Original Article

Epiaortic Ultrasound-Guided True Lumen Cannulation of Ascending Aorta in Acute Aortic Dissection Type A

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Background: The choice of arterial inflow for acute Stanford type A aortic dissection repair remains controversial. The axillary artery should be considered as first choice for cannulation, but this technique is time-consuming. The ascending aortic cannulation provides antegrade perfusion and can be performed rapidly but there are several concerns such as aortic rupture, extension of dissection, and false lumen cannulation.

Objective: To compare the establishment time of cardiopulmonary bypass (CPB) and postoperative outcomes of the two cannulation techniques that provide antegrade perfusion, which was direct true lumen cannulation on the dissected ascending aorta using epiaortic ultrasound-guided and axillary artery cannulation in Siriraj Hospital.

Materials and Methods: The authors retrospectively reviewed all the 30 cases of acute aortic dissection type A using two different cannulation methods performed between February 2011 and May 2017. Direct true lumen ascending aortic cannulation was performed using the epiaortic ultrasound-guide with Seldinger technique in 12 patients, and axillary artery cannulation was performed in 18 patients.

Results: The direct true lumen ascending aortic cannulation was safely performed in all patients. None of them had aortic rupture. Skin incision to CPB time was significantly faster in the epiaortic ultrasound-guided ascending aortic cannulation group at 29±8 versus 49±14 minutes ($p<0.001$). The 30-day mortality and postoperative adverse events, such as ischemic stroke, acute kidney injury, visceral organ and limb malperfusion showed no statistically significant difference from the axillary artery cannulation method.

Conclusion: Epiaortic ultrasound-guided true lumen cannulation of ascending aorta in the treatment of acute aortic dissection type A is safe and feasible. Skin incision to CPB time can be performed faster and provided good outcome compared to the axillary artery cannulation technique.

Keywords: Acute aortic dissection, Ascending cannulation, Epiaortic ultrasound

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Stanford type A acute aortic dissection is a life-threatening emergency condition that cause high mortality and morbidity such as stroke, acute kidney injury, visceral organ, and limb malperfusion. Femoral artery cannulation remains the standard cannulation site for repair acute aortic dissection type A. However, retrograde blood flow has a potential risk of cerebral embolization and organ malperfusion[1-3]. As an alternative inflow, the axillary artery has the advantage of antegrade perfusion, which prevents retrograde thromboembolism and organ malperfusion[4-6]. However, this technique is time-consuming and is not suitable for rapid establishment in the hemodynamic instable patients. Additionally, in small patient, narrow axillary artery may be insufficient caliber for arterial inflow. Furthermore, dissected axillary artery cannot be used for arterial inflow. Recently, several centers reported the result of acute aortic dissection type A repair by direct cannulation into true lumen of the dissected ascending aorta. This technique can be performed rapidly and safely, and useful in cases of dissected axillary artery[7-13]. Direct true lumen cannulation on the dissected ascending aorta using epiaortic ultrasound-guided has been performed in Siriraj Hospital since February 2016. The authors evaluated its safety and rapidity. The aim of the present study was to compare the skin incision to established cardiopulmonary bypass (CPB) time and postoperative outcomes of the two cannulation techniques providing antegrade perfusion, which was direct true lumen cannulation on the dissected ascending aorta using epiaortic ultrasound-guided and axillary artery cannulation in Siriraj Hospital.

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Materials and Methods

The present study was approved by Siriraj Institutional Review Board (Si 429/2017). The study design was a retrospective review of 30 cases of acute aortic dissection type A performed by single surgeon in Siriraj Hospital using two different cannulation methods between February 2011 and May 2017. Direct true lumen ascending aortic cannulation was performed using the epiaortic ultrasound-guide with Seldinger technique in 12 patients, and axillary artery cannulation was performed in 18 patients. The primary end point was establishment of CPB time. The secondary end points were rates of postoperative death, 30-day mortality, and postoperative adverse events such as ischemic stroke, acute kidney injury, visceral organ malperfusion, limb malperfusion, and brachial plexus injury.

Surgical procedure

Surgery was performed through median sternotomy, 3 mg/kg of heparin was administered as required to achieve an activated clotting time of higher than 400 seconds. In case of direct true lumen ascending aortic cannulation, epiaortic ultrasonography was used to identify true and false lumen. After the needle was punctured within the true lumen under epiaortic ultrasonography, a guidewire was advanced into the true lumen. The position of the guidewire was confirmed by transesophageal echocardiography. Then the aortic cannulation site was dilated with 3-staged dilators. The 19-Fr femoral arterial cannula (Bio-Medicus: Medtronic, Inc., Minneapolis, MN, USA) was then inserted over the guidewire. A double-purse-string sutures was placed around the aortic cannula to ensure it was fixed snugly. In case of axillary artery cannulation, the right axillary artery was access via infraclavicular incision. After the axillary artery was identified and dissected, the 8-mm Gelweave vascular tube graft was end to side anastomosed to the right axillary artery using 5-0 polypropylene continuous suture. The 19-Fr femoral arterial cannula (Bio-Medicus: Medtronic, Inc., Minneapolis, MN, USA) was inserted to the vascular graft and fixed tightly. Then CPB was established with a 2-stage venous cannula. The patient was cooled down to 25°C. After the aorta was cross-clamped and opened, Custodiol HTK solution was infused directly into the coronary ostium in direct true lumen ascending aortic cannulation cases. In case of axillary artery cannulation, the combined antegrade and retrograde cold blood cardioplegia was given every 20 minutes. After heart ceased, the appropriate procedures for a proximal aorta and aortic valve were performed. Bioglue was sprayed to the anastomosis. The aortic valve and anastomosis were tested, and the CPB flow was stopped after the body temperature reached 25°C. Selective antegrade cerebral perfusion was started by using cerebral oxygenation monitoring. During this circulatory arrest, the aortic cannula was removed, and the aortic arch was explored. If the tear was found in the aortic arch, then total arch replacement was performed using 4-branch Gelweave graft. If the tear was confined to the ascending aorta, hemiarch replacement was performed using Ante-Flo Gelweave graft. The heart was de-aired via side branch of the graft then the CPB was re-established using side branch of the graft. When rewarming was completed, the patient could be weaned off from CPB.

Statistical analysis

All statistical analyses were performed using the commercial statistical PASW Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA). The continuous variables were expressed as the means ± standard deviation. The categorical variables were presented as total numbers of patients and percentages. Comparisons between continuous variables were performed using Student t-test, and the categorical variables were compared by the chi-square (χ^2) test. A p-value of less than 0.05 was considered to be statically significant.

Results

Preoperative patient characteristics are shown in Table 1. The two groups were similar with regard to preoperative patient characteristics except acute severe aortic regurgitation was significantly higher in the epiaortic ultrasound-guided ascending aortic cannulation group at 50% versus 11.11%, (p=0.018).

The authors found the direct true lumen ascending aortic cannulation under epiaortic ultrasound-guide was safe, and none of the patients had aortic rupture. However, one patient had false lumen cannulation after establishing CPB for a few minutes, then, changed to right femoral artery cannulation. The operative times and procedures are listed in Table 2. In the epiaortic ultrasound-guided ascending aortic cannulation group, the operations performed were ascending aortic replacement plus hemiarch replacement in six patients, ascending aortic replacement plus hemiarch replacement and aortic valve replacement in one patient, ascending aortic replacement plus hemiarch replacement and coronary artery bypass surgery (CABG) in one patient, ascending aortic

Table 1. Preoperative patient characteristics

	Epiaortic US guided ascending aortic cannulation (n=12); n (%)	Axillary artery cannulation (n=18); n (%)	p-value
Age (year); mean±SD	53.9±13.3	58.6±16.3	0.419
Sex: male/female	6/6	13/5	0.216
Underlying diseases			
CAD	0 (0.00)	1 (5.56)	0.406
DM	0 (0.00)	4 (28.57)	0.079
HT	2 (16.67)	1 (5.56)	0.320
CVA	1 (8.33)	0 (0.00)	0.213
CKD	2 (16.67)	4 (28.57)	0.707
• No dialysis	2 (16.67)	3 (16.67)	
• Dialysis	0 (0.00)	1 (5.56)	
DLP	1 (8.33)	4 (28.57)	0.317
PAD	1 (8.33)	0 (0.00)	0.213
COPD	0 (0.00)	0 (0.00)	0.001
Axillary artery dissection	1 (8.33)	0 (0.00)	0.213
Post cardiac arrest	1 (8.33)	1 (5.56)	0.765
Cardiac tamponade	1 (8.33)	3 (16.67)	0.511
Aortic rupture	0 (0.00)	1 (5.56)	0.406
Acute aortic regurgitation	6 (50.00)	2 (11.11)	0.018
Ischemic stroke	2 (16.67)	1 (5.56)	0.320
Visceral malperfusion	0 (0.00)	0 (0.00)	0.001
Renal malperfusion	1 (8.33)	1 (5.56)	0.765
Limb malperfusion	1 (8.33)	4 (28.57)	0.317
Shock status	1 (8.33)	0 (0.00)	0.213
LVEF			0.797
Unknown	2 (16.67)	2 (11.11)	
Good (>49%)	8 (66.67)	14 (77.78)	
Fair (30% to 49%)	2 (16.67)	2 (11.11)	
Poor (<30%)	0 (0.00)	0 (0.00)	
Previous thoracic operation	0 (0.00)	0 (0.00)	0.001
Inotrope	1 (8.33)	0 (0.00)	0.213
Ventilator	1 (8.33)	1 (5.56)	0.511
Coronary artery involvement	0 (0.00)	1 (5.56)	0.406

US=ultrasound; CAD=coronary artery disease; DM=diabetes mellitus; HT=hypertension; CVA=cerebrovascular accident; CKD=chronic kidney disease; DLP=dyslipidaemia; PAD=peripheral arterial disease; COPD=chronic obstructive pulmonary disease; LVEF=left ventricular ejection fraction; SD=standard deviation

replacement plus total arch replacement in one patient, Bentall's procedure plus hemiarch replacement in two patients, and Bentall's procedure plus hemiarch replacement and CABG in one patient. In the axillary artery cannulation group, the operations performed were ascending aortic replacement in seven patients, ascending aortic replacement plus hemiarch replacement in seven patients, ascending aortic replacement plus total arch replacement in one patient, ascending aortic replacement plus total arch replacement and proximal descending replacement in one patient, and Bentall's procedure in two patients. There were no significant differences in operative time (p=0.380), CPB time (p=0.172), and circulatory arrest time (p=0.535). Establishment of CPB time was significantly faster in the epiaortic ultrasound-guided ascending aortic cannulation group at 29±8 versus 49±14 minutes, (p=0.000).

Operative mortality and morbidities are listed in Table 3. No perioperative death was found. There

Table 2. Operative procedures

	Epiaortic US guided ascending aortic cannulation (n=12); n (%)	Axillary artery cannulation (n=18); n (%)	p-value
Aortic procedures			
Aortic root replacement	0 (0.00)	2 (11.11)	0.232
Ascending aortic replacement	0 (0.00)	7 (38.89)	0.014
Hemiarch/partial arch replacement	8 (66.67)	7 (38.89)	0.136
Total arch replacement	1 (8.33)	1 (5.56)	0.765
Aortic root and hemiarch replacement	3 (25.00)	0 (0.00)	0.025
Total arch and proximal descending aortic replacement	0 (0.00)	1 (5.56)	0.406
Proximal procedure			0.304
Aortic root replacement	3 (25.00)	2 (11.11)	
Supracoronary anastomosis	9 (75.00)	16 (88.89)	
Distal procedure			0.653
Total arch replacement	1 (8.33)	2 (11.11)	
Less than total arch replacement	11 (91.67)	16 (88.89)	
Asscociated procedures			
CABG	2 (16.67)	1 (5.56)	0.320
Aortic valve resuspension	7 (58.33)	2 (16.67)	0.016
Aortic valve replacement	1 (8.33)	0 (0.00)	0.213
ECMO	1 (8.33)	0 (0.00)	0.213
Swab packing	2 (16.67)	0 (0.00)	
Operation time (minute); mean±SD	345±118	311±91	0.380
Skin to CPB time (minute); mean±SD	29±8	49±14	<0.001
CPB time (minute); mean±SD	116±56	138±54	0.172
Cross-clamp time (minute); mean±SD	114±44	94±35	0.182
Use of circulatory arrest; mean±SD	12 (100)	17 (94.44)	0.406
Circulatory arrest time (minute); mean±SD	25±21	30±15	0.535
Use of SCP	5 (41.67)	2 (11.11)	0.053
SCP time (minute); mean±SD	27±5	55±36	0.096

US=ultrasound; CABG=coronary artery bypass grafting; ECMO=extracorporeal membrane oxygenation; CPB=cardiopulmonary bypass; SCP=selective cerebral perfusion; SD=standard deviation

were no statistically significant differences between the two groups regarding 30-day mortality, which were 16% in the aortic group and 11% in the axillary group, (p=0.317), intensive care unit (ICU) stay, which was 5 with 2 to 8 days in the aortic group and 5 with 2 to 8 days in the axillary group, (p=0.848), hospital stay, which was 12, 8 to 16 days in the aortic group and 15 with 4 to 25 days in the axillary group, (p=0.646), or weaning form ventilator time, which was 94 with 27 to 162 hours in the aortic group and 108 with 7 to 210 hours in the axillary group, (p=0.826). Other postoperative adverse events such as cardiac and pulmonary complication or bowel and limb ischemia did not show any significant differences between the two groups. One patient in the axillary group had right brachial plexus injury but just only musculocutaneous branch. The patient in the aortic group who was cannulated in false lumen, did not have major adverse event except blue toe syndrome. After received heparin, he improved.

Discussion

Epiaortic ultrasound-guided true lumen cannulation of ascending aorta is fast, uncomplicated, and provide antegrade perfusion. The advantage over the axillary cannulation is that it can be performed in dissected axillary artery and is suitable in hemodynamic instable patients. Moreover, this technique does not require the second incision, and peripheral vascular injury and brachial plexus injury can be avoided. However, false lumen cannulation and aortic rupture should be of concern in this technique.

Table 3. Post-operative course

	Epiaortic US guided ascending aortic cannulation (n=12); n (%)	Axillary artery cannulation (n=18); n (%)	p-value
30-day mortality	2 (16.67)	2 (11.11)	0.531
ICU stay (day)	5, (2 to 8)	5, (2 to 8)	0.848
Hospital stay (day)	12, (8 to 16)	15, (4 to 25)	0.646
Ventilator (hour)	94, (27 to 162)	108, (7 to 210)	0.826
Complication			
Cardiac complication	2 (16.67)	2 (11.11)	0.661
Pulmonary complication	5 (41.67)	5 (27.78)	0.429
Neurologic complication	1 (8.33)	4 (22.22)	0.317
Renal complication	3 (25.00)	2 (11.11)	0.400
• No dialysis	1 (8.33)	0 (0.00)	
• Dialysis	2 (16.67)	2 (11.11)	
GI complication	0 (0.00)	0 (0.00)	0.001
Limb ischemia	0 (0.00)	1 (5.56)	0.406
Sepsis	1 (8.33)	4 (22.22)	0.317
Brachial plexus injury	0 (0.00)	1 (5.56)	0.406
Re-operation	0 (0.00)	3 (16.67)	0.329

US=ultrasound; ICU=intensive care unit; GI=gastrointestinal; SD=standard deviation

In the present study, the surgeon cannulated into the false lumen in one patient, despite epiaortic ultrasound and transesophageal echocardiography guidance. These may be the large intimal tear that provide equal perfusion in the true and false lumen. The false lumen cannulation can be recognized after CPB was established because of sudden pressure elevation in the arterial cannula. Then, the CPB was stopped and switched to femoral artery cannulation. These patients were safe with no aortic rupture.

Limitation

Although the present study has reached its aims, there were some unavoidable limitations. First, this was a retrospective review, so the cannulation site was not chosen at random but according to patient status and surgeon preference. Second, the population of the present study is small, with only 30 patients that included 12 in aortic group and 18 in axillary group and might not represent the significant difference in 30-day mortality or other adverse events. Third, the present study was a report of a single surgeon experience, and the results may not be generalized to other settings.

Conclusion

Epiaortic ultrasound-guided true lumen cannulation of ascending aorta in the treatment of acute aortic dissection type A can be performed rapidly and safely. The 30-day mortality and postoperative adverse events such as ischemic stroke, acute kidney injury, visceral organ and limb malperfusion were not different from the axillary artery cannulation.

What is already known on this topic?

Several centers report the result of acute aortic dissection type A repair by direct cannulation into true lumen of the dissected ascending aorta. This technique can be performed rapidly and safely but there are several concerns such as aortic rupture, extension of dissection, and false lumen cannulation.

What this study adds?

Epiaortic ultrasound-guided true lumen cannulation of ascending aorta in the treatment of acute aortic dissection type A is safe and feasible. It provides faster skin incision to CPB time and a good outcome compared to the axillary artery cannulation technique.

Conflicts of interest

The authors declare no conflict of interest.

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