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Research Article

Comparison of Outcome of Total Arch Replacement for Type A Aortic Dissection using Trifurcated Branch Graft vs Island Technique- A Single Centre Experience

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Abstract

Objective

To compare the outcome between trifurcated graft vs island technique for the treatment of type A aortic dissection in a single centre.

Method

From september 2017 to september 2020, we studied 87 patients retrospectively, who underwent total arch replacement for type A aortic dissection. Out of which 51 patients, age (47.45 ± 10.47) years, 39(76.47%) males and 12 (23.52%) females were surgically corrected by trifurcated branch graft technique and 36 patients age (52.75 ± 10.32) years, 27 (75%) males and 9 (25%) females with island technique. In both the groups, peri- operative outcomes were compared. Patients were followed up for 3 months and 6 months in both the groups.

Result

Elective Surgery was done in 16 (31.37%) and 6 (16.66%) in trifurcated branch graft and island group respectively. Selective antegrade cerebral perfusion (SACP) was given by the Axillary artery in {48 (94.11%) in trifurcated group and 3 (8.33%) in island group, p=<.00001}.SACP was given by Innominate artery {5 (9.83%) in trifurcated group and 33 (91.66%)

in island group, p=<.00001}. Trifurcated branch group and Island group had Cardiopulmonary Bypass time, cross clamp time, total circulatory arrest time of (245 ± 33.30), (117.62 ± 29.38), (54.33 ± 13.19) min and (195.88 ± 32.83), (70.11 ± 20.62), (33.52 ± 8.683) (p=<.00001); respectively. 30 day mortality was 5(9.83%) in trifurcated group and 3 (8.33%) in island group (p=0.815).

Conclusion

Trifurcated branched graft and island technique, have comparable results, only prerequisite being surgeons comfortability and experience. Trifurcated branch graft being associated with longer CPB, cross clamp and circulatory arrest time, but with no difference in overall adverse outcomes or mortality.

Keywords: Total arch replacement; Type A dissection; Trifurcated branch graft; Island technique

1. Introduction

Acute Type A Aortic Dissection Surgery is one the most challenging and lethal surgery in the cardiovascular domain, it has a very high morbidity and high mortality [1]. There are many surgeries described in the literature. Although there is no single optimal technique for type A aortic dissection, mostly commonly done surgical procedures done for total arch replacement are trifurcated branch graft technique and island (en bloc) technique [2,3]. These surgeries no doubt demand a certain higher level of experience and expertise from the cardiac surgeons. There are very few articles in literature comparing the perioperative and early outcomes. Here, we retrospectively study the peri- operative and early outcomes of two surgical techniques done in a single centre. We aim to show the comparative peri-operative outcomes and differences in operative mortality between two groups.

2. Materials and methods

The present study was conducted in a single centre, "The First Affiliated Hospital of Zhengzhou University" China. This retrospective study was approved by our local ethics committee, and individual patient consent was taken.

2.1 Patient selection

In this study, we took a total of 87 patients who underwent surgery for Type A Aortic Dissection from September 2017 to September 2020. Out of which Group A, n=51 patients were surgically corrected by Trifurcated branch graft technique, with mean age 47.45 ± 10.47 years, {39 (76.47%) males and 12 (23.52%) females} and Group B, n=36 patients with island (en bloc) technique mean age 52.75 ± 10.32 years {27 (75%) males and 9 (25%) females}. Moderate to Severe hypothermic circulatory arrest with temperature drift between 25-32°C with selective antegrade cerebral perfusion (SACP) through axillary artery in 51 (58.62%) patients and direct brachiocephalic cannulation in 38 (43.62%) patients was used. Other concomitant procedures were done as needed. 2 (3.92%) patients in group A, had undergone previous cardiac surgery. 5 (9.80%) and 3 (8.33%) patients had Marfan syndrome in group A and group B respectively. Elective surgery was done in 22 (25.28%) patients {16 (31.37%) in group A and 6 (16.66%) in group B} while emergency surgery was done in 65 (74.71%) patients {35 (68.62%) in group A and 30 (83.33%) in group B}. Primary intimal tear was found in ascending aorta in 79 (90.80%) patients {45 (88.32%) and 34 (94.44%) in group A and B respectively, (p=0.323, ns)}. Innominate artery and carotid artery involvement was seen in 8 (9.19%) patients {5 (9.80%) and 3 (8.33%) in group A and B respectively}. Descending aorta was stented i.e frozen elephant trunk, in 85 (97.70%) patients. Preoperative

variables are given in table 1 below.

Variable	Total Both Cohort (n=87)	Trifurcated Branched Graft group (n = 51)	Island (En bloc) group (n = 36)	p Value
Age (year)	49.64 ± 10.67	47.45 ± 10.47	52.75 ± 10.32	0.01
Male	66(75.86%)	39(76.47%)	27(75%)	0.874
Female	21(24.13%)	12(23.52%)	9(25%)	0.874
Height (cm)	172.9 ± 5.6	173.82 ± 4.53	70.14 ± 7.16	0.032
Weight (kg)	70.86 ± 8	71.37 ± 8.6	70.14 ± 7.16	0.241
BMI (kg/m^2)	23.67 ± 1.91	23.61 ± 2.3	23.76 ± 1.18	0.357
BSA (m^2)	1.84 ± 0.13	1.85 ± 0.13	1.82 ± 0.13	0.17
LVEF (%)	54.9 ± 5.74	55.6 ± 5.8	52.36 ± 5.89	0.082
Associated Comorbidities				
Hypertension	38(43.67%)	23(45.09%)	15(41.66%)	0.75
Diabetes Mellitus	4(4.59%)	3(5.88%)	1(2.77%)	0.495
Coronary artery disease	5(5.74%)	4(7.84%)	1(2.77%)	0.317
Renal Dysfunction	2(2.29%)	2(3.92%)	0	0.509
Neurological Deficit	3(3.44)	3(5.88%)	0	0.263
Previous Cardiac Surgery	2(2.29%)	2(3.92%)	0	0.509
Marfan Syndrome	8(9.19%)	5(9.80%)	3(8.33%)	0.815
COPD	5(5.74%)	2(3.92%)	3(8.33%)	0.383
Timing of Surgery				
Elective	22(25.28%)	16(31.37%)	6(16.66%)	0.12
Emergency	65(74.71%)	35(68.62%)	30(83.33%)	0.12
Primary Tear				
Ascending Aorta	79(90.80%)	45(88.32%)	34(94.44%)	0.323
Arch of Aorta	8(9.19%)	6(11.76%)	2(5.55%)	0.323
Arch involvement	85(97.70%)	49(96.07%)	36(100%)	0.509
Innominate/Carotid involvement	8(9.19%)	5(9.80%)	3(8.33%)	0.815

Table 1: Pre-operative data and variables

2.2 Surgical technique

A routine standard median sternotomy approach was done for all the cases in this study. Cardiopulmonary bypass was established after heparinization, using axillary cannulation in 48 (94.11%) patients in group A and 3 (8.33%)patients in group B, innominate artery cannulation for 5 (9.83%) patients in group A and 33 (91.66%) patients in group B, femoral artery cannulation and right atrium cannulation was done in all the cases. Left ventricle was vented through the left superior pulmonary vein in all the cases. Direct Antegrade cardioplegia through coronary ostia was given in all the cases for both the groups. We used Del Nido cardioplegia for all patients for myocardial

protection. Retrograde cardioplegia in addition to antegrade cardioplegia was used in 2 cases in Group A patients. All the patients were operated under moderate to severe hypothermic circulatory arrest with temperature drift between 22°C to 32°C.

2.3 Trifurcated Branch Graft technique

A four branched prefabricated aortic graft was used, with three branches for the supra aortic vessel anastomosis and one for arterial perfusion. The exact length and orientation for distal anastomosis depended on the surgeon's experience and varied from patient to patient. After arresting the heart, the trifurcated graft was cutted and trimmed according to respective patients' aorta size and 3 vessel orientation. Ascending aorta and all three supra aortic vessels were disconnected and clamped. Direct visual insertion of frozen elephant trunk (stent) for distal arch descending aorta was done in all the patients. Distal anastomosis of the trifurcated branched graft with the stented mount was done under deep hypothermic circulatory arrest with selective antegrade perfusion to the brain through the axillary artery with 10 ml/kg.min. Innominate artery anastomosis to one of the branches of the graft was done. After deairing, Innominate artery clamp was released and anterograde circulation was initiated through the fourth arm of the branched graft. Consequently, left common carotid and left subclavian anastomosis was done and respective clamps were released after deairing. Repeat cardioplegia was given as required. Proximal anastomosis of the graft to native aorta was done. Coronary buttons were reimplanted. Concomitant procedures were done as required for respective patients. Deairing and rewarming was done and CPB was discontinued. Ligation and resection of the fourth branch of the graft was done. Hemostasis and routine closure was done in all patients.

2.4 Island (en bloc) technique

Distal aorta is clamped and heart arrested by direct antegrade coronary cardioplegia. An ascending aorta composite graft is used, which is inverted and pushed into the left ventricle. Retrograde perfusion is continued through the femoral artery. Proximal aortic root anastomosis to native aorta with the inverted graft is done. The graft is everted out and coronary button anastomosis is done. Cardioplegia is given again through the graft to check the leak and patency of coronaries. The proximal graft is clamped. Distal native aorta clamp is released and is dissected in such a way that supra aortic vessels are intact on the native aorta and in continuous with the native descending aorta. Selective antegrade cerebral perfusion was given through the innominate artery in 33 cases and through the axillary artery in 3 cases. Selective Direct visual insertion of frozen elephant trunk (stent) in the descending aorta was done for all the patients. The distal part of the graft was bevelled and anastomosed to the island of the three supra aortic vessels intact and anastomosis is completed with the proximal part of the stented mount. Deairing and rewarming was done and a proximal aortic clamp was released. Concomitant procedures were done as required for the respective patients. CPB discontinued. Hemostasis and routine closure was done.

2.5 Statistical analysis

All the continuous variables in the data were expressed as mean±standard deviation (SD) and Student t test was used for comparing normally distributed data. For categorical data, comparison was done by $\chi 2$ test and Fisher exact test according to scale and distribution level. P value of < 0.05 was considered statistically significant.

Follow up

All patients had complete follow up at 3 months and 6 months with CT scan available in 100% of patients.

3. Results

3.1 Operative data

Selective antegrade cerebral perfusion was prefered by axillary artery in total 54 (62.06%) cases {51 (100%) in group A and 3 (8.33%) in group B due to the innominate artery extension, p=< 0.00001} and by innominate artery in total 33 (37.93 %) cases {33 (91.66%) in group B and none in group A, p=< 0.00001}. Mean cardiopulmonary bypass time, cross clamp time and circulatory arrest time was significantly longer in group A than group B {245 ± 33.30 and 195.88 ± 32.83, (p=< 0.00001)}, {117.62 ± 29.38 and 70.11 ± 20.62, (p=< 0.00001)}, {54.33 ± 13.19 and 33.52 ± 8.683, (p=< 0.00001)}. Additional procedures done along with repair of the aortic arch, transfusion of packed Red blood cells, FFP and Platelets was not much different in both the cohort. Extracorporeal Support was given in the form of IABP for 3 (3.44%) patients {2 (3.92%) in group A and 1 (2.77%) in group B, (p=0.773)} and in form of ECMO for 6 (6.89%) patients {3 (5.88%) in groupA and 3 (8.33%) in group B, (p=0.656)} (Table 2).

Variable	Total Both Cohort (n = 87)	Trifurcated Branched Graft group (n = 51)	Island (En bloc) group (n = 36)	p Value
Cannulation				
Axillary Artery	54(62.06%)	51(100%)	3(8.33%)	< 0.00001
Femoral Artery	87(100%)	51(100%)	36(100%)	N.A
Innominate Artery	33(37.93 %)	0	33(91.66%)	< 0.00001
Operative Time (min)				
CPB	224.67 ± 40.93	245 ± 33.30	195.88 ± 32.83	< .00001
Cross clamp	97.96 ± 35.05	117.62 ± 29.38	70.11 ± 20.62	< .00001
Total Circulatory arrest	45.72 ± 15.43	54.33 ± 13.19	33.52 ± 8.683	< .00001
Cardioplegia route				
Antegrade	87(100%)	51(100%)	36(100%)	N.A
Retrograde	2 (2.29%)	2(3.92%)	0	0.509
Type of Cardioplegia				
St Thomas	0	0	0	N.A
Del nido	87(100%)	51(100%)	36(100%)	N.A
Degree of Hypothermia	25-32°C	25-32°C	25-32°C	N.A
Additional Procedure				
Bentall	31(35.63%)	22(43.13%)	9(25%)	0.081
Valve Sparing Root Surgery	17(19.54%)	11(21.56%)	6(16.66%)	0.57
Aortic Valve Repair	0	0	0	
CABG	5(5.74%)	4(7.84%)	1(2.77%)	0.317
Descending Aorta Stenting	85(97.70%)	49(96.07%)	36(100%)	0.509

Transfusion				
Packed RBC (unit)	5.4 ± 1.37	5.52 ± 1.36	5.22 ± 1.39	0.153
FFP (unit)	5.28 ± 1.22	5.43 ± 1.22	5.08 ± 1.22	0.097
Platelets (unit)	0.93 ± 0.66	0.94 ± 0.78	0.91 ± 0.43	0.432
Extracorporeal Support				
IABP	3(3.44%)	2(3.92%)	1(2.77%)	0.773
ECMO	6(6.89%)	3(5.88%)	3(8.33%)	0.656

Table 2: Operative data and variables

3.2 Early outcomes, operative mortality and morbidity

Ventilation time and length of ICU stay was not much significant in both the groups {35.82 ± 24.77 vs 37.88 ± 28.14, (p=0.359) and {3.23 ± 1.43 vs 2.86 ± 1.24 (p=0.105)}. Overall, hospital stay was little prolonged in group A compared to group B {10.8 ± 6.37 vs 7.77 ± 1.26 (p=0.003)}, we assume this prolongation may be due to 2 (3.92%) patients in group A who needed reexploration. Reexploration for bleeding was needed for 2 (3.92%) patients in group A, which may be the reason for little prolonged stay in the overall cohort of group A. Cardiogenic shock was observed in 5 (9.80%) vs 4 (11.11%) patients in group A and group B respectively. Both the respective cohort A and B had 2 (3.92%) vs 2 (5.55%) patients with stroke and 3 (5.88%) vs 3 (8.33%) patients with respiratory failure. 4 (7.84%) vs 3 (8.33%) patients were identified with renal failure and were on hemodialysis or hemofiltration. In both the cohorts, none of the patients had sepsis or visceral and limb ischemia. Overall operative mortality was 8 (9.19%) for both the cohort {5 (9.83%) for group A and 3 (8.33%) for group B}. 3 (5.88%) in group A and 2 (5.55%) in group B died of multi organ dysfunction syndrome (Table 3). 2 out of 5 patients in group A and 1 out of 4 patients in group B died, who were in cardiogenic shock, while the rest were able to manage to bring out of cardiogenic shock with help of extracorporeal support.

Variable	**Total Both Cohort (n = 87)**	**Trifurcated Branched Graft group (n = 51)**	**Island (En bloc) group (n = 36)**	**p Value**
Ventilation time (hrs.)	36.67 ± 26.08	35.82 ± 24.77	37.88 ± 28.14	0.359
ICU stay (days)	3.08 ± 1.36	3.23 ± 1.43	2.86 ± 1.24	0.105
Hospital stay (days)	9.55 ± 5.15	10.8 ± 6.37	7.77 ± 1.26	0.003
Re-Exploration	2 (2.29%)	2(3.92%)	0	0.509
Sepsis	0	0	0	N.A
Cardiogenic Shock	9 (10.34%)	5(9.80%)	4(11.11%)	0.843
MODS	5 (5.74%)	3(5.88%)	2(5.55%)	0.948
Low Cardiac Output	11 (12.64%)	6(11.76%)	5(13.88%)	0.769
Stroke/TIA	4 (4.59%)	2(3.92%)	2(5.55%)	0.72
Respiratory failure	6 (6.89%)	3(5.88%)	3(8.33%)	0.656
Renal Failure	7 (8.04%)	4(7.84%)	3(8.33%)	0.934

Hemodialysis/Hemofiltration	7 (8.04%)	4(7.84%)	3(8.33%)	0.934
Arrhythmia	3 (3.44%)	1(1.96%)	2(5.55%)	0.365
Visceral Ischemia	0	0	0	N.A
Limb Ischemia	0	0	0	N.A
Operative Mortality	8 (9.19%)	5(9.83%)	3(8.33%)	0.815

Table 3: Post-operative data and variables

4. Discussion

Aorta and aortic arch surgeries remain one of the most difficult surgeries which demand a high level of experience and expertise. The optimal approach for arch reconstruction is still debatable and largely depends on the volume of the centre and the surgeon's experience and comfort. Operative mortality for aortic arch surgery still is very high around 9% to 34% [4,6]. Intimal resection, obliteration of false lumen and replacement of aorta remains the mainstay of surgical treatment [7-11]. While, brain and other organ protection including myocardium and postoperative renal failure plays a vital role in prognosis of the patient. Various surgical approaches have been described in the literature from classical Elephant trunk technique to hybrid procedures and also total endovascular stenting [12-15]. Two most commonly performed surgeries now are total arch replacement with trifurcated branch graft and island (en bloc) technique [16]. Several methods have been developed to protect the brain like hypothermia, perfusion with cold blood, perfusion of the brain by retrograde manner and selective antegrade cerebral perfusion (SACP), these methodologies have reduced operative mortality and have enhanced good brain protection. Comparing Trifurcated branch graft technique with island (en bloc) technique for acute type A aortic dissection, each has several advantages and disadvantages. Trifurcated Branch Graft technique has several merits over en bloc technique as each supra aortic vessels is anastomosed separately to the respective native vessel, lower body perfusion is established by the fourth arm of the graft which reduces the malperfusion to visceral organs and spinal cord by lowering ischemic time, selective antegrade cerebral perfusion in combination with this technique protects the brain and reduces stroke and any CNS events remarkably. While the disadvantage of trifurcated branch graft technique is that it needs five anastomosis comparing to island technique which requires only two, so each supra aortic vessels has to be grafted and anastomosed individually and at most of the instance the left subclavian artery is very deep to dissect and anastomosed it to the graft. The most common complication of any surgery is bleeding, and surgery for aortic dissection demands a high level of skill for anastomosis and hemostasis. Aortic arch surgery has a special challenge, to protect the brain and at the same time anastomosis has to be completed and circulation has to be restarted in a minimum time frame. This special circumstance makes island technique a bit challenging. Although it needs only two anastomoses, i.e the proximal anastomosis to the native aorta and distal anastomosis with the proximal part of the stented graft in descending aorta together with the complete island of the supra aortic vessel. It has to be completed before the lower body, myocardium and brain blood flow has to be restarted. The most catastrophic part of this anastomosis is to control bleeding from the anastomosis, especially if there is

bleeding after initiating cardiopulmonary bypass from the dorsal aspect of the island of distal anastomosis, where hemostasis is comparatively easier in trifurcated graft technique. Although Island technique does have merit of only one anastomosis over all three supra aortic vessels, which can be achieved with experience and expertise.

5. Conclusions

Surgery for Type A aortic arch replacement is very complex and with high mortality. Two techniques, trifurcated branch graft and island technique did not show any significant difference in overall outcomes and post-operative or 30 day mortality. Island technique was associated with shorter CPB, cross clamp and total circulatory arrest time with respect to trifurcated branch graft technique. Trifurcated branched graft and island technique, both can be used to replace the aortic arch with comparable results, the only prerequisite being surgeons comfortability and experience.

Declaration

Ethics approval and consent to participate

This Retrospective Study was approved by our local ethics committee, and individual patient consent was taken.

Consent for publication

Not applicable

Availability of data and materials

All data generated or analysed during this study are included in this published article.

Competing interests

The authors have no conflicts of interest to declare.

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Authors' contributions

Authors Kamran Yunus Inamdar and Xu Hua Shan wrote the manuscript text and did statistical calculation. Author Wen Bing, Zhao Guochang, Singh Chhatrapratap, and Zhao Wen Zeng helped in collection of data and prepared tables. All authors have reviewed the manuscript.

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