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Ahmed S. Emara
Benha University

Hussein A. Zaher
National Heart Institute

Mahmoud F. El-Safty
National Heart Institute, drsaftey222@gmail.com

Mohamed A. El-Badawy
National Heart Institute

Mohamed A. El-Hady
National Heart Institute

See next page for additional authors

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Short-term results of off-pump and on-pump aortic arch debranching during type I hybrid arch repair: A single-center experience

Authors

Ahmed S. Emara, Hussein A. Zaher, Mahmoud F. El-Safty, Mohamed A. El-Badawy, Mohamed A. El-Hady, and Mostafa M. Abdalraouf

Original Article

Short-term results of off-pump and on-pump aortic arch debranching during type I hybrid arch repair: A single-center experience

Mohamed A. El-Badawy[a], Mostafa M. Abdalraouf[b], Ahmed S. Emara[c], Hussein A. Zaher[a], Mohamed A. El-Hady[d], Mahmoud F. El-Safty[a]

Departments of [a]Cardiothoracic Surgery, [d]Cardiology, National Heart Institute, [b]Department of Cardiothoracic Surgery, Sheikh Zayed Specialized Hospital, Giza, [c]Department of Cardiothoracic Surgery, Faculty of Medicine, Benha University, Benha, Egypt

Abstract

Background

Compared with off-pump surgeries, cardiopulmonary bypass (CPB) is associated with a high systemic inflammatory response and with substantial myocardial injury, especially in high-risk subgroups. Every effort should be exerted to minimize the role of CPB without affecting the safety and outcome. Classically, aortic arch surgeries were done using CPB and deep circulatory arrest together with cerebral brain protection strategies. With the development of endovascular techniques, the role of CPB decreased. Management of aortic arch pathologies carries special needs, specifically rerouting of the great vessels and preparing a landing zone.

Objectives

To assess the effectiveness and safety of off-pump aortic arch debranching during type I hybrid aortic arch repair.

Patients and methods

We report our single-center experience of rerouting aortic arch branches (debranching) without using CPB, consisting of bypass grafting of the aortic arch branches off pump, preparing a landing zone for endovascular aortic repair. The preoperative, operative, and postoperative data were collected and analyzed retrospectively. Starting from 2015, 20 low-risk patients were subjected to type I aortic arch hybrid repair, whereas the Dacron tube graft was anastomosed to a normal ascending aorta, preparing a landing zone to the subsequent stenting of arch and descending aorta. CPB was used in 10 patients, and off-pump technique was used in the remaining group. Preoperative, operative, and postoperative data were collected and analyzed to compare the results.

Results

All surgeries went uneventful, with mean operative time of 141.5 ± 24.3 min for group I (on-pump group) and 137.5 ± 14.6 for group II (off-pump group). There were no conversions to CPB in off-pump group. There was no sternotomy for bleeding in off-pump group, compared with only one patient explored for postoperative bleeding in CPB group. All patients in both groups went without any neurological deficit of significance, with no mortality in the 30 days of follow-up.

Conclusion

Off-pump debranching of aortic arch followed by endovascular repair is a safe and reproducible technique, compared with the gold standard technique using CPB. However, further efforts using intraoperative cerebral perfusion monitoring techniques should be considered in the future.

Keywords: Aortic aneurysm, aortic arch, beating heart, cardiopulmonary bypass, debranching, repair

Introduction

With the increased prevalence and incidence of thoracic aortic disease including aneurysm over recent decades, together with increased life expectancies and the combined

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Correspondence to: Mahmoud F. El-Safty, MD, Department of Cardiothoracic Surgery, National Heart Institute, 233d Hadayek Al Ahram, Giza, Egypt.
E-mail: drsaftey222@gmail.com

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comorbidities of progressing age, there is a rising need of better and less complicated plan of management of these pathologies [1].

Classically, surgical repair of the aortic arch necessitates cardiopulmonary bypass (CPB) and hypothermic circulatory arrest, but it still carries substantial rates of mortality and morbidity, especially in the elderly. Using CPB carries a high systemic inflammatory response [2,3].

With the development of endovascular options, surgical component of the plan is decreasing, and a hybrid strategy developed. The main target of a hybrid approach is to serve as an alternative in high-risk patients with aortic arch pathology that would require complex conventional approach, with arch replacement in the first step and open descending repair in the second. A hybrid aortic arch repair essentially has three main domains: (a) surgical debranching of aortic arch branching, (b) creation of proper proximal and distal landing zones, and (c) endovascular stent grafting of the aortic arch [4].

There are three types of aortic arch repair. According to the proximal landing zone, type I repair consists of directing the aortic arch vessels to the native ascending aorta using Dacron tube graft. This means that the proximal landing zone is the native ascending aorta. Type II entails that the ascending aorta requires reconstruction before receiving the arch vessels, and type III for the more complicated category of patients as in mega-aorta syndrome [5].

The aim of our work is to assess the safety of off-pump rerouting aortic arch branches (debranching), during type I aortic arch repair.

Patients and methods

Starting in 2015, to 2109, 20 patients were subjected to type I hybrid aortic arch repair, where the ascending aorta was pathology free. A total of 16 patients had arch and descending aortic aneurysm, and three patients of CPB group had chronic aortic dissection compared with only one patient in the off-pump group.

Inclusion criteria

Low-risk patients with aortic arch and descending aortic pathology requiring repair were included.

Exclusion criteria

Patients with previous sternotomy, thoracotomy, bleeding disorders, previous neurological deficit, age above 60 years old, and chronic renal impairment were excluded. We excluded patients who require intervention to prepare distal landing zone. We also excluded patients who needed CPB for any cardiac repair.

Preoperative assessment

This included careful history and examination (clinical assessment), preoperative computed tomographic angiogram, preoperative renal function, and echocardiography.

Hemodynamic and cerebral perfusion monitoring: all procedures were performed under general anesthesia. Blood pressure was monitored invasively via bilateral radial and unilateral femoral artery catheters to monitor the upper and lower body blood pressures. Moreover, 5-lead ECG and pulse-oximetry were performed. A central venous catheter in the internal jugular vein for medications, infusions, and monitor central venous pressure was inserted. Core body temperature was monitored via naso-pharyngeal probe. There were no available cerebral perfusion monitoring techniques at our center.

Surgical technique

All patients were done through full sternotomy. Adequate dissection and mobilization of the great vessels was done. In CPB group, aorta and single double-staged venous cannulation was used in all patients after full heparinization (400 IU/kg body weight, to an activated clotting time of around 480 s). We did not cross clamp the aorta or give cardioplegia.

We use an 8-mm Dacron tube graft to the left subclavian branch, and a bifurcating (16.8 × 8) or (18.9 × 9) for the other two vessels. We did not divert the left subclavian branch in all patients, especially in off-pump groups, as it may not be easily accessible, but when it will be doable, we always start with it.

Distal anastomosis of the bifurcating limb of the tube graft to the left common carotid and innominate vessels was done using sequential clamping. Then ascending aorta was side clamped, and the de-aired Dacron tube graft was then anastomosed end to side into the ascending aorta. The tube graft of the left subclavian is then anastomosed to either ascending aorta or the main stem of the bifurcating Dacron tube graft.

After successful debranching, and assessment of conscious level, endovascular repair was done in another setting within two days of the debranching.

Postoperative assessment

It included duration of mechanical ventilation, ICU stay, and inotropic support. Documentation of complications included re-exploration for bleeding, low cardiac output syndrome, and neurological complications. Laboratory workup included postoperative renal function, liver function, and complete blood count. Follow-up echo at day 1 and before discharge was requested. Moreover, data about wound infection and early postoperative mortality were collected.

Follow-up

In the study, 30-day follow-up for mortality and any possible complications was done, and computed tomographic angiography was done 1 month after the operation.

Ethical considerations

The study was approved by the institutional Ethics Committee of National Heart Institute no. HNI-00015.

Statistical analysis

Data were collected, revised, coded, and entered to the Statistical Package for Social Science (IBM Corp. Released

2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp), version 20. The qualitative data were presented as number and percentages, whereas the quantitative data were presented as mean, SD, and ranges when their distribution was found to be parametric.

The comparisons between groups with qualitative data were done by using χ^2 test and/or Fisher exact test when the expected count was found to be less than 5.

The comparison between two independent groups with quantitative data and parametric distribution was done by using independent *t* test. The confidence interval was set to 95%, and the margin of error accepted was set to 5%.

Results

Both groups were matched regarding age and sex. In group I, seven patients had hypertension and three patients had diabetes mellitus, whereas in group II, nine patients had hypertension and only one patient had diabetes mellitus.

In group I, seven patients had aortic aneurysm and three patients had aortic dissection, and in group II, nine patients had aortic aneurysm and one patient had aortic dissection. No significant difference was found between both group regarding aortic arch diameter and serum creatinine (Table 1).

Intraoperative mean bypass time in group I (CPB group) was 43.3 ± 9.4 min. No significant difference was found between the two groups regarding total operative time. Innominate artery in both groups had been anastomosed end to end to one limb of bifurcate tube graft. Common carotid artery anastomosed by end to end to one limb in nine patients and end to side of one limb in the remaining patient in group I, whereas in group II, in all patients, it was anastomosed end to end to one limb of the bifurcating tube graft. Regarding subclavian artery, one patient had end to end to one limb of the bifurcating tube graft, one had been ligated, and eight patients had their subclavian anastomosed to a separate 8 mm Dacron graft. However, in group II, subclavian artery was ligated in four patients and anastomosed to a 8-mm Dacron graft in six patients (Table 2).

No patient in group II needed to be converted to on-pump procedure.

Regarding postoperative data, no significant difference was found between the studied group except for bleeding, which was observed in one patient in group I who needed exploration (Table 3). There were no significant postoperative angiographic findings.

There was a significant difference regarding preoperative and postoperative serum creatinine in both groups (Table 4), with no significant difference between both groups.

Discussion

We reported our experience in type I hybrid aortic arch repair, where we do debranching of aortic arch off pump in selected patients. Our study included 20 patients, where 16 patients were subjected to on-pump beating heart debranching, and other patients underwent off-pump debranching.

There are many trials comparing conventional open repair with hybrid repair, for example, Milewski *et al*. [6], and Lee *et al*. [7]; they compared two groups of undergoing either the conventional elephant trunk procedure with endovascular completion or aortic debranching followed by endovascular arch replacement.

Moreover, there are many trials discussing the newer, but less available techniques like Snorkel and chimney procedures. However, these techniques expose the patient to risk of type I endoleak and retrograde type A aortic dissection [8].

Comparing different techniques of performing arch debranching is of value regarding effectiveness and safety. Performing off-pump debranching is demanding in terms of left subclavian artery rerouting. We believe that performing a complete rerouting of all aortic arch branches is always preferable, and this technique is still technically easier with standard methods using CPB. However, in selected patients and after confirmation of collateral perfusion, subclavian ligation and might also be adequate [1].

Table 1: Patients' characteristics and preoperative data of both groups

Variables	Group I (on pump) [*n* (%)]	Group II (off pump) [*n* (%)]	*P*
Age	51.7±4.8	53.7±4.5	0.35
Sex			
Male	7 (70)	8 (80)	0.6
Female	3 (30)	2 (20)	
Comorbidities			
Hypertension	7 (70)	9 (90)	0.3
DM	3 (30)	1 (10)	
Pathology			
Aneurysm	7 (70)	9 (90)	0.3
Chronic dissection	3 (30)	1 (10)	
Aortic arch diameter	4.3±0.3	4.2±0.4	0.8
Renal function	0.9±0.14	0.8±0.17	0.5

DM, diabetes mellitus.

Table 2: Operative data

Variables	Group I (on pump) [*n* (%)]	Group II (off pump) [*n* (%)]	*P*
Operative time	141.5±24.3	137.5±14.6	0.7
Debranching			
Innominate artery end-to-end anastomosis to one limb of the bifurcating tube graft	10 (100)	10 (100)	
Left common carotid			
End-to-end to one limb of the bifurcating tube graft	9 (90)	10 (100)	0.5
End-to-side to one limb of the bifurcating tube graft	1 (10)	0	
left subclavian			
End-to-end to one limb of the bifurcating tube graft	1 (10)	0	0.3
Ligated	1 (10)	4 (40)	
Anastomosed to 8-mm Dacron graft	8 (80)	6 (60)	
Intraoperative bleeding	0	0	

Table 3: Postoperative data

Variables	Group I [*n* (%)]	Group II [*n* (%)]	*P*
Mechanical ventilation (h)	3.4±1.2	3.1±1.3	0.5
ICU stay (h)	4.8±12.4	47.9±14.9	0.97
Exploration for bleeding	1 (10)	0	0.005
Neurological deficit	0	0	
Serum creatinine	1.12±0.29	1.06±0.17	0.58
Mortality	0	0	
Infection	0	0	
Postoperative angiography, significant findings	0	0	

Table 4: Comparison between preoperative and postoperative serum creat. in both groups

Variables	Group I	Group II
Preoperative	0.89±0.1	0.84±0.2
Postoperative	1.12±0.3	1.06±0.2
P	0.036 (S)	0.01 (HS)

HS, highly significant; S, significant.

According to our experience, we can overcome this limitation by offering left subclavian to left common carotid bypass before doing off-pump debranching, in patients in whom their preoperative evaluation revealed sure anatomical difficulty. This tailored plan of management is for patients with major risk factor for CPB.

Regarding postoperative bleeding and exploration, we have only one patient in CPB group, and there was no hemodynamic instability, which compared with a cohort done by Ghazy *et al*. [1], who reported one fatal bleeding, and it was comparable with open group. It is of value to report that a cohort of Ghazy *et al*. [1] included a higher risk group of patients with multiple morbidities than we have included in our study.

In our study, we had no patient with postoperative neurological deficit. This may be explained by the selection criteria in our group of patients. This was not similar to the data reported from other studies, as they included more risky patients with older age groups, for example, Geisbüsch *et al*. [9], and Marullo *et al*. [10], and Brechtel *et al*. [11].

According to our results and after comparing results of previous studies, we do recommend being selective in patients doing hybrid technique, especially those who we will offer an off-pump option.

We also consider that absence of brain perfusion monitoring techniques is a limiting factor in the assessment of the effect of clamping and graft layout, and preoperative assessment of angiographic studies may not be enough, especially in high-risk patients.

It was clear enough that every single patient should be carefully evaluated and investigated before offering a given plan of management.

Conclusion

With the development of endovascular techniques, a hybrid repair became available. According to our experience, type I aortic arch hybrid repair can be done safely and effectively in selected patients. Further studies with intraoperative brain perfusion monitoring are needed together with long period of follow-up on a larger group of patients.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other

clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest
There are no conflicts of interest.

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