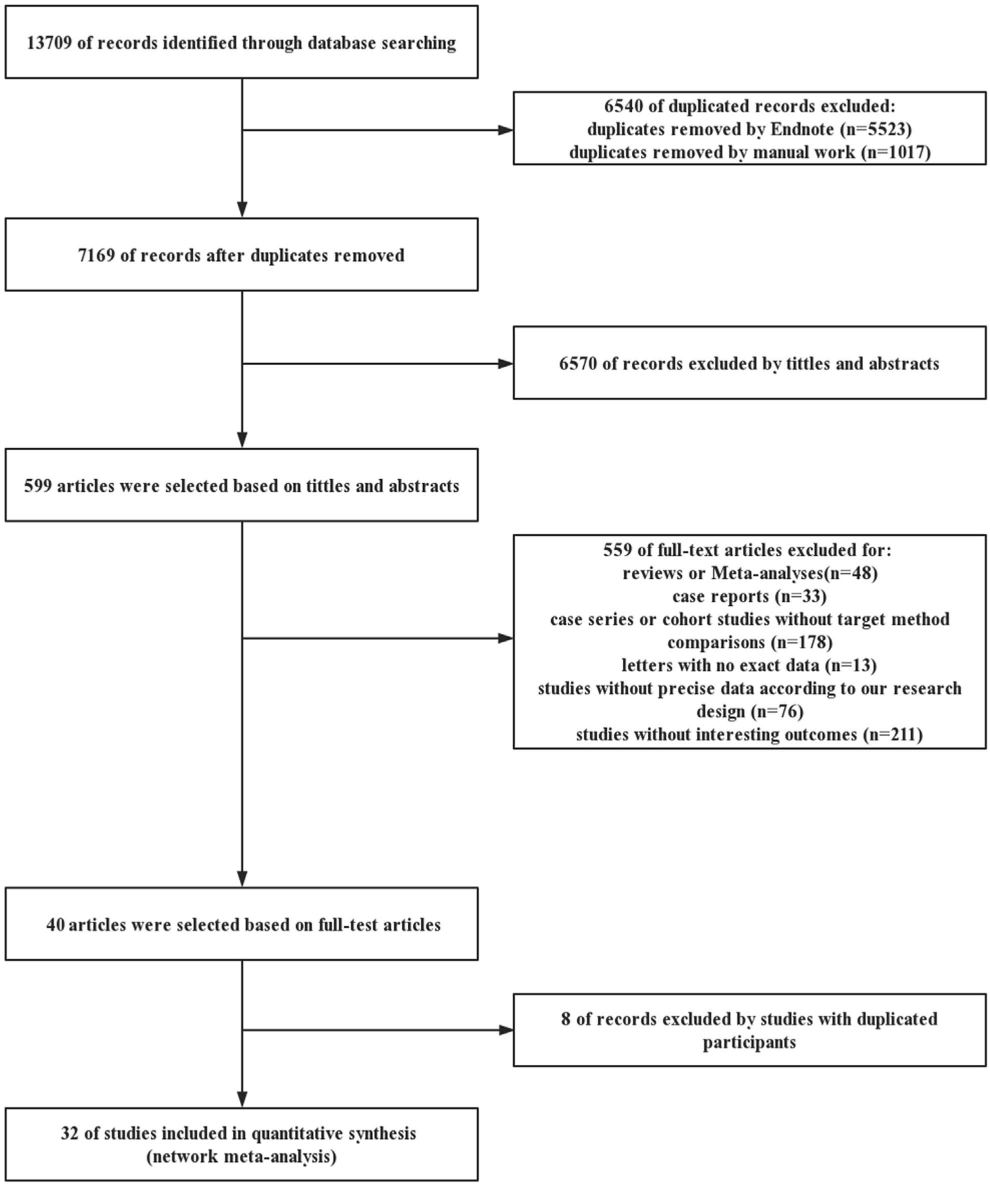

Fig. 1. Flow diagram of the search and screening process.

3. Results

3.1. Description of the included studies and the network

Overall, 13709 citations were identified by the search. Of these, 32 studies (3 RCTs and 29 OCS) involving 6772 participants were included (Fig. 1). The number of studies that involved DHCA, DHCA + ACP, DHCA + RCP and MHCA + ACP were 16, 19, 23 and 15, respectively. The details of the included studies were summarized in Table 1 and Table S1. Preoperative neurological deficits were shown in Table S2. The details of these comparisons were shown in Table S3. Fig. 2 showed the network of eligible comparisons for PND and mortality. Fig. S1 showed the contributions of pairwise comparisons in the NMA.

3.2. Assessment of risk of bias within studies

Quality assessments of OCS were performed with the NOS. All the studies had scores of at least 6 and were therefore recognized as high-quality observational studies (Table S4). The results of ROBINS-I showed that numbers of OCS which were recognized as low risk, moderate risk, and serious risk were 9, 11, and 9, respectively (Table S5). The 2009 Updated Method Guidelines for Systematic Reviews in the Cochrane Back Review Group were used to assess the quality of RCTs, and all the included studies met least 6 of the 12 criteria. Hence, they were recognized as high-quality studies (Table S6).

3.3. Assessment of inconsistency

Overall inconsistency was not observed in terms of PND (χ^2 = 6.310, p = .709) or mortality (χ^2 = 3.770, p = .806). No significant differences were observed in loop or pairwise comparisons of PND and mortality between direct and indirect results (Table S7 and Fig. S2). Hence, the consistency model of the NMA was used, and the results were reliable.

3.4. Network meta-analysis

In pairwise comparisons in the NMA, the three brain protection strategies with cerebral perfusion had lower RRs for PND and mortality than DHCA alone. In terms of the RRs for PND, MHCA + ACP were

Table 1
Basic information of included studies.

Study	Year	Journal	Study type	Country	Method	Total Sample size	Operation time	Disease type	Surgery type
Wu	2017	Perfusion	OCS	China	B vs D	109	2013–2014	M	Arch reconstruction
Kamenskaya	2017	J Extra Corpor Technol	RCT	Russia	A vs D	58	2011–2012	Type I chronic aortic dissection"	Ascending aorta and/or aortic arch replacement
Keeling	2017	Ann Thorac Surg	OCS	multiple	B vs D	1338	2000–2015	M	Total replacement
Ma	2016	Thorac Cardiovasc Surg	OCS	China	B vs D	99	2010–2013	Type A	Total replacement
Stamou	2016	Ann Cardiothorac Surg	OCS	USA	A vs C vs D	364	2000–2010	Type A	Total replacement
Vallabhajosyula	2015	Ann Thorac Surg	OCS	USA	C vs D	376	2008–2012	Aortic aneurysm	Hemiarch aortic reconstruction
Svensson	2015	J Thorac Cardiovasc Surg	RCT	USA	B vs C	121	2003–2010	M	Total replacement
Kaneko	2014	J Thorac Cardiovasc Surg	OCS	USA	A vs B vs C	467	2002–2012	M	Hemiarch aortic reconstruction
Widemann	2013	J Thorac Cardiovasc Surg	OCS	Austria	A vs C	238	1987–2011	AADA	Ascending aorta and/or aortic arch replacement
Calafiore	2013	Eur J Cardiothorac Surg	OCS	Saudi Arabia/ Italy	A vs B vs C	456	1988–2009	M	Ascending aorta and/or aortic arch replacement
Misfeld	2012	Ann Thorac Surg	OCS	Germany	A vs C	271	2003–2009	M	Arch reconstruction
Krahenbuhl	2010	Eur J Cardiothorac Surg	OCS	Switzerland	A vs B	145	2004–2007	M	N
Milewski	2010	Ann Thorac Surg	OCS	Italy	C vs D	776	1997–2008	M	Arch reconstruction
Matthew	2010	Aortic Symposium Meeting	OCS	USA	B vs C	37	2003–2007	Type A	N
Halkos	2009	J Thorac Cardiovasc Surg	OCS	USA	A vs D	271	2004–2007	M	Proximal thoracic aorta and/ or aortic arch replacement
Apaydin	2009	J Cardiothorac Surg	OCS	Turkey	A vs B vs C	132	1993–2006	M	Arch reconstruction
Apostolakis	2008	J Cardiothorac Surg	OCS	Greece	B vs C	48	1998–2006	AADA	Arch reconstruction
Kaneda	2005	Scandinavian Cardiovascular Journal	OCS	Japan	C vs D	37	1995–2003	M	Ascending aorta and/or aortic arch replacement
Zierer	2005	Thorac Cardiovasc Surg	OCS	Germany	C vs D	56	1999–2003	AADA	N
Harrington	2004	Circulation	RCT	UK	A vs D	42	2001–2003	M	N
Neri	2004	Ann Thorac Surg	OCS	Italy	A vs B vs C	48	1999–2003	M	N
Tan	2003	Ann Thorac Surg	OCS	Netherlands	A vs C vs D	126	1986–2001	AADA	N
Eusanio	2003	J Cardiothorac Surg	OCS	Netherlands	A vs D	289	1995–2001	M	Ascending aorta and/or hemiarch replacement
Matalanis	2003	Ann Thorac Cardiovasc Surg	OCS	Australia	A vs B vs C	62	1996–2000	M	N
Niinami	2003	J Cardiothorac Surg	OCS	Japan	B vs C	39	1985–2000	distal aortic arch aneurysm	N
Suat	2002	Med Sci Monit	OCS	Turkey	B vs C	23	1995–2002	M	Total replacement
Sinatra	2001	Ann Thorac Surg	OCS	Italy	A vs B vs C	85	1992–1998	AADA	N
Kitamura	2001	Ann Thorac Surg	OCS	Japan	C vs D	60	1997–1999	M	Total replacement
Usui	1999	Eur J Cardiothorac Surg	OCS	Japan	B vs C	166	1990–1996	AADA	N
ahn	1997	Cardiovasc Surg	OCS	Korea	A vs B vs C	47	1986–1994	Type A	N
Nakajima	1996	Eur J Cardiothorac Surg	OCS	Japan	C vs D	303	1977–1994	M	N
Kitamura	1995	Eur J Cardiothorac Surg	OCS	Japan	B vs C	83	1985–1993	aortic arch aneurysm	N

OCS: Observational cohort study, RCT: Randomized controlled trial, A: DHCA alone, B: DHCA + ACP, C: DHCA + RCP, D: MHCA + ACP, M: Mixed with aortic arch aneurysm and aortic dissection, Type I: aortic dissection type I (Debakey Classification), AADA: Acute aortic dissection type A (Stanford Classification), Type A: aortic dissection type A (Stanford Classification), Arch reconstruction: Partial or total arch replacement, N: Not clearly mentioned or multiple surgical methods.

lower than those of DHCA + ACP (RR: 0.83; 95% CI: 0.51–1.34, 95% PrI: 0.34–1.98, p = .477) and DHCA + RCP (RR: 0.80; 95% CI: 0.52–1.23, 95% PrI: 0.34–1.86, p = .269). In terms of the RRs for mortality, DHCA + RCP was the best choice (Fig. 3).

Cumulative probability plots and SUCRA analysis were performed to rank brain protection strategies in terms of PND and mortality. The two statistical analyses reached consistent results. Fig. 4A shows the ranks in the NMA with cumulative ranking probability plots. In terms of RRs for PND, MACA + ACP was the best choice, DHCA alone was the worst choice, and DHCA + ACP was not significantly different from DHCA + RCP. In terms of the RRs for mortality, the rankings were DHCA + RCP, MHCA + ACP, DHCA + ACP and DHCA alone from the best choice to the worst choice. Fig. 4B shows the cumulative ranking according to the SUCRA analysis. The larger the SUCRA value, the better the brain protection strategy was. In terms of PND, the SUCRA values for of DHCA, DHCA + ACP, DHCA + RCP and MHCA + ACP were 15.8, 55.8, 5.9 and 77.5, respectively. In terms of mortality, the SUCRA values of DHCA, DHCA + ACP, DHCA + RCP and MHCA + ACP were 1.3, 37.3, 96 and 65.4, respectively. After overall evaluation of PND and mortality, MHCA + ACP and DHCA + RCP seemed to be better brain protection strategies for patients undergoing proximal aortic surgery (Fig. 5).

3.5. Risk of bias across studies and quality of evidence for primary outcomes

Network funnel plots were created to check for publication bias in the NMA *(*Fig. S3*)*. Only a slight publication bias in terms of PND was observed after visually inspection using the criterion of symmetry.

As the NMA included both RCTs and OCS, we could not get exact quality levels of evidence for the primary outcomes. We provide the details of influence factors (Table S8).

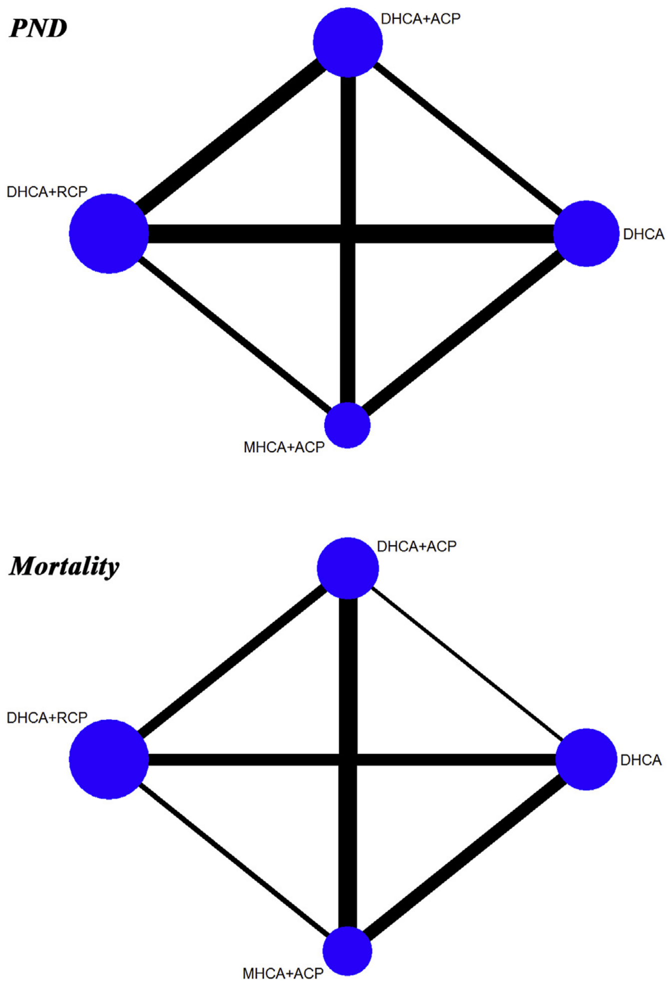

Fig. 2. Network meta-analysis of eligible comparisons. The width of the lines is proportional to the number of trials comparing every pair of treatments. The size of every circle is proportional to the number of participants (sample size).

4. Discussion

In 1975, Griepp reported his experience with prosthetic replacement of the aortic arch with HCA [1]. DHCA has achieved great success later, but some studies have indicated that DHCA alone might be insufficient. Animal studies showed that the cerebral metabolic rate at 20 °C was still 20% of the normal level and did not decrease significantly as the temperature continued to decline [16]. Clinical research showed that the safe length of time for DHCA ranged from 20 to 30 min [16–18]. Neurological deficits and mortality increased markedly after that time [19]. Hence, surgeons began to use cerebral perfusion techniques such as ACP and RCP combined with HCA to achieve better cerebral protection. Most recent studies have confirmed better effects of these techniques in terms of PND and mortality than of DHCA alone, especially in complex proximal aortic surgery [20]. Effective cerebral perfusion provides oxygen and substrates to the brain and protects against the effects of toxic waste due to ischaemia on the brain.

However, there were still some surgeons who thought DHCA alone was enough. They suggested that the majority of permanent neurologic injuries were due to strokes resulting from embolic phenomena and were not directly related to the method of cerebral protection used [21]. They provided evidence that DHCA alone was as safe as other adjunct complex cerebral protection techniques and allowed simplified surgery without additional risk [22]. In this NMA, HCA combined with cerebral perfusion showed a highly favourable effect on PND and mortality compared with DHCA alone. Effective cerebral perfusion should be actively addressed, as extra oxygenated blood flows into the brain, allowing adequate surgical time, especially during complex aortic arch surgeries, such as total replacement of the aortic arch. However, we must mention that cerebral perfusion is not necessary for all patients. If surgeons could finish the surgery in a short time, they may not need to perform cerebral perfusion. Putting a cannula inside a cerebral artery that can be diseased and the presence of valves in the cerebral venous territory make cerebral perfusion source of complications.

Considering the advantages of effective cerebral perfusion, surgeons began to look for the best cerebral perfusion technique. As a technique involving arterial cannulation, ACP supplies effective extra cerebral oxygen and might attenuate the cerebral metabolic deficits seen after HCA [23]. Surgeons can raise the nasopharyngeal temperature during circulatory arrest from deep hypothermia to moderate hypothermia with ACP to reduce the damage caused by excessively low temperatures. However, axillary artery cannulation with a second incision was reported to have potential complications associated with axillary artery exposure, including brachial plexus injury, haematoma formation, and axillary artery injury [24].

Because of the disadvantages of ACP, surgeons sought another simple cerebral perfusion technique. RCP via the superior vena cava was an easy technique with advantages of removing solid emboli from the arterial branches of the arch and avoiding any manoeuvres to the arch vessel, which can be atheromatic [25]. However, most clinical evidence has suggested that RCP is not superior to ACP in terms of PND [26]. Experimental studies have shown that the cerebral blood flow velocity and pulsatility index after post arrest cardiopulmonary bypass both decreased with RCP, and indicators of progressive ischaemic injury changed earlier with RCP than with ACP [27]. Another major problem with RCP was how much blood flow could enter the brain. An animal study of nonhuman primates revealed that 90% of the blood was shunted to the inferior caval vein (IVC), and less than 1% of the RCP inflow returned to the aortic arch [28]. In the NMA, DHCA + RCP was superior to DHCA + ACP in terms of mortality and not significantly different in terms of PND. RCP could lead to lower mortality because it is associated with less injury and shorter time of surgery, but the effectiveness of reducing PND with RCP during aortic arch surgery should be carefully reassessed.

The appropriate temperature during HCA + ACP was another important topic. The cerebral metabolic rate decreased more slowly with DHCA, and the cerebral blood flow supported by the autoregulatory system decreased considerably as the temperature decreased [29]. Hence, compared with MHCA, DHCA did not reduce the cerebral metabolic rate significantly but led to important changes in the autoregulatory system. DHCA increased inflammation, acidosis, vasospasm and ischaemia-reperfusion injury to a greater degree than MHCA [30]. Furthermore, DHCA requires more time for cooling and rewarming than MHCA. Moderate hypothermia also prevents the haemoglobin-oxygen dissociation curve from moving to the left, increasing the release of oxygen to the brain [31]. Animal experiments have shown that the consumption of energy stores in neurons during circulatory arrest and rewarming in DHCA was greater than that during circulatory arrest in MHCA [32]. Even though DHCA has many disadvantages, it is able to reduce the cerebral metabolic rate. Hence, these clinical comparisons were important. Recent studies including a high-quality multicentre study [10] confirmed the advantages of MHCA + ACP compared with DHCA + ACP. In the NMA, MHCA + ACP had better results in terms of PND and mortality than DHCA + ACP with cumulative ranking probability plots and SUCRA analysis. Considering this evidence, moderate hypothermia should probably be recommended when performing ACP.

We used two classical quality assessment tools (NOS and Method Guidelines for Systematic Reviews) and all the included studies passed the quality assessments. ROBINS-I and GRADE are new approaches to report the bias recommend by Cochrane Group. With the help of them, we truthfully and objectively reported the bias of the NMA. We

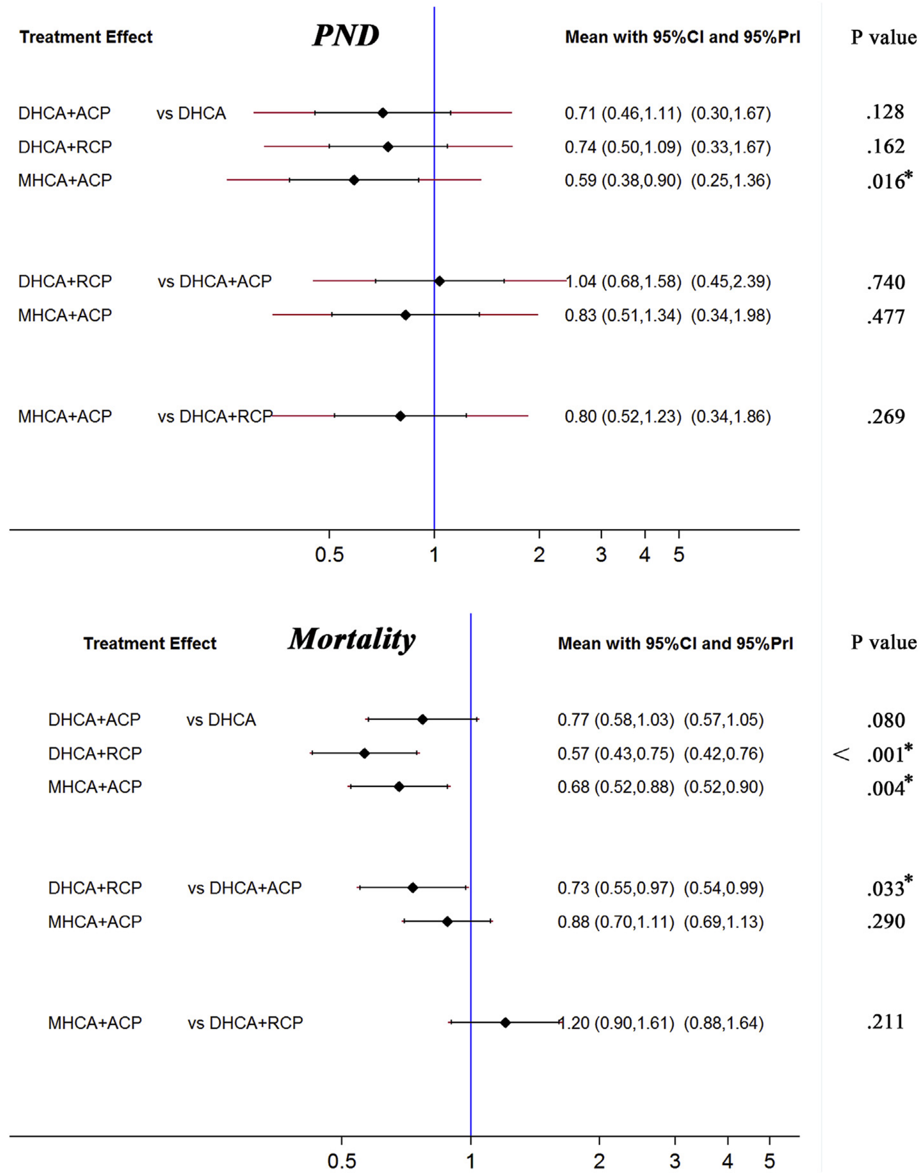

Fig. 3. Forest plot for pairwise comparisons in the network. CI: confidence interval; PrI: predicted intervals, "*": P value is less than 0.05.

declared that the potential bias of the NMA should not be ignored. We confirmed that there were no inconsistences in the NMA with 3 different methods, and the publication bias was slight.

Some limitations of this study should be mentioned. First, most of the included studies were OCS other than RCTs. Second, heterogeneity caused by combination of different centers, surgeons and mixture of different pathologies should not be ignored. The study put together patients with acute aortic dissections and with elective surgery on the aortic arch. However, the randomization as such patients might be extremely complex, considering the heterogeneity of this cohort that could include aneurysm and dissection, old atherosclerotic and young connective tissue disorders, means very different patients. We must point out that surgeons should select method by their own wills because each of them works perfectly in the hands of a specific surgeon, but not necessarily in the hands of another one.

However, to our knowledge, this is the first NMA to include a systematic review of brain protection strategies during proximal aortic surgery. From the results of the NMA, DHCA + RCP and MHCA + ACP seem to be appropriate brain protection strategies during proximal aortic surgery and more clinical studies involving pairwise comparisons between them are needed. Further studies involving evaluation of powerful tool such as delayed rewarming should be performed.

5. Conclusions

Effective cerebral perfusion should be actively considered. Retrograde perfusion (RCP) can reduce mortality and will not increase risks of PND compared with antegrade perfusion (ACP) when performing DHCA. Moderate hypothermia should be recommended when performing ACP. DHCA + RCP and MHCA + ACP seem to be appropriate brain protection strategies during proximal aortic surgery and more clinical studies involving pairwise comparisons between them are needed.

Ethical approval

The study was performed based on published data. More ethical approval was not needed. The study protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO, CRD42018094824). Furthermore, we published the protocol. The protocol was cited as ***Fan S, Wang D, Wu C, Pan Z, Li Y, An Y et al. Effects of 4 major brain protection strategies during aortic arch surgery: A***

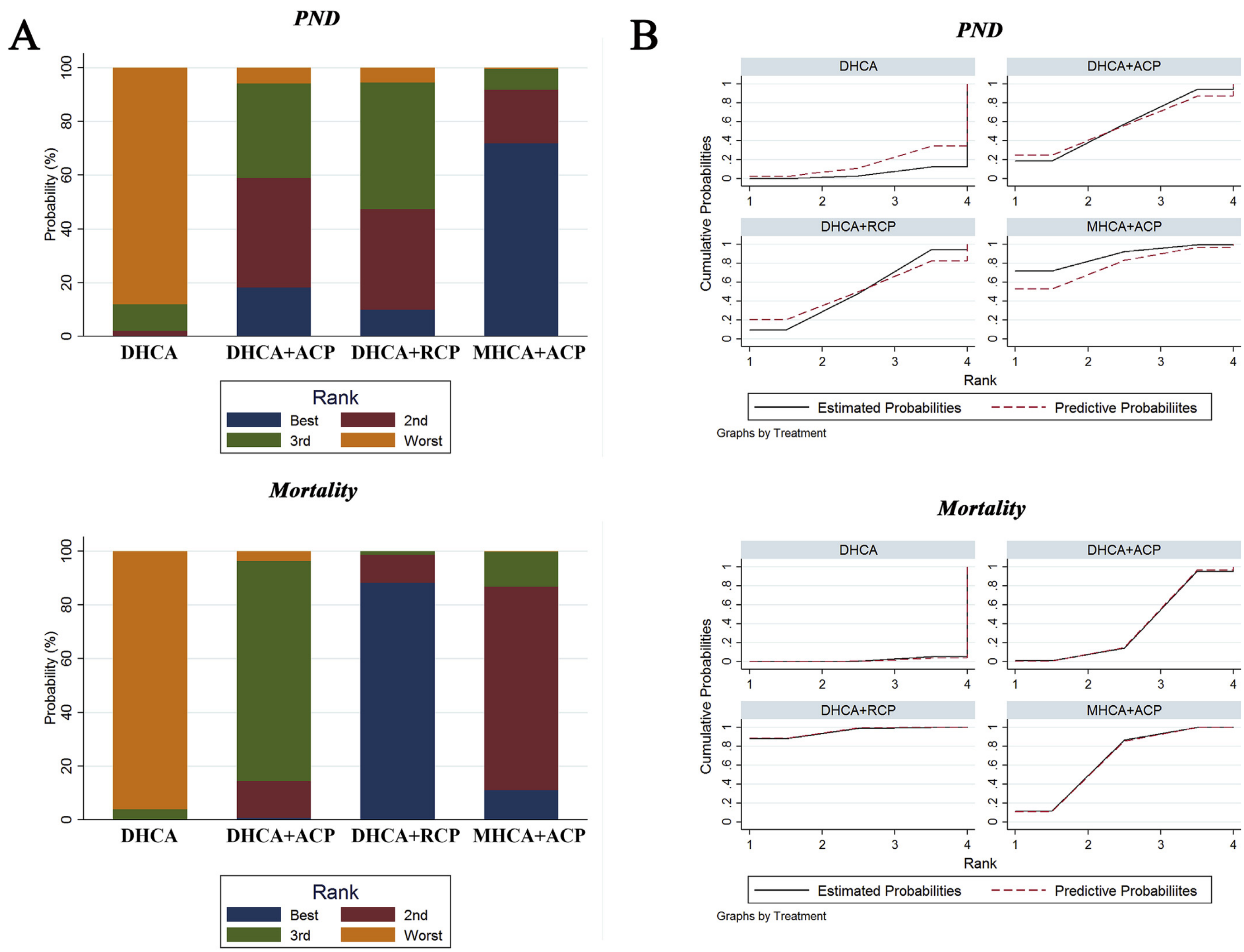

Fig. 4. A: Bar plots for ranking the probabilities of treatment. The horizontal axis shows the possible rank of each treatment (from best to worst, according to the outcome). The size of each bar corresponds to the probability of each treatment being at a specific rank. Fig. 4B: Cumulative ranking probability plots. The horizontal axis shows the possible rank of each treatment (from best to worst, according to the outcome). The vertical axis shows the cumulative probability for each treatment to be the best option, between the best two options, among the best three options, and so on.

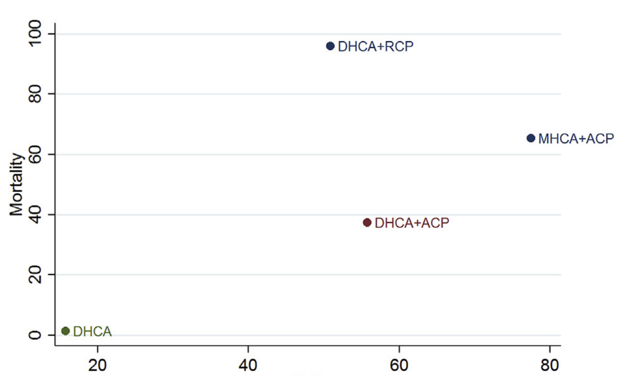

Fig. 5. Ranking of mortality and PND by SUCRA. The larger the SUCRA value, the better the result.

protocol for a systematic review and network meta-analysis using Stata. Medicine 2018;97:e11448.

Sources of funding

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Author contribution

Shulei Fan: conceptualization, methodology, validation.

Hongbo Li: validation, formal analysis, investigation, resources, writing original draft preparation.

Daoxin Wang: investigation, visualization.

Chun Wu: investigation, data curation.

Zhengxia Pan: investigation, data curation.

Yonggang Li: investigation, data curation.

Yong An: investigation, supervision, funding acquisition.

Gang Wang: investigation.

Jiangtao Dai: investigation.

Quan Wang: conceptualization, methodology, software, formal analysis, resources, writing review, editing.

Conflicts of interest

None.

Research registration unique identifying number (UIN)

The study protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO, CRD42018094824). https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=94824.

Guarantor

Quan Wang.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Data statement

We provided complete raw data in the supplemental materials.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijsu.2019.01.009.

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