Heart, Lung and Circulation (2019) **28,** 1740–1746
1443-9506/04/$36.00
https://doi.org/10.1016/j.hlc.2018.08.024

ORIGINAL ARTICLE

One-Stage Repair of Adult Aortic Coarctation and Concomitant Cardiac Diseases: Ascending to Abdominal Aorta Extra-Anatomical Bypass Combined with Cardiac Surgery☆

Yi-Peng Ge, MD, Cheng-Nan Li, MD, Li-Jian Cheng, MD, Tie Zheng, MD, Jun Zheng, MD, Yong-Min Liu, MD, Jun-Ming Zhu, MD*, Li-Zhong Sun, MD

Beijing Aortic Disease Center, Beijing Anzhen Hospital, Capital Medical University, Beijing, China

Received 11 May 2018; received in revised form 25 August 2018; accepted 30 August 2018; online published-ahead-of-print 22 September 2018

Background To evaluate one-stage repair with ascending to abdominal aorta extra-anatomical bypass combined with cardiac surgery for adult aortic coarctation (COA) concomitant with cardiac diseases.

Methods Between February 2009 and September 2016, 24 consecutive patients (79.17% male, mean age 36.04 ± 13.67 years) with COA and concomitant cardiac diseases underwent one-stage repair (ascending to abdominal aorta extra-anatomical bypass combined with cardiac surgery). Two (2) patients who underwent off-pump coronary artery surgery combined with ascending to abdominal aorta bypass did not require cardiopulmonary bypass. Twenty-two (22) patients underwent one-stage repair under cardiopulmonary bypass.

Results No in-hospital mortality was observed. There was a significant reduction in baseline systolic blood pressure from 159.80 ± 23.58 to 127.0 ± 6.86 mmHg. Mean upper-lower limb blood gradient pressure decreased significantly from 37.80 ± 8.73 to 11.47 ± 2.12 mmHg after surgery. Two (2) patients required prolonged mechanical ventilation for respiratory dysfunction. One patient needed temporary continuous renal replacement therapy. No re-exploration for bleeding and gastrointestinal complications was needed. There was no postoperative paraplegia or permanent neurological abnormalities. Grafts were patent for all patients and no graft-related complications were observed in the hospital. Median follow-up was 41.50 months (interquartile range [IQR] 16.75–64.50 months) and 6-year survival was 76.39%. Median number of antihypertensive drugs was 0 (IQR 0–1), which was a significant reduction compared with preoperative drugs (2, IQR 1–3).

Conclusions Ascending to abdominal extra-anatomical aorta bypass combined with cardiac surgery is a safe and effective one-stage repair technique for patients with COA concomitant with cardiac diseases.

Keywords Ascending to abdominal aorta bypass • Aortic coarctation • Cardiac disease

☆The research was carried out at Beijing Anzhen Hospital.

*Corresponding author at: Beijing Aortic Disease Center, Beijing Anzhen Hospital, Capital Medical University, Anzhen Road 2#, Chaoyang District, Beijing, 100029, China. Tel: 86-10-64456588; Fax: 86-10-64456588., Email: anzhenzjm@163.com

Introduction

Aortic coarctation (COA) accounts for 5–7% of congenital heart disease [1]. COA can occur as an isolated anomaly; however, it can be associated with other cardiovascular pathologies, which adds to the complexity of intervention. The common cardiac malformations include bicuspid aortic valve, ventricular septal defect, and patent ductus arteriosus [2,3]. Several options exist for the operative management of COA combined with cardiac diseases in adult patients. One-stage repair is a major challenge for surgeons. The purpose of this study was to evaluate the safety and effectiveness of ascending to abdominal aorta extra-anatomical bypass combined with cardiac surgery for adults with COA concomitant with cardiac diseases.

Materials and Methods

Patients' Data

Between February 2009 and September 2016, 24 consecutive adult patients (19 male, 5 female, mean age 36.04 ± 13.67 years) with COA concomitant with cardiac diseases underwent one-stage repair with ascending to abdominal aorta extra-anatomical bypass combined with cardiac surgery. Cardiac malformations and left ventricular dysfunction were measured by ultrasound cardiography. Aortic coarctation was measured with aortic computed tomography angiography (CTA). The mean upper-lower limb blood gradient pressure was 37.80 ± 8.73 mmHg. The main clinical characteristics are shown in Table 1. The Ethics Committee of Anzhen Hospital approved this retrospective study and waived the need for individual patient's consent. Resting hypertension is defined as systolic blood pressure >140 mmHg or diastolic blood pressure >90 mmHg [4].

Table 1 Main clinical characteristics of patients (n = 24).

Variable	Value
Age (years)*	36.04 ± 13.67
BSA(m^2)*	1.78 ± 1.81
Male gender	19(79.17)
Mean upper-lower limbs blood gradient pressure (mmHg)*	38.00 ± 9.34
Stroke	0
Smoking	4(16.67)
IDDM	0
Reoperation	1(4.17)
LVEF(%)*	61.00 ± 8.17
CPB time (min)*	107.27 ± 34.56
Aortic cross-clamp time(min)*	72.59 ± 28.98

Abbreviations: BSA, body surface area; IDDM, insulin-dependent diabetes mellitus; LVEF, left ventricular ejection fraction; CPB, cardiopulmonary bypass.
Note: Values in parentheses are percentages.
*Values are mean ± SD.

Operative Technique

The surgical procedure is shown in Figure 1. The ascending to abdominal aortic bypass was performed through a median sternotomy laparotomy, with the patient in the supine position. A midline incision was made from the suprasternal notch to the navel. After the peritoneal cavity was entered, the infrarenal abdominal aorta was selected as the site of distal anastomosis. After clamping the infrarenal abdominal aorta, a vascular prosthesis (diameter 16–18 mm) (Vascutek, Ltd., Inchinnan, UK) was anastomosed to the infrarenal abdominal aorta in an end-to-side manner. The cardiopulmonary bypass (CPB) arterial line was bifurcated for two arterial cannulation sites. The right axillary artery was cannulated and flowed to the upper body. The vascular prosthesis of the abdominal aorta was cannulated to perfuse the lower body. After CPB was instituted, the intracardiac lesion was repaired. The other graft (diameter 16–18 mm) was anastomosed to the ascending aorta. The right thoracic cavity was opened and the graft was passed through the right thoracic cavity, with the terminal of the graft above the diaphragm.

After patients were weaned off CPB, the vascular prosthesis of the abdominal aorta was routed around the duodenum at the ligament of Treitz and through the transverse mesocolon into the lesser sac, passed posteriorly to the stomach, and then curved anteriorly to pass through the gastrohepatic mesentery (between the stomach and liver). It was then passed through a hole in the diaphragm. Two (2) grafts were anastomosed in an end-to-end fashion around the diaphragm. Three-dimensional CT reconstruction of artificial blood vessels is shown in Figure 2.

Follow-Up

Patients were followed up with a mailed questionnaire or telephone call, by contacting the referring cardiologist or general practitioner.

Statistical Analysis

The continuous variables are described as mean ± standard deviation or median, and the categorical variables are presented as proportions and percentages. The difference in mean upper–lower limbs blood gradient pressure before and after surgery was analysed by paired *t* test and numbers of antihypertensive drugs by nonparametric paired *t* test using PASW Statistics for Windows version 18.0 (IBM, Armonk, NY, USA). GraphPad Prism for Windows version 5.0 (GraphPad Software, San Diego, CA, USA) was used to create the survival curve and graphs.

Results

Hospital Outcome

There was no in-hospital mortality. Table 2 shows the types of concomitant cardiac surgery. The mean CPB time was 107.27 ± 34.56 minutes. The mean intensive care unit stay

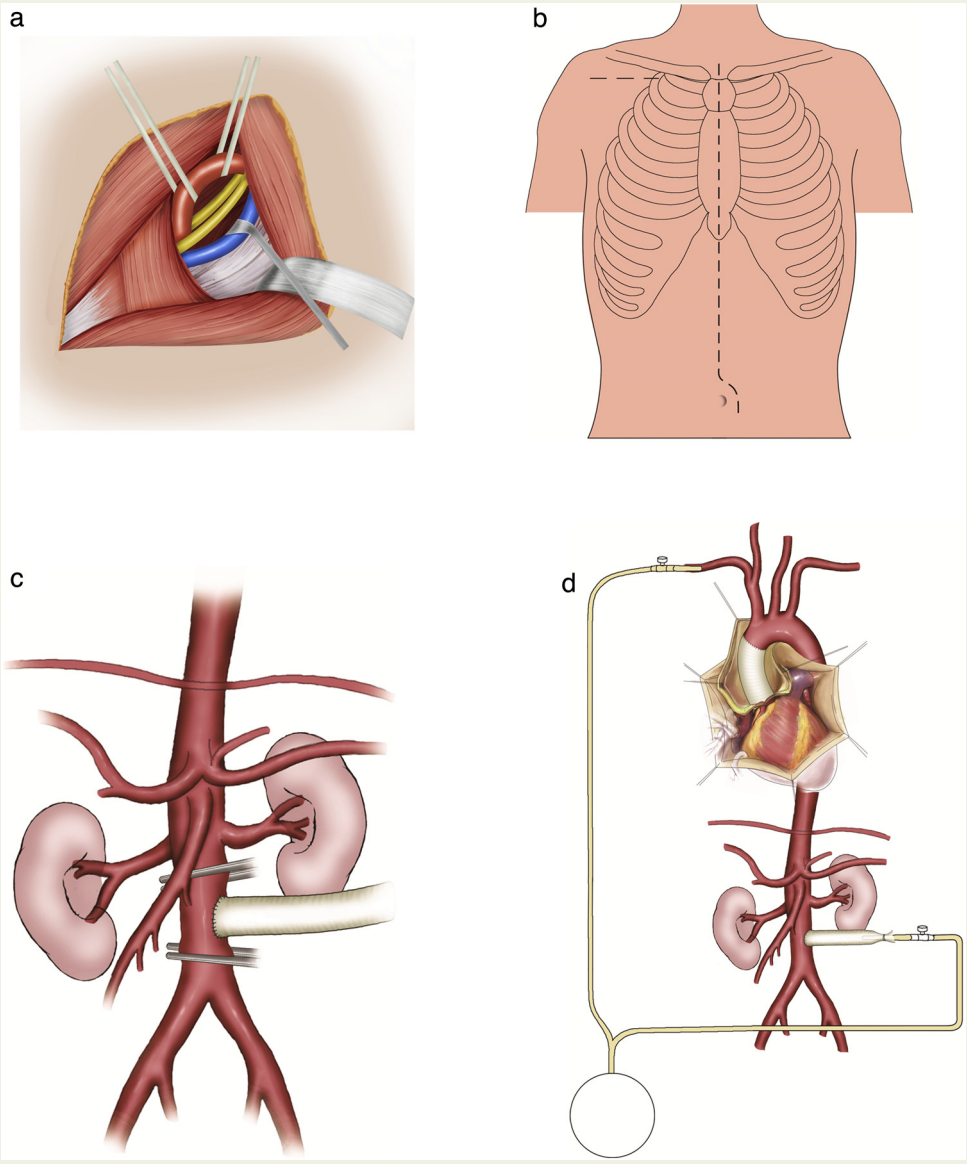

Figure 1 Surgical procedure.
A: right axillary artery
B: median sternotomy-laparotomy
C: vascular prosthesis anastomose to the infrarenal abdominal
D: intracardiac lesion repair

time was 35.22 ± 50.41 hours and the mean mechanical ventilation time was 19.50 ± 17.64 hours. Two patients required prolonged mechanical ventilation for respiratory dysfunction. One patient needed temporary continuous renal replacement therapy. No re-exploration for bleeding and gastrointestinal complications was needed. There was no postoperative paraplegia and permanent neurological abnormalities. The average time of drains *in situ* was 5.35 ± 3.10 days. Table 3 shows the postoperative drainage features. Concomitant intracardiac lesions were treated successfully in all patients. An aorta CTA scan was performed for all patients before discharge from hospital. The grafts were patent for all patients and no graft-related complications were observed in the hospital.

There was a significant reduction in baseline systolic blood pressure from 159.80 ± 23.58 to 127.0 ± 6.86 mmHg ($p = 0.01$) after surgery (Figure 3). The mean upper-lower limb blood gradient pressure decreased significantly from 37.80 ± 8.73 to 11.47 ± 2.12 mmHg after surgery ($p = 0.001$). The mean upper-lower limb blood gradient pressure for all patients was <20 mmHg. There was also a significant reduction in the mean number of antihypertensive drugs from two (interquartile range [IQR] 1–3) preoperatively to one (IQR 1–2) postoperatively ($p = 0.047$) (Figure 4).

Figure 2 Three-dimensional computed tomography angiography reconstruction of artificial blood vessel.

Table 2 Types of concomitant cardiac surgery.

Type	N
Bentall procedure	9
Bentall + CABG	1
David procedure	1
Off-pump CABG	2
PDA occlude + VSD repair	1
VSD repair	2
VSD repair + AVR	1
VSD repair + AVR + PDA occlude	1
Wheat's procedure	1
Ascending aorta replacement	1
AVR	4
Total	24

Abbreviations: CABG, coronary artery bypass grafting; PDA, patent ductus arteriosus; VSD, ventricular septal defect; AVR, aortic valve replacement.

Table 3 Postoperative drainage features.

Variable	Value
Total drainage (mL)	2425.87 ± 1435.79
Total drainage (mL/kg/day)	7.48 ± 3.11
Drains in situ (days)	5.35 ± 3.10

Late Survival and Blood Pressure Outcomes

Follow-up information was available in 22 patients. The median follow-up among survivors was 41.50 months (IQR 16.75–64.50 months). Follow-up revealed two post-discharge deaths. One patient died of bypass graft infection 5 years after initial surgery. One patient died of sudden cardiac arrest 3.5 years after initial surgery. The 6-year survival was 76.39% (Figure 5). All grafts were patent at the end of follow-up.

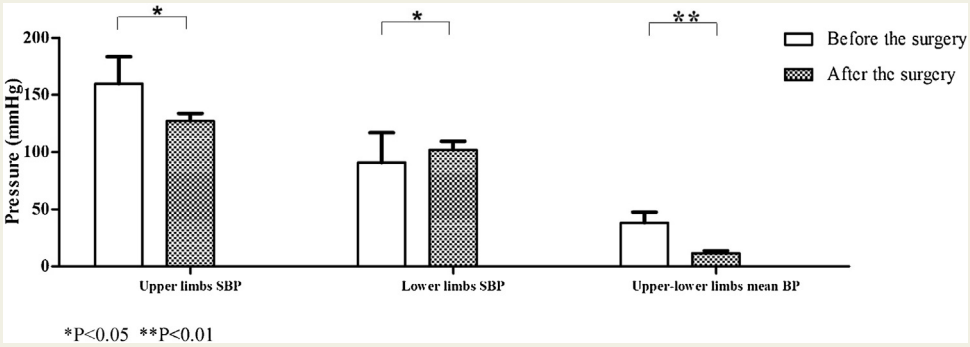

Figure 3 Change in blood pressure before and after surgery.

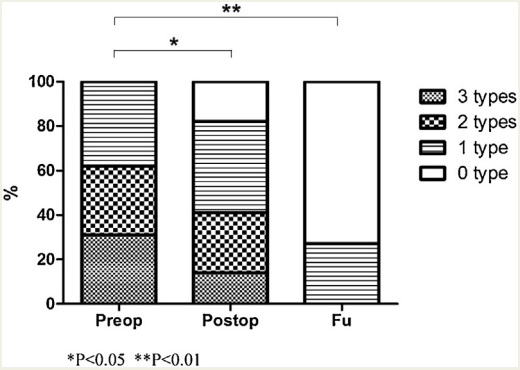

Figure 4 Change in antihypertensive medications.

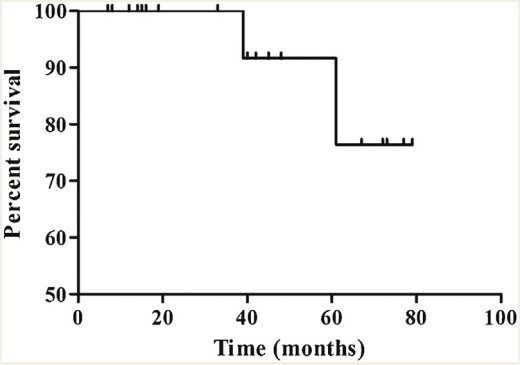

Figure 5 Survival of patients undergoing one-stage repair for adults aortic coarctation concomitant with cardiac diseases.

Seven (7) patients needed to take one antihypertensive drug to control mild hypertension despite an excellent gradient reduction. Fifteen (15) patients were normotensive and did not need antihypertensive treatment. The median number of antihypertensive drugs was 0 (IQR 0–1), which was a significant reduction compared with number of drugs before surgery (2, IQR 1–3) ($p = 0.001$) (Figure 4).

Discussion

Aortic coarctation correction usually involves the use of one of the following techniques: resection of the abnormal aortic segment and end-to-end anastomosis; subclavian flap aortoplasty; graft patch aortoplasty; bypass grafting; or percutaneous balloon aortoplasty. However, when COA is combined with cardiac diseases, the treatment strategy continues to be controversial with regard to the best and safest approach. Traditional options in these circumstances may include a staged approach with sternotomy and thoracotomy. Conventional anatomic repair of the COA by posterolateral thoracotomy requires mobilisation of the aorta in the presence of collateral blood vessels, which may be extensive in adults with long-standing coarctation. Damage to the recurrent laryngeal or phrenic nerves, chylothorax and spinal cord ischaemia may occur. Moreover, there is a considerably increased cardiac risk when coarctation surgery is performed before severe concomitant cardiac pathology has been addressed. Anatomical surgical repair in patients with complex forms of coarctation is associated with high mortality and morbidity [5,6]. Many cases are treated with palliative rather than corrective surgical procedures [7,8].

Extra-anatomical bypass represents a strategy that allows a single-stage repair of coarctation and concomitant cardiac pathology through median sternotomy. Edie first described the ascending to descending bypass through a left thoracotomy and median sternotomy with grafts [9]. Wukasch first described ascending-abdominal aorta bypass through a median sternotomy laparotomy [10]. Vijayanagar described aortic bypass posterior to the heart through a median sternotomy [11]. The literature of extra-anatomical bypass is not extensive nowadays. Most authors prefer ascending to descending bypass. In Said's study [12], 80 consecutive patients with complex coarctation underwent ascending to descending posterior pericardial aortic bypass through a median sternotomy, which included the largest number of patients to the best of our knowledge. The author concluded that ascending to descending aortic bypass could be performed with low morbidity and mortality. However, re-exploration for postoperative bleeding was 8%, atrial fibrillation was 17% and postpericardiotomy syndrome was 2%

[12]. The incidence of postoperative bleeding in other studies varied from 5 to 10%, which is higher than routine coronary artery or valvular surgery [13–15]. Our team performed 10 ascending to descending aortic bypasses 10 years ago [15]. Our initial experience showed that descending aortic anastomotic haemorrhage is a severe complication. We strongly emphasise that meticulous control of bleeding is mandatory for a safe descending aortic anastomosis, because the location is difficult to reach in the event that further intervention is needed to control the bleeding while weaning the patient from CPB. It has been reported that the average duration for postoperative pericardial drains *in situ* is 7 days after ascending to descending aortic bypass [16]. It is reasonable to speculate that the prolonged effusions are related to intrapericardial implantation of a long graft segment. Other complications include delayed mediastinitis and pericardial effusion, which also might be related to transudation of plasma through the grafts of the pericardial cavity. As for ascending to abdominal aorta bypass technique in our centre, we placed the graft in the right pleural cavity, which facilitated possible median sternotomy reoperation in the future, and reduced the postoperative drain time *in situ*. The average time of drain *in situ* was 5.35 days in our study, which is shorter than that of ascending to descending aortic bypass [16]. The transudation of plasma through the grafts enters the right pleural cavity, which might explain why we had no delayed mediastinitis and pericardial effusion.

Potential drawbacks of the use of prosthetic material are thrombosis, infection and aneurysm. Although late true aneurysm is well known after prosthetic patch aortoplasty, true aneurysm may also be observed after ascending to descending aortic bypass [17]. The mechanisms might include congenital weakness of the descending aortic anastomotic site, abnormal tension caused by rigidity of the graft against the aortic wall. The abdominal aorta anastomotic site is far from the coarctation and the aortic wall is normal. Theoretically, the probability of true aneurysm of the abdominal aorta is low. In fact, true aneurysm did not occur in our study. Graft infection represents one of the severe complications associated with high mortality. Vogel studied 12,626 patients who underwent, between 1987 and 2005, open repair for abdominal aortic aneurysms. The 2-year rate of aortic graft infection was 0.19% [18]. The general consensus with graft infection is that infected graft material should be completely removed and replaced by autogenous material or reconstructed extra-anatomically, as conservative management is usually associated with poor outcome [19,20]. In the current study, one patient suffered graft infection 5 years after initial surgery. We chose conservative treatment and the patient died of infection finally.

Paraplegia is a rare but devastating complication after coarctation repair. The probability of spinal complications after coarctation repair is 0–0.5% [21,22,23]. Ungerleider and colleagues reviewed 973 patients from the Society of Thoracic Surgeons Congenital Heart Surgery Database since 2010 and found that the incidence of spinal cord injury was zero [23]. Older age is associated with an increased incidence of paraplegia. Lerberg and associates reported an incidence of 5% for patients older than 11 years [22]. Paraplegia occurs due to an ischaemic insult to the spinal cord. The advantage of employing extra-anatomical bypass is that extensive dissection and cross-clamping of the aorta are avoided. What is more, the use of CPB, which is mostly necessary to repair concomitant cardiac pathology, also can minimise the risk of paraplegia. Clinical and experimental studies have shown that distal aortic pressure >70 mmHg can preserve spinal blood flow [24]. In our centre, cannulation of the abdominal aorta through a prosthetic graft is used for CPB to maintain high distal perfusion pressure, which also eliminates the risk of spinal cord ischaemia. In the current study, we did not document paraplegia in any patient, which points to the safety of the ascending to abdominal aorta bypass.

The incidence of gastrointestinal complications (GIC) after cardiac surgery is variably reported in studies with an average incidence of approximately 1.2% in recent 10 years [25]. The most common complication reported overall is gastrointestinal bleeding, accounting for approximately 35% of GIC [25]. The ascending to abdominal aorta bypass technique may increase the GIC theoretically. The potential complications include graft infection, mechanical ileus, aortoduodenal fistula, gastrointestinal bleeding, and so on. The literatures of GIC after ascending to descending aorta bypass or ascending to abdominal aorta bypass are rare. Previous reports have focussed on the prevalence and the outcome of GIC, after open repair of infrarenal aortic aneurysm. The incidence of GIC ranges from 5.4% to 8.6% [26,27,28]. Although a number of possible risk factors for GIC have been proposed, visceral hypoperfusion appears to be the common pathologic mechanism [29,30,31]. In current research, using of upper and lower body perfusion technique may decrease the risk of visceral hypoperfusion, which could contribute to the low incidence of GIC.

In our study, there was a significant reduction in baseline systolic blood pressure from 159.80 ± 23.58 to 127.0 ± 6.86 mmHg ($p = 0.01$) after surgery, which was similar to the results of ascending to descending aortic bypass reported by Said [12]. However, in that study, although the average number of antihypertensive drugs decreased significantly during the early postoperative period, this difference did not persist during long-term follow-up. He concluded that older age might be the reason. In our study, we found that the significant difference persisted during mid-term follow-up. It should be noted the follow-up time of our study was shorter than in the previous study. Hager and associates demonstrated that only 30% of patients were normotensive without drug therapy at the age of 40–49 years and only 10% were normotensive at the age of 50–72 years [32]. However, even if complete elimination or long-lasting reduction of medical therapy is not achieved, the initial reduction of antihypertensive therapy also emphasises the effectiveness of ascending to abdominal aorta bypass technique during and immediately after surgery.

Limitations

The main limitation of this study was the small sample size.

Conclusions

The in-hospital outcome and mid-term results were satisfactory. Ascending to abdominal aorta extra-anatomical bypass combined with cardiac surgery is a safe and effective one-stage repair technique for adult patients with COA concomitant with cardiac diseases.

Acknowledgment

This work was supported by National Science & Technology Support Program of China (No.2015BAI12B03) and Beijing Major Science & Technology Projects from Beijing Municipal Science & Technology Commission (No.Z171100001017083).

Conflict of Interest

Nothing to declare.

References

[1] Torok RD, Campbell MJ, Fleming GA, Hill KD. Coarctation of the aorta: management from infancy to adulthood. World J Cardiol 2015;7(11):765–75.
[2] Warnes CA. Bicuspid aortic valve and coarctation: two villains part of a diffuse problem. Heart 2003;89(9):965–6.
[3] Becker AE, Becker MJ, Edwards JE. Anomalies associated with coarctation of aorta: particular reference to infancy. Circulation 1970;41(6):1067–75.
[4] Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo Jr JL, et al. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. JAMA 2003;289(19):2560–72.
[5] Pennington DG, Liberthson RR, Jacobs M, Scully H, Goldblatt A, Daggett WM. Critical review of experience with surgical repair of coarctation of the aorta. J Thorac Cardiovasc Surg 1979;77(2):217–29.
[6] Fisher M, Sacco RL. Prophylactic neuroprotection for cerebral ischemia. Stroke 1994;25(5):1075–80.
[7] Grinda JM, Mace L, Dervanian P, Folliguet TA, Neveux JY. Bypass graft for complex forms of isthmic aortic coarctation in adults. Ann Thorac Surg 1995;60(5):1299–302.
[8] Caspi J, Ilbawi MN, Milo S, Bar-El Y, Roberson DA, Thilenius OG, et al. Alternative techniques for surgical management of recoarctation. Eur J Cardiothorac Surg 1997;12(1):116–9.
[9] Edie RN, Janani J, Attai LA, Malm JR, Robinson G. Bypass grafts for recurrent or complex coarctations of the aorta. Ann Thorac Surg 1975;20 (5):558–66.
[10] Wukasch DC, Cooley DA, Sandiford FM, Nappi G, Reul Jr GJ. Ascending aorta abdominal aorta bypass: indications, technique, and report of 12 patients. Ann Thorac Surg 1977;23(5):442–8.
[11] Vijayanagar R, Natarajan P, Eckstein PF, Bognolo DA, Toole JC. Aortic valvular insufficiency and postductal aortic coarctation in the adult: combined surgical management through medial sternotomy: a new surgical approach. J Thorac Cardiovasc Surg 1980;79(2):266–8.
[12] Said SM, Burkhart HM, Dearani JA, Connolly HM, Schaff HV. Ascending-to-descending aortic bypass: a simple solution to a complex problem. Ann Thorac Surg 2014;97(6):2041–7.
[13] Izhar U, Schaff HV, Mullany CJ, Daly RC, Orszulak TA. Posterior pericardial approach for ascending aorta-to-descending aorta bypass through a median sternotomy. Ann Thorac Surg 2000;70(1):31–7.
[14] Yin K, Zhang Z, Lin Y, Guo C, Sun Y, Tian Z, et al. Surgical management of aortic coarctation in adolescents and adults. Interact Cardiovasc Thorac Surg 2017;24(3):430–5.
[15] Wang R, Sun LZ, Hu XP, Ma WG, Chang Q, Zhu JM, et al. Treatment of complex coarctation and coarctation with cardiac lesions using extra-anatomic aortic bypass. J Vasc Surg 2010;51(5):1203–8.
[16] Brink J, Lee MG, Konstantinov IE, Cheung MM, Goh TH, Bennett M, et al. Complications of extra-anatomic aortic bypass for complex coarctation and aortic arch hypoplasia. Ann Thorac Surg 2013;95(2):676–81.
[17] Fujita T, Fukushima N, Taketani S, Kadoba K, Kagisaki K, Imagawa H, et al. Late true aneurysm after bypass grafting for long aortic coarctation. Ann Thorac Surg 1996;62(5):1511–3.
[18] Vogel TR, Symons R, Flum DR. The incidence and factors associated with graft infection after aortic aneurysm repair. J Vasc Surg 2008;47(2):264–9.
[19] Cernohorsky P, Reijnen MM, Tielliu IF, van Sterkenburg SM, van den Dungen JJ, Zeebregts CJ. The relevance of aortic endograft prosthetic infection. J Vasc Surg 2011;54(2):327–33.
[20] Sharif MA, Lee B, Lau LL, Ellis PK, Collins AJ, Blair PH, et al. Prosthetic stent graft infection after endovascular abdominal aortic aneurysm repair. J Vasc Surg 2007;46(3):442–8.
[21] Liberthson RR, Pennington DG, Jacobs ML, Daggett WM. Coarctation of the aorta: review of 234 patients and clarification of management problems. Am J Cardiol 1979;43(4):835–40.
[22] Lerberg DB, Hardesty RL, Siewers RD, Zuberbuhler JR, Bahnson HT. Coarctation of the aorta in infants and children: 25 years of experience. Ann Thorac Surg 1982;33(2):159–70.
[23] Ungerleider RM, Pasquali SK, Welke KF, Wallace AS, Ootaki Y, Quartermain MD, et al. Contemporary patterns of surgery and outcomes for aortic coarctation: an analysis of the Society of Thoracic Surgeons congenital heart surgery database. J Thorac Cardiovasc Surg 2013;145(1):150–7.
[24] Laschinger JC, Cunningham Jr JN, Nathan IM. Experimental and clinical assessment of the adequacy of partial bypass in maintenance of spinal cord blood flow during operation on the thoracic aorta. Ann Thorac Surg 1983;36(4):417–26.
[25] Rodriguez R, Robich MP, Plate JF, Trooskin SZ, Sellke FW. Gastrointestinal complications following cardiac surgery: a comprehensive review. J Card Surg 2010;25(2):188–97.
[26] Li C, Yang WH, Zhou J, Wu Y, Li YS, Wen SH, et al. Risk factors for predicting postoperative complications after open infrarenal abdominal aortic aneurysm repair: results from a single vascular center in China. J Clin Anesth 2013;25(5):371–8.
[27] Kim GS, Ahn HJ, Kim WH, Kim MJ, Lee SH. Risk factors for postoperative complications after open infrarenal abdominal aortic aneurysm repair in Koreans. Yonsei Med J 2011;52(2):339–46.
[28] Alpagut U, Kalko Y, Dayioglu E. Gastrointestinal complications after transperitoneal abdominal aortic surgery. Asian Cardiovasc Thorac Ann 2003;11(1):3–6.
[29] Spotnitz WD, Sanders RP, Hanks JB, Nolan SP, Tribble CG, Bergin JD, et al. General surgical complications can be predicted after cardiopulmonary bypass. Ann Surg 1995;221(5):489–96.
[30] Christenson JT, Schmuziger M, Maurice J, Simonet F, Velebit V. Postoperative visceral hypotension the common cause for gastrointestinal complications after cardiac surgery. Thorac Cardiovasc Surg 1994;42(3):152–7.
[31] Valentine RJ, Hagino RT, Jackson MR, Kakish HB, Bengtson TD, Clagett GP. Gastrointestinal complications after aortic surgery. J Vasc Surg 1998;28(3):404–11.
[32] Hager A, Kanz S, Kaemmerer H, Schreiber C, Hess J. Coarctation long-term assessment (COALA): significance of arterial hypertension in a cohort of 404 patients up to 27 years after surgical repair of isolated coarctation of the aorta, even in the absence of restenosis and prosthetic material. J Thorac Cardiovasc Surg 2007;134(3):738–45.