» **Original Article** «

Direct and Transapical Central Cannulation for Acute Type A Aortic Dissection

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Objective: The choice of cannulation site for the treatment of acute Stanford type A aortic dissection is much debated. We believe that central cannulation is quick to perform, easy to use, and safe to manage acute type A aortic dissection.

Materials and Methods: We retrospectively investigated 26 cases of acute aortic dissection performed using two different central cannulation methods between April 2011 and March 2012. Direct ascending aortic cannulation was performed using the Seldinger technique in 20 patients, and transapical ascending aortic cannulation was performed in six patients in whom puncture was difficult.

Results: Patients were 21–86 years old (mean age, 67 years). The surgical techniques used to treat aortic dissection were hemiarch repair in 21 patients and total arch replacement in 5 patients. The mean length of surgery was 393 min. One death (3.8%) was attributed to intestinal ischemia.

Conclusion: During surgery for acute aortic dissection, central cannulation using either transapical or direct puncture can be performed quickly and safely, and satisfactory short-term outcomes can be obtained. Because acute aortic dissection can present with various conditions, there is no single perfect surgical or cannulation method; therefore, the choice of surgical procedure should be individualized for each patient.

Keywords: aortic dissection, central cannulation, ascending cannulation

Introduction

The choice of cannulation site for the treatment of acute Stanford type A aortic dissection is much debated.^{1,2)} Although femoral artery cannulation has been traditionally performed,³⁾ central cannulation has recently been more favorably considered from the perspective of preventing malperfusion and embolism.⁴⁾ In addition, cannulation techniques such as axillary artery cannulation, direct ascending aortic cannulation, and transapical ascending aortic cannulation are gaining popularity.^{5–7)} We have historically performed tran-

sapical ascending aortic cannulation as a standard procedure to manage acute type A aortic dissection,⁷⁾ but we have recently used direct ascending aortic cannulation where possible because it is easier to perform. We use intraoperative epiaortic ultrasonography to determine if puncture and cannulation of the true aortal lumen are possible, and the cannulation catheter is then inserted under ultrasound guidance using the Seldinger technique. If difficulties are encountered during puncture, transapical ascending aortic cannulation is performed. We believe that ascending aortic cannulation is quick to perform, easy to use, and safe to manage acute type A aortic dissection.

In this study, we investigated 26 cases of acute aortic dissection performed between April 2011 and March 2012.

Materials and Methods

We retrospectively investigated 26 cases of acute aortic dissection performed using two different central

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cannulation methods between April 2011 and March 2012. Direct ascending aortic cannulation was performed using the Seldinger technique in 20 patients, and transapical ascending aortic cannulation was performed in 6 patients in whom puncture was difficult. In addition, concomitant femoral artery and ascending aortic cannulation were performed in 1 patient with concomitant intestinal malperfusion syndrome. When determining the cannulation site, preoperative computed tomography imaging (CT) was used to predict whether it would be possible to puncture the true lumen of the ascending aorta. However, each surgeon ultimately used epiaortic ultrasonography findings to determine the feasibility of this procedure intraoperatively. The surgical techniques used to treat aortic dissection were hemiarch repair in 21 patients and total arch replacement in 5 patients.

Direct ascending aortic cannulation using the Seldinger technique

Following median sternotomy, heparin was administered, systolic blood pressure was maintained at 100 mmHg or less, the pericardium was incised, and venous canulae were inserted into the superior and inferior vena cava. If epiaortic ultrasonography determined that puncture of the true lumen of the ascending aorta would be possible, then the surface of the aorta at the expected puncture site was marked with gentian violet. A 4-0 polypropylene mattress suture was placed at the marked site, and an 18- or 20-Fr thin-walled arterial cannula (Fem-Flex II arterial cannulae: Edwards Life Sciences Corporation, Irvine, California, USA) was inserted into the aorta using the Seldinger technique under epiaortic ultrasonography guidance. After insertion, epiaortic ultrasonography was used to confirm that the tip of the cannula was correctly inserted into the true lumen. Extracorporeal circulation using a heart-lung machine was initiated, and epiaortic ultrasonography and transesophageal echocardiography were used to confirm the route from the cannula to within the true lumen.

Transapical ascending aortic cannulation

Using epiaortic ultrasonography, if it was determined that puncture would be difficult, 1-cm long incision was made with a scalpel in the left ventricular cardiac apex, and a 7-mm cannula (Sarns Soft-flow Extended Aortic cannula: Terumo Cardiovascular Systems Corporation, Ann Arbor, Michigan, USA) was inserted

into the ascending aorta. Epiaortic ultrasonography and transesophageal echocardiography were then used to confirm the position and perfusion of the cannula. Repair of the site of cardiac apex cannulation was achieved by placing a 3-0 monofilament mattress suture after reconstructing the proximal edge of the aorta.⁷⁾

Surgical procedures

At our institution, the basic policy is to treat acute Stanford type A aortic dissection using a vascular prosthesis of the ascending aorta. The patients are placed into deep hypothermic circulatory arrest with rectal and bladder temperatures of below 25°C and a pharyngeal temperature of below 20°C. To create the distal aortic anastomosis, the distal aorta is opened under retrograde cerebral perfusion, and as much of the lesser curvature of the aortic arch as possible is resected; a hemiarch repair is then performed. Entry occurs via the greater curvature of the aortic arch; if the resection of the entry is difficult during hemiarch repair or if an aneurysm affects the aortic arch or the patient has Marfan syndrome, selective cerebral perfusion is concomitantly used and total arch replacement is performed. No glue is used during the reconstruction of the distal edge, whereas either BioGlue (Cryolife, Kennesaw, Georgia, USA) or GRF glue (Cardial, Technopole, Sainte-Etienne, France) is used during the reconstruction of the proximal edge. The anastomosis of the aorta and vascular graft are generally performed using the adventitial inversion technique.^{8,9)}

Statistical analysis

The continuous variables are expressed as the means $\pm$ standard deviation. Comparisons between continuous variables were performed using a one-way analysis of variance (ANOVA), and the categorical variables were compared by the χ^2 test. A P-value of <0.05 was considered to be statically significant. All statistical analyses were performed using the commercial statistical SPSS version 15.0 software program for windows (SPSS, Chicago, Illinois, USA).

Results

Patient characteristics (Table 1)

Preoperative patient backgrounds are shown in Table 1. Patients were 21–86 years old (mean age, 67 years). In the operating room, blood pressure was below

Table 1 Preoperative patients characteristics

Preoperative variables	Direct (n = 20)	Transapical (n = 6)	Total (n = 26)	P value
Age (years)	66.6 ± 15.7	69.7 ± 14.0	67.3 ± 15.1	0.672
Male gender	12 (60%)	3 (50%)	15 (57.7%)	1
Marfan syndrome	1 (5%)	0	1 (3.8%)	1
Previous stroke	1 (5%)	1 (16.7%)	2 (7.7%)	1
Shock	3 (15%)	1 (16.7%)	4 (15.4%)	1
Cardiac tamponade	3 (15%)	1 (16.7%)	4 (15.4%)	1
Cerebral ischemia	2 (10%)	1 (16.7%)	3 (11.5%)	1
Intestinal ischemia	0	1 (16.7%)	1 (3.8%)	0.24
Limb ischemia	0	1 (16.7%)	1 (3.8%)	0.24
Resuscitation	0	1 (16.7%)	1 (3.8%)	0.24

80 mmHg in four patients due to the onset of cardiac tamponade. One of these patients had been transferred from the emergency center to the operating room after undergoing resuscitation, which included endotracheal intubation and cardiac massage. In relation to malperfusion syndrome, the brain was affected in three patients, the bowel in one, and the lower extremities in one. Intestinal ischemia was also observed in the patient with ischemia of the lower extremities. Cerebral ischemia was defined as permanent or transient loss of consciousness. Intestinal ischemia was defined as having abdominal symptoms with definite CT findings of mesenteric artery occlusion. The patients just having mesenteric artery dissection without definite occlusion or symptoms were eliminated from intestinal ischemia.

Intraoperative parameter(s) (Table 2)

We determined that the puncture and cannulation of the ascending aorta was possible in 20 of 26 patients, and none of them experienced intraoperative difficulties. Additionally, transapical ascending aortic cannulation was performed with no difficulty in the remaining 6 patients. The surgical duration and summary of intraoperative data, including the technique used, is shown in Table 2. Hemiarch repair was performed in 21 patients, whereas total arch replacement was performed in five. One patient with Marfan's syndrome was observed to have high-grade aortic regurgitation and tricuspid regurgitation prior to the operation; therefore, the patient underwent simultaneous tricuspid annuloplasty and aortic root reconstruction using the Bentall procedure. Two patients required a second run of extracorporeal circulation in order to achieve hemostasis after the termination of extracorporeal circulation; one of them hemorrhaged from the posterior surface of the aortic root, and the other hemorrhaged

from the apical cannulation insertion site. Additional hemostasis for these patients was performed under extracorporeal circulation for safety reasons and was easily achieved.

Postoperative mortality and morbidities (Table 3)

Complications and death during the early postoperative period are shown in Table 3. One patient was suspected of having preoperative intestinal ischemia. The patient underwent transapical ascending aorta and femoral artery cannulation concomitantly provided symptomatic improvement and survived. However, 1 patient who only underwent direct ascending aorta cannulation developed intestinal ischemia postoperatively and subsequently died; thus, one death (3.8%) was attributed to intestinal ischemia. The patient's superior mesenteric artery was dissected and branched from false lumen preoperatively, although enhanced normally on contrast enhanced CT. One patient having preoperative impaired consciousness probably due to left internal carotid artery dissection suffered a permanent left hemisphere stroke and required a tracheostomy due to respiratory complications. Ultimately, the patient was weaned from the ventilator and transferred to a separate rehabilitation facility. There were no other differences observed between the direct and transapical ascending aortic cannulation groups. All other surviving patients were ambulatory at discharge.

Discussion

The ideal intraoperative cannulation method for acute aortic dissection needs to be quick, easy, and safe. In recent years, several surgeons have preferred axillary artery cannulation to prevent complications such as cerebral complications and malperfusion.^{6,10,11} When

Table 2 Intraoperative variables

Intraoperative variables	Direct (n = 20)	Transapical (n = 6)	Total (n = 26)	P value
Type of repair				
Hemiarch repair	16 (80%)	5 (83.3%)	21 (80.7%)	1
Total arch replacement	4 (20%)	1 (16.7%)	5 (19.2%)	1
Concomitant procedures				
Aortic root repair (Bentall)	1 (5%)	0	1 (3.8%)	1
TAP	1 (5%)	0	1 (3.8%)	1
F-F bypass	0	1 (16.7%)	1 (3.8%)	0.231
Second run for hemostasis	1 (5%)	1 (16.7%)	2 (7.7%)	0.415
Operating time (min)	384 ± 108.8	396.8 ± 94.1	387.6 ± 104.0	0.809

TAP: tricuspid annuloplasty; F-F bypass: femorofemoral bypass

Table 3 Postoperative variables

Postoperative variables	Direct (n = 20)	Transapical (n = 6)	Total (n = 26)	P value
Permanent stroke	1 (5%)	0	1 (3.8%)	1
Reoperation for hemastasis	1 (5%)	0	1 (3.8%)	1
Deep sternal infection	0	0	0	NA
Intestinal ischemia	1 (5%)	0	1 (3.8%)	1
In-hospital mortality	1 (5%)	0	1 (3.8%)	1

NA: not available

compared with femoral artery cannulation, axillary artery cannulation is considered to be much safer and more useful,^{6,10,11} but greater surgical skill is required to expose the axillary artery than the femoral artery; moreover, the lack of speed and convenience involved in the procedure are disadvantages when using a side graft for axillary artery cannulation compared with femoral artery cannulation. In addition, during axillary artery cannulation, problems such as cerebral ischemia and ischemia of the upper extremities can occur; thus, it may not be useful in all cases.^{12–14} Furthermore, the use of cannulation of the ascending aorta to treat acute aortic dissection has also been reported.^{4,5,15,16} Some institutions (such as ours) use the Seldinger technique for artery puncture and cannulation,^{15,17} while others use direct cannulation for ordinary open heart surgery.^{5,16} Both methods have been reported to be useful. At our institution, if preoperative ultrasound findings determine that puncture is safe, puncture of the true lumen of the ascending aorta is performed using the Seldinger technique; however, transapical ascending aortic cannulation is performed under the following conditions: stenosis of the true lumen, unstable hemodynamics, difficult puncture because of the distance between the true lumen and surface of the ascending aorta. During this study, four patients presented in a state of preoperative shock, but one received transapical ascending aortic cannulation because there was not sufficient

time to perform direct ascending aorta cannulation. Ultrasound-guided puncture is difficult in some patients depending on the morphological characteristics of the ascending aortic dissection, but we believe that ascending aorta puncture and ultrasound-guided cannulation is rapid and safe in most patients.

In 1976, Wada, et al. published the first paper on transapical cannulation. They conducted an experimental study and investigated its use in clinical cases, and found that it was a rapid and physiologically sound procedure.¹⁸ We have been performing transapical ascending aortic cannulation as a standard procedure to manage acute aortic dissection for some time; as a result, we can perform this procedure when direct cannulation of the ascending aorta is difficult. During the early stages of implementing ascending aorta cannulation, there was a great deal of uncertainty involved, and it was common to avoid direct ascending aorta cannulation and switch to the comparatively easier transapical ascending aortic cannulation method. However, after gaining experience by performing the procedure on an increased number of patients, the surgeons are now able to perform direct puncture of the ascending aorta more quickly, safely, and reliably. Therefore, the percentage of procedures involving transapical ascending aortic cannulation has begun to decline. During this study period, transapical aortic cannulation was performed in 6 of the 26 cases of type A aortic dissection. However, in the

subsequent 2-year period from April 2012 to March 2014, acute aortic cannulation was performed in 39 cases, and transapical aortic cannulation was performed only in two cases. No problems occurred in the 37 cases of direct aortic puncture, suggesting that direct puncture can be performed safely in most cases of aortic dissection.

In our experience until date, apart from a rare case for which hemostasis was required at the repaired site of the cardiac apex, there have been no major problems in conducting transapical aortic cannulation. Initially, transapical aortic cannulation was a standard procedure in which, as a rule, assessment of the cannulation position was mainly performed by an anesthetist using transesophageal echocardiography (TEE). However, depending on the skill of the TEE practitioner, there were cases where the assessment could not be performed rapidly. Therefore, the procedure has recently been modified so that the assessment of the cannulation position by the surgeon now includes the use of epiaortic echo. We believe that as the use of epiaortic echo for observation increases, cannulation to the true lumen by direct puncture may become possible in cases of type A acute aortic dissection. In these cases, the true lumen comes in close contact with the front or side of the aorta, enabling easy puncture without passing through a false lumen. Therefore, we started using direct puncture, and in time puncture through a false lumen became possible. Although a repair of the cannulation site in the left ventricle is required during transapical aortic cannulation, the technique has the advantage of reducing the likelihood of hemorrhagic complications because the puncture site for direct cannulation is in the area that will be resected. In addition, the surgeon can make a direct judgment using the epiaortic echo. Further, dependence on a transesophageal echocardiographer is not required. Whenever possible, transaortic cannulation is performed by direct aortic puncture cannulation, which appears to be a better procedure.

If patients have no preoperative malperfusion, ascending aorta cannulation (directly or transapical) can be quick, safe, and useful, because it is possible to recreate preoperative conditions. However, in patients who present with concomitant preoperative malperfusion, we believe that it is necessary to evaluate each patient individually to determine whether concomitant femoral artery cannulation or axillary artery cannulation is required. Furthermore, in patients with rupture,

ascending aortic cannulation may be at considerable risk of serious bleeding. In such cases, peripheral cannulation should be chosen for safety. Malperfusion as a result of a branch dissection cannot be improved by central cannulation alone; therefore, cannulation from a peripheral artery must be considered. Impaired consciousness may occur, and in cases where perfusion of the true lumen of cervical branches can be improved by axillary artery cannulation according to CT findings, axillary artery cannulation must be used concomitantly. Cannulation from the femoral artery must be considered for cases such as lower limb ischemia and intestinal ischemia. In cases of cardiac tamponade, rupture of the aorta after incision into the pericardium is an important problem that must always be considered. In such cases, preparations should be in place to enable prompt cannulation from the femoral artery. Incision of the pericardium in acute aortic dissection is performed slowly, taking time to make the incision, while an anesthetist ensures that the blood pressure is maintained low. In cases of tamponade in particular, the incision should be made while the blood pressure is maintained at or below 80 mmHg. However, even when all precautions are taken, we have experienced cases of rupture of the aorta after incision of the pericardium. Before this study, we have experienced a rupture case, in which the ascending aorta is quickly transected and a cannula inserted directly in the true lumen, then the ascending aorta and the cannula are fixed with a tourniquet and surgery was continued. To avoid such risks as a tightrope, particularly in cases of serious cardiac tamponade, it is critical that prior preparations are in place for peripheral artery cannulation.

Familiarity with the advantages and disadvantages of various cannulation methods and selection of the one that suits the condition of an individual case are crucial. Blindly accepting a single method of cannulation is extremely risky.²⁾ In cases with organ ischemia, TEE as well as CT is helpful for making appropriate strategy.¹⁹⁾ Femoral artery cannulation is not always risky and is useful in most cases.³⁾ The procedure can be performed safely and effectively, even in cases of malperfusion and cardiac tamponade, by monitoring radial artery pressure on both sides and by performing concomitant observation using transesophageal echocardiography.²⁰⁾

Because this study is retrospective and conducted over a short time period at a single institution, limitations

include a small patient population and that comparisons with other cannulation sites, such as peripheral cannulation, were not possible to perform. In addition, the decision to use cannulation was placed at the surgeon's discretion. Therefore, further studies with larger patient populations are necessary.

Conclusion

During surgery for acute aortic dissection, ultrasound-guided cannulation of the ascending aorta using either transapical or direct puncture can be performed quickly and safely, and satisfactory short-term outcomes can be obtained. Because acute aortic dissection can present with various conditions such as malperfusion and cardiac tamponade, there is no single perfect surgical technique or cannulation method; therefore, the choice of surgical procedure should be individualized for each patient.

Disclosure Statement

The authors have no conflict of interest to disclose with respect to this article.

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