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CASE REPORT

Arterial inflow line equipped with a side arm for circulatory support and catheter insertion during transcatheter aortic valve implantation for limited vascular access

Takashi Murakami[1] · Ryoji Sada[3] · Yosuke Takahashi[1] · Shinsuke Nishimura[1] · Kazuki Mizutani[2] · Asahiro Ito[2] · Shinichi Iwata[2] · Tokuhiro Yamada[4] · Minoru Yoshiyama[2] · Toshihiko Shibata[1]

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Abstract
Transcatheter aortic valve implantation was performed on a 78-year-old patient. Elective circulatory support with cardiopulmonary bypass was planned because of left ventricular function impairment and hemodynamic instability. Limited vascular access was due to a severe atherosclerotic aorta distal to the origin of the left carotid artery. The right arm was the only safe vascular access site. However, at least 2 vascular access sites for angiographic catheter and inflow of circulatory support were required. An arterial inflow line equipped with a side arm was developed to enable single access to the right axillary artery to be used for the above purposes.

Keywords Transcatheter aortic valve implantation · Shaggy aorta · Cardiopulmonary bypass · Axillary artery cannulation

Introduction

A severely atherosclerotic aorta, or shaggy aorta, is contraindicated as an access route for catheter procedures. Careful selection of an alternative route is mandatory for avoiding embolic complications during transcatheter aortic valve implantation (TAVI). When circulatory support is required, one of the limited access sites is deprived by the insertion of the arterial cannula for arterial perfusion, leading to further access site shortage. We report a case of a patient with aortic stenosis and severe atherosclerotic aorta, who successfully underwent TAVI with circulatory support using an arterial line equipped with a side arm for catheter insertion.

✉ Takashi Murakami
takashimurakami24@hotmail.com

[1] Department of Cardiovascular Surgery, Osaka City University Graduate School of Medicine, 1-4-3 Asahimachi, Abenoku, Osaka 545-8585, Japan

[2] Department of Internal Medicine and Cardiology, Osaka City University Graduate School of Medicine, Osaka, Japan

[3] Department of Clinical Engineering, Osaka City University Graduate School of Medicine, Osaka, Japan

[4] Department of Anesthesiology, Osaka City University Graduate School of Medicine, Osaka, Japan

Case

A 78-year-old man was transferred to our institute due to severe aortic stenosis. He had a previous history of stroke with mild residual disability, percutaneous coronary artery intervention, and stage 4 chronic kidney disease. Heart failure was intensively treated with inotropes and diuretics, which barely maintained his hemodynamics. Echocardiography revealed severe aortic stenosis with an aortic valve area of 0.68 cm^2. The left ventricular end-diastolic dimension was 61 mm and ejection fraction was 20%. Moderate mitral regurgitation due to leaflet tethering was also noted. Computed tomography (CT) angiography revealed a severely atherosclerotic aorta, starting from the origin of the left common carotid artery to the origin of visceral branches (Fig. 1). Furthermore, the anterior wall of the distal ascending aorta was complicated by the presence of atheroma and calcification. Evaluation of neck vessels by magnetic resonance imaging (MRI) revealed occlusion of the left internal carotid and left vertebral arteries and severe stenosis of the right common carotid artery. The risk of open surgery was deemed high, with a predicted mortality of 22.2% by STS Score. Therefore, TAVI was elected.

Only the right arm was regarded as safe for vascular access for avoiding the risk of embolization, including the development of embolic stroke, because of extensive and

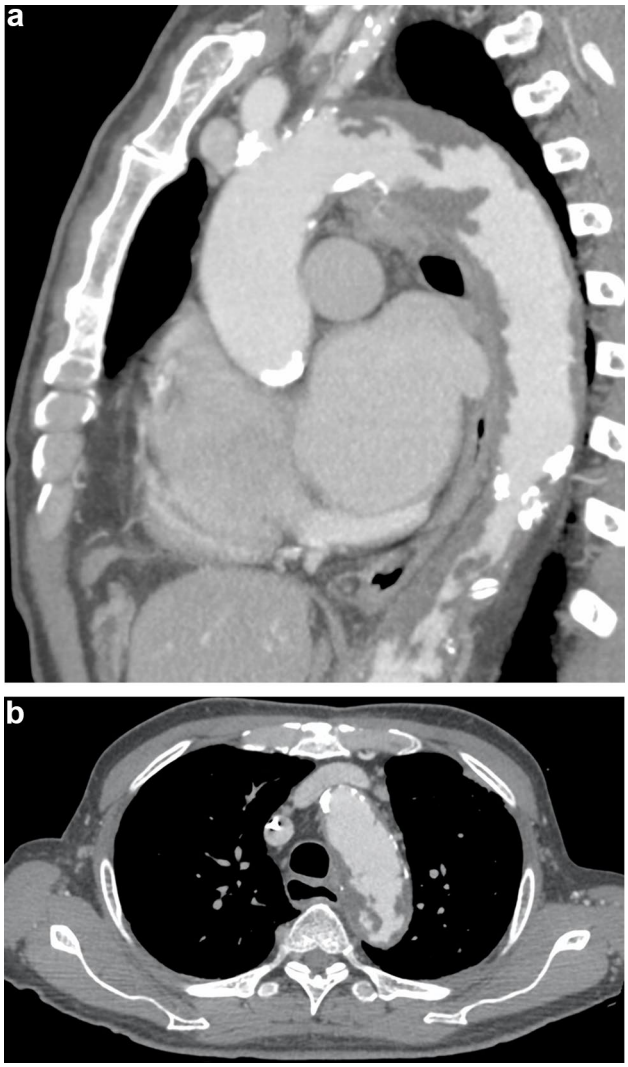

Fig. 1 **a** Preoperative computed tomographic angiogram showing a severely atherosclerotic aorta, including the aortic arch and descending aorta. **b** The anterior wall of the distal ascending aorta was complicated with atheroma and calcification, excluding the indication for direct aortic approach for transcatheter aortic valve implantation

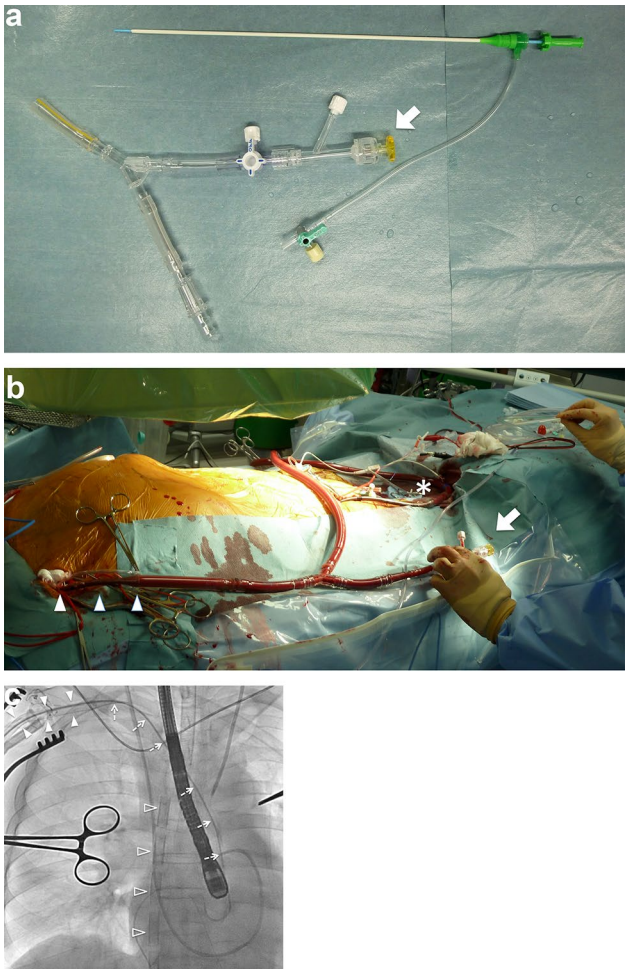

Fig. 2 **a** Catheter insertion port (arrow) was incorporated to the arterial perfusion line using a Y-shaped connector. **b** An arterial cannula (arrow heads) was inserted into the right axillary artery, and the venous drainage cannula (asterisk) was inserted into the right femoral vein. The introducer sheath was about to be inserted into the catheter insertion port (arrow). **c** An angiographic catheter (dotted arrows) was inserted through the arterial cannula (arrow heads). Hollow arrowheads indicate the venous drainage cannula

severe atherosclerosis of the aorta, and at the origin of the left carotid artery. The transapical approach was adopted to create an access point for TAVI. We initiated elective cardiopulmonary bypass support after induction of anesthesia considering the high possibility of circulatory collapse during TAVI. After anesthesia induction, the patient's hemodynamics were barely tolerated. We developed an arterial inflow equipped with a side arm for both the arterial inflow for cardiopulmonary support and catheter insertion from the right axillary artery as a single access site. As shown in Fig. 2, the arterial inflow consisted of a 10-mm tube and a catheter insertion port, which were connected by a Y connector. A 16-Fr arterial cannula (OptiSite, Edwards Lifesciences LCC, Irvine, CA, USA) was inserted into the right axillary artery that was surgically exposed at the deltopectoral groove. The side arm-equipped arterial inflow line was connected and de-aired. The venous drainage cannula was inserted from the right femoral vein up into the right atrium, and partial circulatory support was initiated. The left femoral vein was accessed for the pacing catheter.

A 6-Fr introducer sheath was inserted from the catheter insertion port (Fig. 2a) along with a 5-Fr Pigtail catheter that was advanced to the ascending aorta (Fig. 2c). The left ventricular apex was accessed using a 4-Fr sheath, followed by stiff wire advancement across the aortic valve, into the right subclavian artery, and then through the arterial cannula into the arterial inflow line. A 24-Fr Ascendra-plus introducer sheath (Edwards Lifesciences LCC, Irvine, CA, USA) was

inserted along the stiff wire. A Sapien XT was implanted. Hemodynamics were maintained, and he was weaned off cardiopulmonary bypass with inotropic support. The patient was transferred back to the referring hospital 16 days postoperatively. There were no signs of clinically evident embolic complications, although brain MRI or enhanced CT scan could not be performed to thoroughly investigate the evidence because of the patient's impaired renal function, as well as the difficulty in physically restraining the patient to the bed for a considerable time.

Discussion

Circulatory support during TAVI procedure is rare. According to a report by Shreenivas et al. 109 (4.3%) out of 2525 patients were subjected to cardiopulmonary bypass during TAVI [1]. They concluded that cardiopulmonary bypass is associated with a poor prognosis and its pre-emptive use needs reconsideration. However, TAVI is indicated for certain instances when circulatory collapse is highly anticipated, such as in our patient who presented with severely impaired left ventricular function and an inotrope-dependent condition. Furthermore, emergent establishment of cardiopulmonary bypass may be performed via transfemoral access. However, retrograde perfusion from the femoral artery is associated with a higher incidence of stroke compared to central cannulation [2]. Stroke risk due to retrograde perfusion increases in proportion to the burden of atherosclerosis [3]. Considering the patient's risk profile, we determined that axillary cannulation should be the first-line treatment for inflow for circulatory support during TAVI. Furthermore, axillary cannulation may be protective against embolic stroke in these patients, at least on the ipsilateral hemisphere [4–6]. Therefore, elective circulatory support via the right axillary artery access was employed.

Hollier et al. defined shaggy aorta as an extensive atheromatous disease with diffuse ulcers associated with soft, loosely held debris, and indicated that catheterization through a shaggy aorta can easily dislodge soft atheroma, causing distal embolization of the visceral arteries [7]. Transapical access for TAVI was adopted to avoid passage of the high-profile delivery system of the aortic prosthesis through the shaggy aorta. The stiff guidewire is usually advanced into the descending aorta during transapical TAVI. Instead, it was advanced through the brachiocephalic artery into the perfusion line, to avoid the shaggy aorta. The direct aortic approach is another alternative to avoid passage through the aortic arch and thoracic descending aorta. However, the direct aortic approach was excluded as a treatment option for our patient because of the pathology of the distal ascending aorta.

The right arm of our patient was regarded as the only site for safe vascular access, preventing stroke. Our arterial inflow equipped with a side arm enabled simultaneous use of one access point for both circulatory support and catheter insertion. Our method can be used for the combination of circulatory support in other catheter procedures, such as percutaneous coronary intervention, intra-aortic balloon pumping, and others.

An arterial cannula with a side arm, which is used for minimally invasive cardiac surgery along with endo-balloon aortic occlusion, is now commercially available outside Japan (EndoReturn Cannula, Edwards Lifescience LCC). It provides for a single site for the IntraClude intra-aortic occlusion device (Edwards Lifesciences LCC, Irvine, CA, USA). The side arm has a rotating hemostatic valve, which allows for passage of the 10.5-Fr IntraClude device, and the cannula size is either 21 or 23 Fr. The EndoReturn may be considered excessively large for the purpose of our case, which involves partial circulatory support via axillary artery access and simultaneous insertion of a 6 Fr introducer sheath. A catheter insertion port might enable more precise manipulation than the rotating hemostatic valve. Therefore, it was necessary to develop our hand-made system.

Conclusion

In conclusion, the arterial inflow equipped with side arm for both circulatory support and catheter insertion allowed us to perform transapical TAVI for a patient with limited vascular access. Further, its application can be extended to other forms of endovascular intervention.

Compliance with ethical standards

Conflict of interest Takashi Murakami, Ryoji Sada, Yosuke Takahashi, Shinsuke Nishimura, Kazuki Mizutani, Asahiro Ito, Shinichi Iwata, Tokuhiro Yamada, Minoru Yoshiyama, Toshihiko Shibata have no conflicts of interest.

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