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Original Scientific Paper

UNILATERAL ANTEGRADE CEREBRAL PERFUSION VERSUS DEEP HYPOTHERMIC CIRCULATORY ARREST DURING ACUTE AORTIC DISSECTION REPAIR: A SINGLE CENTER EXPERIENCE

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SUMMARY – Introduction: The gold standard of circulation strategy and arterial cannulation during acute aortic dissection is still indisputable. Unilateral/bilateral antegrade cerebral perfusion (UACP/BACP) and deep hypothermic circulatory arrest (HCA) remains a safe and useful procedure for circulation during management of acute aortic dissection. The aim of our study was to investigate the effectiveness of both unilateral antegrade cerebral perfusion and deep hypothermic circulatory arrest on postoperative outcomes during management of acute aortic dissection repair at our center.

Methods: Our prospective study consisted of 26 patients who underwent acute aortic dissection repair with various circulation strategy. Group A consisted of 14 (53.8%) patients who were operated on under unilateral antegrade cerebral perfusion, while group B consisted of 12 (46.2%) patients who were operated on under deep hypothermic circulatory arrest without cerebral perfusion. Postoperative outcomes included mortality, drainage, blood transfusion (free frozen plasma, erythrocyte suspension), ventilation time and revision due to bleeding.

Results: The average age of our study population was 55.2 ± 16.2 (range 33-83) years. Mortality was observed in 3 (11.5 %) of our patients. There was no significant difference between the groups in terms of mortality and revision due to bleeding ($p > 0.05$). Blood transfusion (erythrocyte suspension and free frozen plasma), drainage and ventilation time were significantly lower in Group A compared with Group B ($p > 0.05$).

Conclusion: Both unilateral antegrade cerebral circulation and deep hypothermic circulatory arrest can be safely used during acute aortic dissection, although unilateral antegrade cerebral circulation has proved to be superior over deep hypothermic circulatory arrest with good postoperative outcomes.

Key words: *acute aortic dissection; unilateral antegrade cerebral perfusion; deep hypothermic circulatory arrest; postoperative outcomes*

Introduction

Acute aortic dissection is associated with a high mortality of more than 50% when it remains un repaired within 48 hours after its onset[1]. Advancements in new techniques for circulation strategy in the management of acute aortic dissection repair has resulted in tremendous improvements, leading to improved outcomes with low morbidity and mortality[2-4]. Despite these improvements, the optimal strategy for circulation during management of acute aortic dissection remains debatable. Some studies have reported better outcomes with their circulation protocol and arterial cannulation strategy for management of acute aortic dissection repair. Our study was aimed at investigating the effectiveness of both UACP and deep HCA on postoperative outcomes during management of acute aortic dissection repair at our center.

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Patients and Methods

Our study was approved by the ethical committee of our hospital. This study was conducted in accordance with the Declaration of Helsinki. The data of all 26 patients who underwent aortic repair due to acute aortic dissection from March 2017 to December 2019 were obtained from our hospital database. Our study population was divided into two groups. Group A consisted of 14 (53.8%) patients who had undergone UACP during acute aortic dissection repair, while Group B consisted of 12 patients who had deep hypothermic circulatory arrest during acute aortic dissection repair. Arterial cannulation was performed through the axillary artery or right common femoral artery. For group A, hypothermia was temperatures above 26 ˚C while for group B it was temperatures between 18 and 22 ˚C. All preoperative, peroperative and postoperative parameters were recorded and evaluated (Table 1). Postoperative outcomes included postoperative mortality,

Table 1. General characteristics

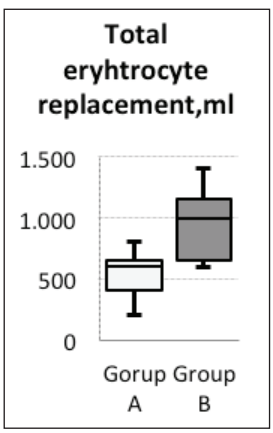
		Min-Max			Median	Mean±sd/n-%		
Age		33.0	-	83.0	52.5	55.2	±	16.2
Gender	Female					17		65.4%
	Male					9		34.6%
HT, n	(-)					6		23.1%
	(+)					20		76.9%
DM, n	(-)					9		34.6%
	(+)					17		65.4%
Aortic Dissection	Type I					19		73.1%
	Type II					7		26.9%
Surgery								
AAR						8		30.8%
AAR+Hemiarch						10		38.5%
Bentall						2		7.7%
Bentall+hemiarch						4		15.4%
Bentall+hemiarch+CABG1						2		7.7%
Total CPB, minutes		85.0	-	200.0	156.0	150.8	±	34.5
Cross clamping time, minutes		48.0	-	102.0	86.0	80.5	±	16.6
Circulatory Arrest, minutes		1.0	-	19.0	14.5	12.7	±	6.1
ICU stay, days		2.0	-	20.0	4.0	5.0	±	3.7
Hospital stay, days		0.0	-	10.0	5.0	5.0	±	2.5
Total eryhtrocyte replacement, mL		200.0	-	1400.0	600.0	730.8	±	288.1
Total FFP used, mL		2.0	-	6.0	3.5	3.4	±	1.2
Total drainage, mL		100.0	-	1750.0	900.0	896.2	±	388.8
Ventilation time, hours		8.0	-	288.0	26.0	41.0	±	59.2
Revision Due to Bleeding, n	(-)					21		80.8%
	(+)					5		19.2%
Mortality, n	(-)					23		88.5%
	(+)					3		11.5%
Cannulation								
Right axillary artery+RA						14		53.8%
Right femoral artery+RA						12		46.2%

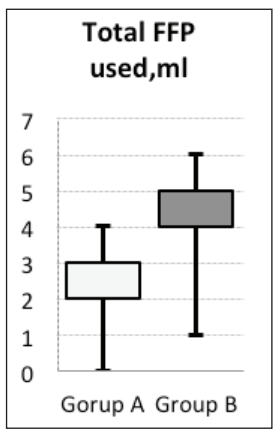
HT-hypertension, DM-diabetes Mellitus, ICU-intensive care unit, AAR-ascending aortic replacement, CABG-coronary artery bypass grafting, RA-right atrium

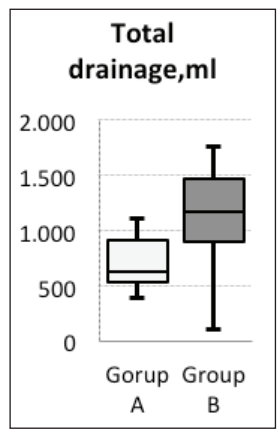
Table 2.

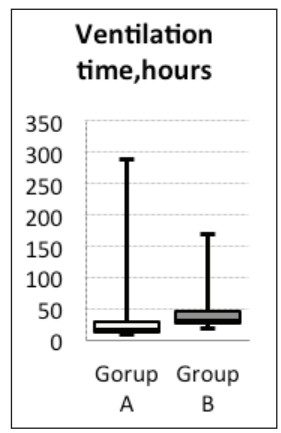
		Group A			Group B			P
		Mean±sd/n-%		Median	Mean±sd/n-%		Median	
Age		52.4 ± 16.4		46.5	58.5 ± 16.0		63.0	0.382 [m]
Gender	Female	9	64.3%		8	66.7%		0.899 [X²]
	Male	5	35.7%		4	33.3%		
HT,n	(-)	3	21.4%		3	25.0%		0.829 [X²]
	(+)	11	78.6%		9	75.0%		
DM,n	(-)	5	35.7%		4	33.3%		0.899 [X²]
	(+)	9	64.3%		8	66.7%		
Aortic Dissection	Type I	11	78.6%		8	66.7%		0.495 [X²]
	Type II	3	21.4%		4	33.3%		
Surgery								
AAR		4	28.6%		4	33.3%		0.793 [X²]
AAR+Hemiarch		5	35.7%		5	41.7%		0.756 [X²]
Bentall		2	14.3%		0	0.0%		0.483 [X²]
Bentall+hemiarch		1	7.1%		3	25.0%		0.306 [X²]
Bentall+hemiarch+CABG1		2	14.3%		0	0.0%		0.483 [X²]
Total CPB,minutes		157.4 ± 29.0		164.5	143.0 ± 39.9		151.0	0.680 [m]
Cross clamping time,minutes		85.8 ± 14.7		89.0	74.3 ± 17.0		80.5	***0.030*** [m]
Circulatory Arrest,minutes		13.1 ± 5.6		14.0	12.2 ± 6.9		15.0	0.979 [m]
ICU stay,days		5.5 ± 4.8		4.0	4.5 ± 1.9		4.0	0.979 [m]
Hospital stay,days		5.1 ± 2.2		5.0	4.8 ± 2.9		5.0	0.832 [m]
Total eryhtrocyte replacement,ml		557 ± 179		600	933 ± 261		1000	***0.001*** [m]
Total FFP used,ml		2.6 ± 0.8		2.0	4.4 ± 0.8		4.0	***0.000*** [m]
Total drainage,ml		711 ± 223		625	1113 ± 436		1175	***0.006*** [t]
Ventilation time,hours		37.4 ± 72.6		16.5	45.3 ± 41.4		32.0	***0.009*** [m]
Revision Due to Bleeding,n	(-)	13	92.9%		8	66.7%		0.091 [X²]
	(+)	1	7.1%		4	33.3%		
Mortality,n	(-)	13	92.9%		10	83.3%		0.580 [X²]
	(+)	1	7.1%		2	16.7%		

[t] t test / [m] Mann-whitney u test / [X²] Chi-square test (Fischer test)









drainage, blood transfusion, ventilation time and revision due to bleeding. The two groups were compared in terms of postoperative outcomes (Table 2).

Surgical technique

All patients were operated on under general anesthesia. Arterial cannulation was performed through the right axillary artery or femoral artery based on the patient's hemodynamic status or easier access. Venous cannulation was performed through the right atrium or the femoral vein. After initiation of CPB, all patients were cooled to core body temperature ranging from 18 to 26 degree Celsius, depending on what type of acute aortic dissection repair or strategy of circulation was selected for a particular patient. UACP was applied in patients in whom arterial cannulation was performed through the axillary artery, whereas deep HCA was applied in patients in whom arterial cannulation was performed through the femoral artery. Axillary cannulation was performed through a 6 mm dacron tupe graft sewn end-to-end to the right axillary artery. Sternotomy was performed, and CPB was initiated. When target temperature was achieved, either UACP or deep HCA was initiated. The dissected aorta was opened, and antegrade cold blood cardioplegia (for every 20 minutes) was delivered through coronary ostia to allow diastolic cardiac arrest. Usually, we repaired the distal part of aorta before hemiarch or total arch replacement, wherein cross clamping was applied on a graft to initiate CPB. Initiation of CPB was accompanied by re-warming to achieve normal body temperature, while repairing the proximal part of the dissecting aorta (including the aortic root and aortic valve if necessary).

Statical analysis

Mean, standard deviation, median, minimum, maximum value frequency and percentages were used for descriptive statistics. The distribution of variables was checked using the Kolmogorov-Simirnov test. Independent Samples T test and the Mann-Whitney U test were used for the comparison of quantitative data. Chi-Square test (Fischer exact test) was used for the comparison of qualitative data. SPSS 26.0 was used for statistical analysis.

Results

The general features of our study group are summarized in Table 1. There were no differences in age, gender, hypertension, diabetes mellitus, ICU stays, hospital stay and mortality between the groups. Surgical mortality throughout the study was observed to be 11.5%. The revision rate was 19.2%. Ascendant aortic replacement (AAR) was performed in 30.8% of patients, AAR with hemiarch was performed in 38.5%, the Bentall procedure was performed in 7.7%, the Bentall procedure with hemiarch was performed in 15.4%, and the Bentall procedure with hemiarch with single vessel CABG was performed in 7.7% of our study population.

Cross clamping time in group A was significantly higher than in group B ($p < 0.05$) (Table 2). Total erythrocyte replacement in group A was significantly lower than in group B ($p < 0.05$). Total FFP in group A was significantly lower than in group B ($p < 0.05$). Total drainage in group A was significantly lower than in group B ($p < 0.05$). Ventilation time in group A was significantly lower than in group B ($p < 0.05$). The rate of revision due to bleeding did not differ significantly between group A and group B ($p > 0.05$). Mortality rate did not differ significantly between the groups ($p > 0.05$), although group B had a higher mortality rate (16.7%) compared with group A (7.1%) (Table 2).

Discussion

Recent developments in science and in the field of medicine have produced to guidelines to overcome catastrophes associated with aortic dissection. Despite of these tremendous developments, there are still many morbidities and mortality associated with surgical aortic dissection repair[5,6]. Aortic dissection repair is very challenging in terms of decision on what type of cerebral perfusion strategy is required and suitable sites for arterial cannulation during the procedure.

In our study, we retrospectively analysed our center's data on aortic dissection repair with a preference for cerebral perfusion strategy that may have effects on postoperative mortality, blood transfusion, ventilation time, bleeding and revision. Our results suggests that moderate hypothermia with unilateral antegrade cerebral perfusion is associated with positive postoperative outcomes (lower mortality, blood transfusion, drainage, revision and shorter ventilation time) compared with deep hypothermic circulatory arrest without cerebral perfusion.

Right axillary artery cannulation has demonstrated better results compared with femoral artery cannulation[7]. Right axillary artery cannulation can be easily

converted to UACP by clamping the proximal part of the innominate artery during circulatory arrest. This makes it reliable and reproducible, with positive postoperative outcomes. Due to cerebral perfusion during the procedure, deep hypothermia is not necessary, which protects the patients from coagulopathy complications that may lead to severe postoperative bleeding, massive blood transfusion and, obviously, subsequent surgical revisions. Some authors have reported low postoperative stroke due to antegrade flow of cerebral perfusion[8]. Although there was no significant difference between our study groups in terms of mortality due to the low number of our study participants, mortality in the UACP group was lower than mortality in the deep HCA group (7.1% versus 16.7%) (Table 2). Many publications have reported mortality ranging from 5% to 12% and a stroke rate ranging from 4.2% to 11.0%[9-11] in patients who had moderate unilateral antegrade cerebral perfusion.

Many studies have demonstrated that UACP is more advantageous compared with deep HCA. UACP limits CPB and also avoid negative effects of deep hypothermia. Deep hypothermia is associated with coagulopathy, which may result in massive blood transfusion as reported by a study performed by Algarni et al.[12]. In our study, deep hypothermia was associated with massive blood transfusion, compared with moderate hypothermia in patients who received UACP.

Coagulopathy disorders and bleeding have been reported to be higher in patients with acute aortic dissection[13]. The circulation strategy during aortic repair may help us tackle these coagulopathy disorders by avoiding deep hypothermia, which may increase the severity of coagulopathy. Our study demonstrated an increase in bleeding in patients who received deep HCA during acute aortic dissection repair compared with patients who received UACP. This resulted in an increase in drainage and revision, which may be related to poor postoperative outcomes such as increase in hospitalization, ventilation period and ICU stay.

Mortality and poor neurologic outcomes have been reported to be low in patients who receives UACP[14]. Although there were no significant difference in terms of mortality between groups in our study due to the low number of patients, a neurologic event was observed in one patient of our study group who had received deep HCA without cerebral perfusion during acute aortic dissection repair. We believe that this cerebral perfusion strategy during aortic repair under moderate hypothermia is superior to the deep hypothermic strategy during circulatory arrest with good postoperative brain functions.

Our low study population number is a limitation of this study due to the fact that our center is small, with few surgeons and few cases of acute aortic dissection. The non-randomized nature of the study is also a limitation. A large number of patients in multicenter studies may be required to confirm the best strategy cerebral protection during acute aortic dissection repair.

Conclusion

Our study has clearly demonstrated that UACP is a good strategy for circulation arrest during aortic dissection repair, with good postoperative results in terms of mortality, bleeding, blood transfusion, ventilation time and revision. We are also convinced that cannulation through right axillary artery during aortic dissection repair is much more advantageous in comparison with femoral artery cannulation during aortic dissection, as it provides more effective and reliable antegrade cerebral perfusion.

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Sažetak

UNILATERALNA ANTEGRADNA CEREBRALNA PERFUZIJA NASPRAM DUBOKOG HIPOTERMIJSKOG CIRKULATORNOG ARESTA TIJEKOM POPRAVKA AKUTNE DISEKCIJE AORTE: ISKUSTVO JEDNOG CENTRA

M. Karaçalılar i *M. Kyaruzi*

Uvod: Zlatni standard cirkulatorne strategije i arterijske kanulacije za akutnu disekciju aorte i dalje je neupitan. Unilateralna/bilateralna cerebralna perfuzija (UACP/BACP) i duboki hipotermijski cirkulatorni arest (HCA) i dalje su siguran i korisni postupci za cirkulaciju tijekom liječenja akutne disekcije aorte. Cilj ove studije bio je istražiti učinkovitost unilateralne antegradne cerebralne perfuzije i dubokog hipotermijskog cirkulatornog aresta na postoperativne ishode tijekom liječenja akutne disekcije aorte u našem centru.

Metode: Naša se prospektivna studija sastojala od 26 pacijenata koji su bili podvrgnuti popravku akutne disekcije aorte uz primjenu različitih cirkulatornih strategija. Skupina A sastojala se od 14 (53,8%) pacijenata koji su operirani pod unilateralnom antegradnom cerebralnom perfuzijom, dok se skupina B sastojala od 12 (46,2%) pacijenata koji su operirani pod dubokim hipotermijskim cirkulatornim arestom bez cerebralne perfuzije. Postoperativni ishodi uključivali su smrtnost, drenažu, transfuziju krvi (slobodna smrznuta plazma, suspenzija eritrocita), vrijeme na ventilatoru i reviziju uslijed krvarenja.

Rezultati: Prosječna dob studijske populacije bila je 55,2 ± 16,2 (raspon 33-83) godina. Smrtnost je zabilježena u 3 (11,5%) pacijenta. Nije bilo značajne razlike među skupinama glede smrtnosti i revizije uslijed krvarenja ($p > 0,05$). Transfuzije krvi (suspenzija eritrocita i slobodna smrznuta plazma), drenaža i vrijeme na ventilatoru bili su značajno niži u skupini A u usporedbi sa skupinom B ($p > 0,05$).

Zaključak: Unilateralna cerebralna perfuzija i duboki hipotermijski cirkulatorni arest sigurne su metode za korištenje kod akutne disekcije aorte, iako se unilateralna cerebralna perfuzija pokazala boljom od dubokog hipotermijskog cirkulatornog aresta uslijed dobrih postoperativnih ishoda.

Ključne riječi: *akutna disekcija aorte; unilateralna cerebralna perfuzija; duboki hipotermijski cirkulatorni arest; postoperativni ishodi*