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Research Article

Descending Aortic Replacement with Third-Part Left Axillary Artery Graft Perfusion

Shigeru Hattori, Kenichiro Noguchi, Yusuke Gunji, Motoki Nagatsuka, Tsuyoshi Yamabe, Hideo Kagaya, Ikuo Katayama, and Tohru Asai

Department of Cardiovascular Surgery, Shonan Kamakura General Hospital, Kanagawa, Kamakura, Japan

Correspondence should be addressed to Shigeru Hattori; shigeru.hattori17@gmail.com

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We introduce a unique perfusion method for open descending aortic repair through a left thoracotomy. Perfusion from femoral artery cannulation is generally adopted in descending aortic replacement surgery. However, in cases with shaggy or partially thrombosed chronic aortic dissection, retrograde perfusion alone has a high risk of embolization and alternative perfusion methods should be considered. Our perfusion method from the third part of the left axillary artery graft is safe, simple, and useful for avoiding postoperative cerebral complications. In the present study, we report the advantages and challenges of this graft-interposed perfusion via the distal left axillary artery for descending aortic replacement.

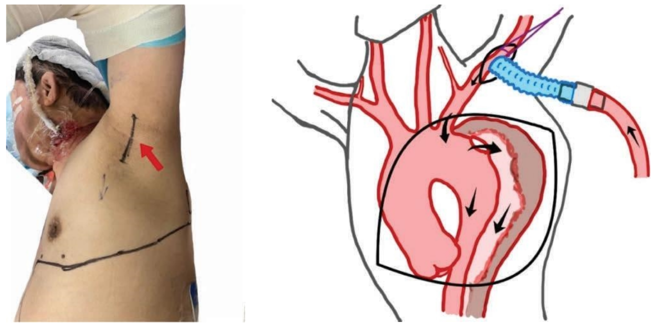
1. Introduction

In the current era of endovascular repair, the number of open descending or thoracoabdominal aortic replacements has remained the same [1]. Some cases with complications, such as poor landing zone, chronic dissection, or difficult access route, may occur, in which endovascular repair is inappropriate and open descending aortic replacement (DAR) is required [1, 2]. The desired outcomes for DAR surgery with low mortality rate, low stroke complications, and good long-term results are those reported by experienced surgeons [3–6]; however, shaggy aorta is one of the risk factors for embolic events [7]. The establishment of the cardiopulmonary bypass (CPB) in DAR is considered a critical factor for safe surgery in shaggy aorta; however, the method for blood perfusion is still up for debate [8–12]. In this study, we have reported on the usefulness of DAR using the third part of the left axillary artery (LAx3) graft perfusion.

2. Technique

The patient was given the right decubitus position, with the chest elevated to approximately 80°. The patient's hips were positioned at about 45°. The left arm was raised above the head, with the axillary artery positioned for easy access in front of the surgical field (Figure 1(a)). In most cases, the left femoral artery and vein were exposed. At the same time, the third part of the left axillary artery (LAx3) was exposed. The skin and subcutaneous tissue were incised, the axillary vein and median nerve were encountered, and the LAx3 was identified beneath them. Low-dose heparin (activated clotting time: 200–250 sec) was administered. A 9 mm woven gelatin-coated polyester vascular graft, J-graft (Japan Lifeline, Tokyo, Japan), was anastomosed end-to-side to the LAx3. The LAx3 graft was connected to the arterial line of the CPB.

A left lateral thoracotomy was carried out through the fifth intercostal space. The fifth posterior and anterior ribs



(a) (b)

Figure 1: (a) The third part of the left axillary artery (red arrow) is located just in front of the surgical field in the right decubitus position with the left arm raised and (b) anastomosed graft and perfusion system. Blood can be safely delivered from the distal axillary artery without dispersing atheroma in the descending aorta.

were incised for good exposure of the aorta. The aorta was dissected free from the lung, esophagus, hemiazygos vein, ligamentum arteriosum, and recurrent laryngeal nerve. Specifically, the proximal and distal anastomosis sites of the aorta were dissected free from their attachments to shorten the circulatory arrest time during anastomosis, and we ligated as many intercostal arteries as possible from outside the aorta.

After full heparinization, standard femoral arterial and venous cannulation was performed. In our series, CPB flow, with a cardiac index of 2.4 L/min per square meter, was obtained with the LAx3 graft perfusion. However, unless there was a risk of embolization from abdominal aortic atherosclerotic plaques or thrombi from the false lumen, concomitant femoral perfusion was used. In cases with a risk of embolization, femoral perfusion was only used for distal perfusion after clamping the mid-descending aorta.

After starting the CPB, the tape of the distal part of the LAx3 was slightly pulled to direct the blood flow to the proximal side. Core cooling was started. A venting cannula was usually inserted into the left atrium through the left upper pulmonary vein. However, in the case of moderate or severe preoperative aortic regurgitation, a venting cannula was preferably inserted through the apex of the heart into the left ventricle. When the heart fibrillates, potassium chloride (20–60 mEq) was administered from the CPB circuit to arrest the heart. Systemic cooling was considered adequate when the patient's nasopharyngeal temperature was about 25°C.

Before the circulatory arrest, the patient was placed in the Trendelenburg position. Then, the CPB flow was arrested, and the venting tube was clamped. The mid-descending aorta was clamped, and the arterial flow was started through femoral perfusion. The aneurysm was incised. During open proximal anastomosis, the blood was kept above the aortic arch to prevent air from entering the neck vessels. After completing the anastomosis and careful de-airing, the proximal perfusion was restarted from the LAx3 graft or side branch of the aortic graft. The rewarming was started gradually. Following the hemostasis of the residual intercostal arteries, distal anastomosis was carried out either with an open distal technique or clamping with the help of femoral perfusion.

2.1. Patient Selection. Between April 2017 and May 2022, 46 patients underwent open surgery for DAR at the Shonan Kamakura General Hospital. Among them, we retrospectively reviewed 13 patients who underwent DAR with LAx3 graft perfusion (Group LAx3) and another 33 patients who underwent DAR with femoral artery perfusion alone because it was considered safe with retrograde perfusion (Group F). Data were collected from computerized medical records. All data were processed using the *R* statistical program, version 3.4.4. Summary statistics were calculated using frequencies and proportions for categorical data and median values and interquartile range for continuous variables. Univariate analyses were performed using the *t*-test or Wilcoxon rank-sum test for continuous variables and the chi-square test or Fisher exact test for categorical variables. P values of <0.05 were considered statistically significant. The study was approved by the institutional review board of the Shonan Kamakura General Hospital on October 31, 2022 (TGE02055-024). The informed consent was obtained from all patients to participate in this study. Patient consent was obtained for the use of his photograph in this article (Figure 1(a)).

3. Results

Preoperative patient characteristics, operative data, and early outcomes are listed in Table 1, and there were no significant differences between the groups LAx3 and F (Table 1). In Group LAx3, there was one in-hospital death (7.7%) due to DIC and no case of cerebral infarction. In Group F, there were two cases of cerebral infarction due to embolism from retrograde perfusion.

4. Discussion

As reported by Corvera and Fehrenbacher [3], the hypothermic open proximal technique is advantageous in descending or thoracoabdominal aortic artery replacement. We used this technique because it is simple and easy to anastomose. The femoral artery is generally used as the blood perfusion route for DAR. However, in cases where retrograde blood perfusion through the diseased aorta is

Table 1: Preoperative patient characteristics, operative data, and outcomes.

Preoperative characteristics	Group LAx3; $n = 13$ n (%) or median (IQR)	Group F; $n = 33$ n (%) or median (IQR)	P value
Age (years)	69 (61–72)	70 (55–76)	0.77
Sex male	8 (61.5)	22 (66.7)	0.74
Size of the aneurysm (mm)	57 (55–65)	59 (53–62)	0.45
Shaggy aorta	5 (38.5)	4 (12.1)	0.09
Thrombosis in false lumen	9 (69.2)	22 (73.3)	1
Operative data and outcomes			
Operation time (min)	280 (233–310)	223 (206–278)	0.16
CPB time (min)	118 (100–132)	111 (98–133)	0.65
Hypothermic circulatory arrest time (min)	19 (13–22.8)	20 (17–23)	0.80
In-hospital death	1 (7.7)	0	0.28
PND	0	2 (6.1)	1
TND	1 (7.7)	1 (3.0)	0.49
Paraplegia	0	0	n.s
Paraparesis	0	0	n.s
ICU stay (days)	3 (1–4)	2 (1–3)	0.28
Hospital stay (days)	11 (10–12)	11 (9–12)	0.50

Continuous data are presented as median and interquartile range; categorical data are shown as the number of observations. ICU: intensive care unit, IQR: interquartile range, PND: permanent neurological dysfunction, and TND: transient neurological dysfunction.

considered inappropriate, alternative routes, such as left ventricular apex [8], ascending aorta [9], right axillary artery [10], left common carotid artery [11], and left subclavian artery in the thoracic cavity [12], have been selected. Although each has been reported to have its advantages, all of them are somewhat complicated or give a poor visual field when the patient is in the right decubitus position. In our institution, perfusion via the graft anastomosed to the LAx3 is the preferred alternative to femoral artery perfusion because this technique is simple and safe. Ogino et al. reported the usefulness of additional blood perfusion using a 10F–16F cannula inserted into the distal right axillary artery for total arch replacement through a median sternotomy [13]. However, there are no reports on the distal left axillary artery graft-interposed perfusion technique for DAR surgery. We adopted the graft-interposed perfusion method because it produces sufficient flow compared with the cannulation method. Blood can be safely delivered from the distal axillary artery without dispersing atheroma in the descending aorta (Figure 1(b)).

The advantages of the LAx3 perfusion are that it is situated behind the axillary vein and median nerve and can be easily exposed. It is located just in front of the surgical field in the right decubitus position with the left arm raised. This artery has less atherosclerosis or calcification. Furthermore, the extension of aortic dissection is rare [14]. Hence, it is suitable for anastomosis. Additionally, the perfusion system does not interfere with the surgical field (Figure 1(b)). There have been no postoperative wound infections or neurological complications in our series.

A necessary precaution in this technique is the flow volume. In our patients, we achieved full flow with axillary artery perfusion alone without complications. However, there is a possibility that flow might be insufficient when the axillary artery is narrow. In that case, concomitant femoral artery perfusion should be considered unless there is a risk of embolization from the diseased aorta. We believe that blood perfusion from the distal part of the axillary artery minimizes the turbulent jet in the aorta. However, if there are thrombi in the aortic arch, they might be dispersed. In such cases, perfusion from the left ventricular apex, ascending aorta, or right axillary artery might be an option.

Overall, in Group LAx3, there was one in-hospital death and no cases of cerebral infarction, paraplegia, and paraparesis (Table 1). Despite having several cases of shaggy aorta and thrombus in the false lumen, this outcome was more desirable as compared with previous reports [14]. In Group F, two cases of cerebral infarction occurred due to embolization despite of preoperative evaluation determining that retrograde blood perfusion was safe.

Currently, the criteria for selecting LAx3 perfusion are atheroma in the true lumen or nondissected aorta and thrombus in the false lumen with confirmed proximal entry.

This study has several limitations. This study was a retrospective analysis of a small cohort of DAR surgery; therefore, further studies with larger sample sizes are required to verify these observations. Future research should compare our results with other techniques used in a larger cohort of similar patients.

5. Conclusion

In selected cases for DAR surgery, our perfusion method with LAx3 graft is a safe and simple alternative to establish a CPB and might reduce the risk of cerebral complications.

Data Availability

The data associated with the study are not publicly available but are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Shigeru Hattori conceptualized the study, performed data curation, performed formal analysis, investigated the study, and visualized and wrote the original draft. Kenichiro Noguchi conceptualized, supervised, and validated the study. Yusuke Gunji supervised and validated the study. Motoki Nagatsuka supervised and validated the study. Tsuyoshi Yamabe wrote, reviewed, and edited the manuscript, supervised the study, validated the study, and performed formal analysis. Hideo Kagaya supervised and validated the study. Ikuo Katayama supervised and validated the study. Tohru Asai supervised the study, performed formal analysis, and wrote, reviewed, and edited the manuscript.

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