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Research Article

Improving Circulatory Support in Cases of Acute DeBakey Type I Aortic Dissection: A Novel Arterial Cannulation Approach and Its Effects on Perfusion and Minimizing Complications

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Objective. Proposing a novel arterial cannulation technique for acute DeBakey type I aortic dissection with severe aortic arch and branch involvement to enhance CPB effectiveness and reduce organ malperfusion complications. *Methods*. The technique involves retrograde insertion of an arterial perfusion tube into the aortic arch through the left common carotid artery. Extracorporeal circulation is established, and total aortic arch replacement with deep hypothermic systemic circulation and a frozen elephant trunk stent placement are performed to restore lower body perfusion. *Results*. Six patients with severe aortic arch and branch involvement underwent the new arterial cannulation technique. All patients had smooth postoperative recoveries without significant complications. *Conclusion*. The novel arterial cannulation technique shows promise in managing acute DeBakey type I aortic dissection with extensive vascular involvement, reducing complications, and enhancing patient outcomes. Further validation with a larger patient cohort is needed to confirm its effectiveness and safety. If successful, this technique could become a valuable addition to treatment strategies for improved outcomes.

1. Introduction

Acute DeBakey type I aortic dissection is a critical cardiovascular condition characterized by a sudden onset and a high case fatality rate [1]. Urgent intervention is necessary to prevent severe complications and mortality. Currently, traditional arterial cannulation methods, such as femoral artery cannulation, axillary artery cannulation, apical cannulation, and left subclavian artery cannulation, are employed in the treatment of aortic dissection [2, 3]. However, these conventional approaches pose challenges for patients with extensive involvement of the aortic arch and its three branches. These methods can result in elevated intraoperative perfusion pressure, excessive cerebral perfusion, and inadequate systemic organ perfusion [4]. These factors are closely associated with poor patient outcomes.

The aim of this article is to propose a novel arterial cannulation strategy for patients with severe involvement of the aortic arch and its three branches. The objective is to facilitate the application and adoption of this new arterial cannulation technique in clinical practice, thereby improving treatment outcomes and enhancing the quality of life of patients with acute DeBakey type I aortic dissection.

2. Methodology

A median sternal incision was made to expose the brachiocephalic trunk, left common carotid artery, and left subclavian artery. The extracorporeal circulation pipeline, three-branch perfusion tube, and puncture catheter were prepared (Figure 1(a)).

Initially, the venous tube was inserted into the right atrium, followed by transection of the proximal end of the left common carotid artery. The arterial perfusion tube was then inserted into the aortic arch. After confirming thoracic artery flow using colour ultrasound (Figure 1(b)), cardiopulmonary circulation was established. For cerebral perfusion, the distal end of the left common carotid artery was connected to the branch perfusion tube (Figure 1(d)).

Once the nasopharynx temperature reached 25°C, the perfusion tube of the brachiocephalic trunk and the branch of the left subclavian artery were inserted. The aortic arch was then cut off, circulation in the lower body was stopped, and antegrade cerebral perfusion was initiated at a rate of 5–8 ml/kg/min. The frozen elephant trunk stent was released into the true lumen of the descending aorta. The distal end of the elephant trunk was anastomosed with the covered stent in an end-to-end fashion, allowing for restoration of lower body perfusion through the fourth branch of elephant trunk. The proximal end of the artificial vessel was anastomosed with the aortic root in an end-to-end fashion. Following rewarming, the left subclavian artery, left common carotid artery, and brachiocephalic trunk were sequentially anastomosed.

This method was utilized for cardiopulmonary bypass in six patients with severe involvement of the aortic arch and its branches.

3. Results

In this clinical study, a novel arterial cannulation technique was applied to six patients with acute DeBakey type I aortic dissection and severe involvement of the aortic arch and its branches. The average age of the patients was 48.7 ± 17.3 years, with a male-to-female ratio of 2 : 1. Most patients presented with hypertension (83.3%) and had aortic involvement of less than 50% with significant compression of the true lumen in the aortic arch and its three branches. Surgical methods included Bentall procedure with aortic arch replacement and descending aortic stent implantation (16.7%) or replacement of the ascending aorta with aortic arch and stent placement in the descending aorta (83.3%).

Using the novel technique, successful extracorporeal circulation was achieved in all patients, with an average circulation time of 214.8 ± 11.3 minutes and aortic occlusion time of 135.0 ± 11.9 minutes. The average nasopharyngeal temperature during surgery was maintained at 25.4 ± 0.6°C, indicating successful deep hypothermic systemic circulation.

Postoperative recovery was uneventful for all patients, with an average ICU stay of 6.8 ± 2.2 days. Extubation was achieved at an average of 27.83 ± 12.54 hours after surgery, and patients showed good bed mobility, with an average duration of 4.5 ± 1.0 days. Three cases (50.0%) experienced pleural effusion, but no other major complications were observed, including cerebral infarction, myocardial infarction, heart failure, postoperative delirium, paraplegia, secondary thoracotomy, incision infection, or liver and kidney dysfunction.

The novel arterial cannulation technique demonstrated favorable outcomes in managing acute DeBakey type I aortic dissection with extensive vascular involvement. Although the study has a limited sample size and lacks a control group, the results are promising. Further investigation with a larger patient cohort is warranted to validate the effectiveness and safety of this approach fully. If proven successful, this technique has the potential to become a valuable addition to treatment strategies for improving outcomes in such cases.

Preoperative planning through a thorough analysis of aortic CTA images and bedside vascular ultrasound played a crucial role in determining the suitability of the novel technique for patients with severe vascular involvement. The specific true luminal involvement of the aortic arch and its three supra-arch branches for each patient is detailed in Table 1.

Table 2 summarizes the preoperative, intraoperative, and postoperative parameters, while Figure 1 illustrates the various steps involved in the novel arterial cannulation technique during extracorporeal circulation and aortic root surgery.

4. Discussion

The smooth establishment of cardiopulmonary bypass (CPB) is a prerequisite for the implementation of vascular replacement surgery and plays a pivotal role in aortic dissection surgery. Choosing the location of cannulation based on vascular involvement is the core of establishing extracorporeal circulation. At present, the axillary artery, femoral artery, femoral axillary joint, central artery, apex of heart, and other parts are often used clinically for arterial intubation [5], but for patients with obvious involvement of the aortic arch and three branches above the arch, conventional intubation methods have the risk of poor organ perfusion and related complications, such as cerebral infarction, paralysis, and delayed recovery, which seriously affect the postoperative rehabilitation and the long-term quality of life of patients [6]. Since January 2022, a new arterial cannulation technique to establish cardiopulmonary bypass has been implemented at our centre. The technique was first implemented in 6 patients who were treated at our centre. In this technique, the sequence of the cardiopulmonary bypass is adjusted, an arterial perfusion tube is retrogradely inserted into the aortic arch through the left common carotid artery, and the aortic blood substitute tube is replaced. In our clinical practice, the incision of the axillary artery and femoral artery was not lengthened in any of the six patients, and no obvious complications occurred during or after the operation. All of the patients recovered and were discharged from the hospital, indicating that this new intubation method has achieved good clinical efficacy and helps to reduce the occurrence of intraoperative and postoperative complications in such patients as well as

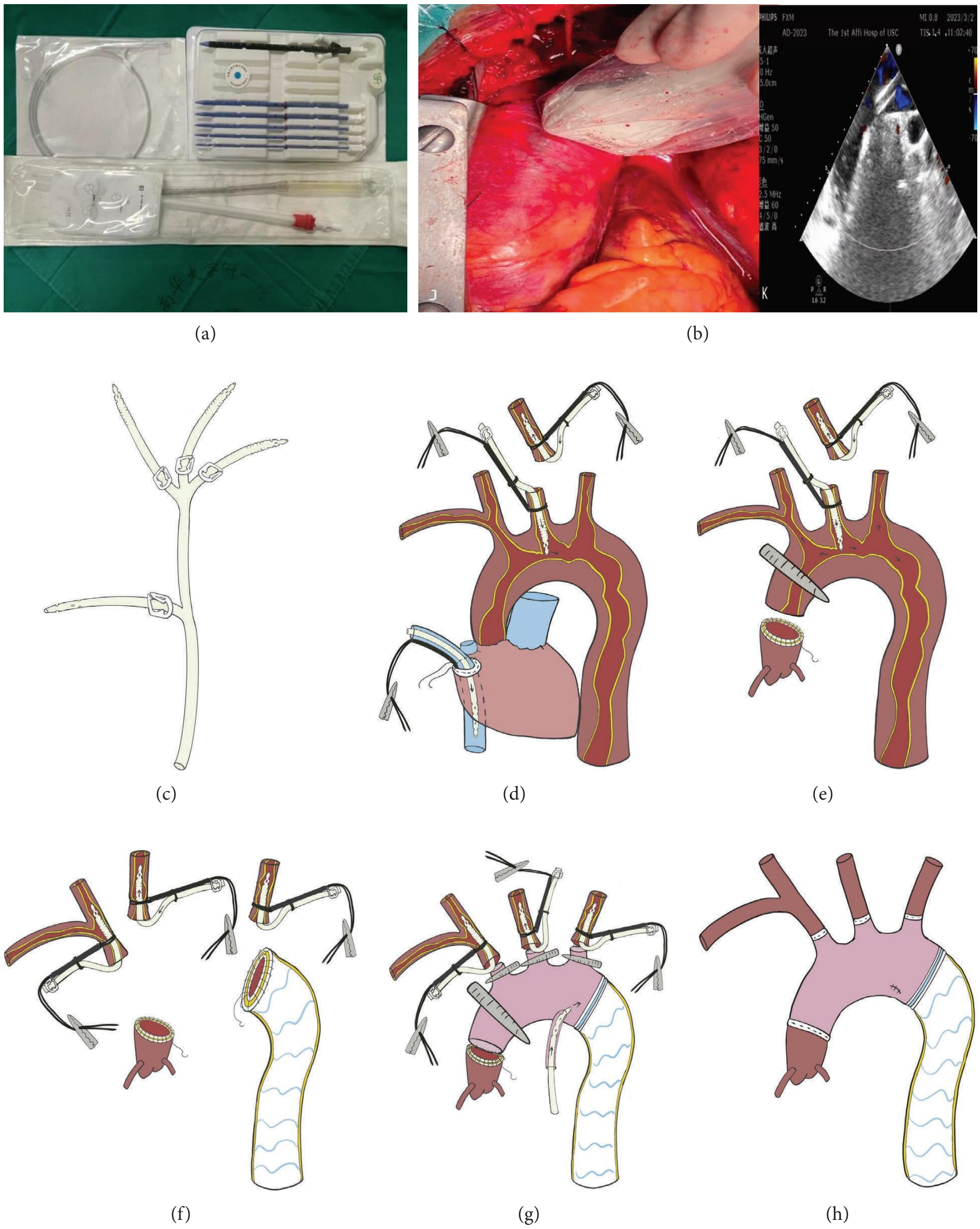

Figure 1: (a) Composition of extracorporeal circulation arteries and arterial puncture devices. (b) Transthoracic vascular ultrasound image. (c) Arterial perfusion tube and three-branch perfusion tube. (d) Establishment of extracorporeal circulation. (e) Aortic root surgery. (f, g) Total aortic arch replacement + frozen elephant trunk technology. (h) Postoperative schematic diagram.

Table 1: True luminal involvement of the aortic arch and three supra-arch branches.

Case	Aortic arch (%)	Cephalbrachial trunk (%)	Left common carotid artery (%)	Left subclavian artery (%)
1	<50	>90	>90	0
2	<50	>50	>50	>50
3	<50	>50	>50	>60
4	<50	>70	>70	>70
5	<50	>80	>80	>50
6	<50	>60	>60	>60

Table 2: Preoperative, intraoperative, and postoperative parameters.

Variable	Value	Stats
Age	Mean ± SD	48.7 ± 17.3
Sex	Male	4 (66.7%)
	Female	2 (33.3%)
Height (m)	Mean ± SD	1.7 ± 0.1
Weight (kg)	Mean ± SD	76.4 ± 17.1
BMI (kg/m^2)	Mean ± SD	27.0 ± 3.7
Hypertension	No	1 (16.7%)
	Yes	5 (83.3%)
Coronary heart disease	No	6 (100.0%)
	Yes	0 (0.0%)
Hyperlipidaemia	No	4 (66.7%)
	Yes	2 (33.3%)
Diabetes	No	6 (100.0%)
	Yes	0 (0.0%)
Surgical method	Bentall + aortic arch replacement + descending aortic stent implantation	1 (16.7%)
	Replacement of ascending aorta + replacement of aortic arch + stent placement of descending aorta	5 (83.3%)
Total drainage flow (ml)	Mean ± SD	1410 ± 200
ICU time (day)	Mean ± SD	6.8 ± 2.2
Awakening time (h)	Mean ± SD	2.8 ± 1.7
Extubation time (h)	Mean ± SD	27.83 ± 12.54
Postoperative complications	None	3 (50.0%)
	Pleural effusion	3 (50.0%)
Postoperative bed mobility (day)	Mean ± SD	4.5 ± 1.0
Surgery time (min)	Mean ± SD	489.3 ± 74.5
Total time of extracorporeal circulation (min)	Mean ± SD	214.8 ± 11.3
Aortic occlusion time (min)	Mean ± SD	135.0 ± 11.9
Rewarming time (min)	Mean ± SD	66.7 ± 10.7
Selective cerebral perfusion time (min)	Mean ± SD	33.5 ± 4.7
Min nasopharyngeal temperature (°C)	Mean ± SD	25.4 ± 0.6
Lower body arrest (min)	Mean ± SD	34.33 ± 4.7

improve the prognosis of such patients. In summary, we have tentatively attempted to establish a new arterial cannulation method for extracorporeal circulation to complete the surgery. In the future, we plan to include more patients for exploration and process improvement to further confirm the effectiveness and safety of this arterial cannulation method.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Disclosure

The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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