Ascending aorta cannulation in acute type A aortic dissection

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Abstract

Objective: Antegrade perfusion for type A acute aortic dissection prevents malperfusion and retrograde cerebral embolism during cardiopulmonary bypass. Prompt establishment of antegrade perfusion via ascending aorta may improve the surgical results of type A dissections, especially in the situations of hemodynamic instability. Thus, we evaluated the efficacy of use of the dissected ascending aorta as an alternative arterial inflow.

Methods: Between 2002 and 2006, 32 patients underwent prosthetic graft replacement of the ascending aorta or hemiarch for acute type A aortic dissection. The ascending aorta was routinely cannulated, in addition to the femoral artery, with a heparin-coating flexible cannula for arterial inflow, using Seldinger technique, and by epiaortic ultrasonographic guidance (n=6). Antegrade systemic perfusion via ascending aorta was performed.

Results: Ascending aorta cannulation was safely performed in all cases. There was no malperfusion or thromboembolism due to ascending aorta cannulation. Cardiopulmonary bypass was established within 30 min after skin incision. There was one in-hospital death due to duodenal bleeding (1/32 = 3.1%), two cases of cerebral infarction (2/32 = 6.3%), and one case of pulmonary embolism. Twenty-nine patients (29/32 = 90.6%) were discharged in New York Heart Association class I and have been followed up uneventfully for a mean of 17 months.

Conclusions: Antegrade perfusion via the ascending aorta was successfully performed with low mortality and morbidity. With ultrasound-guided Seldinger technique, ascending aorta cannulation has a potential to be a simple and safe option that enables rapid establishment of antegrade systemic perfusion in patients with acute type A aortic dissection.

Keywords: Acute aortic dissection; Surgery; Ascending aorta; Epiaortic ultrasound; Perfusion; Emergency

1. Introduction

Despite many advances in surgical strategy and technique for the surgical treatment of Stanford type A acute aortic dissection, operative mortality and morbidity still remain substantial [1]. Surgical result is influenced by perfusion technique and cannulation site for cardiopulmonary bypass [2]. A number of reports advocating the superiority of the axillary artery as an arterial inflow reflect the advantage of antegrade systemic perfusion, which prevents retrograde thromboembolism and organ malperfusion [3,4]. On the contrary, axillary artery inflow may not be suitable for rapid establishment of antegrade perfusion in the cases with hemodynamic instability, since it requires more time for preparation prior to cardiopulmonary bypass [5]. And in patients with a small body, shortage of pump flow due to narrow axillary artery may be of concern [5,6].

Ascending aorta has a potential for an alternative access for cannulation [7–9], which may be suitable for rapid establishment of cardiopulmonary bypass in cases of hemodynamic instability, and also useful in cases of dissected axillary artery and diseased iliac or femoral artery. With the aid of Seldinger technique and epiaortic ultrasound, we employed an antegrade perfusion technique consisting of routine cannulation of the dissected aorta for repair of type A aortic dissection, and evaluated its safety and efficacy.

2. Materials and methods

Between February 2002 and July 2006, 32 patients with Stanford type A acute aortic dissection (mean age 59.4 ± 9.2, 19 men and 13 women) were treated surgically, either urgently or emergently, by prosthetic graft replacement of ascending aorta or hemiarch under deep hypothermic circulatory arrest. The diameter of the ascending aorta was 53.5 ± 5.8 mm on preoperative chest computed tomography (CT). Twenty-four patients (24/32 = 75%) underwent operation within 24 h of dissection. Two patients were declined operation due to irreversible severe neurologic injury during this period. Preoperatively, nine patients presented aortic regurgitation and eight patients exhibited cardiac tamponade. Among the patients with tamponade, three were with rupture and shock and one with shock.
the patients with rupture and shock also presented stroke. In addition, two patients exhibited syncope and two were with limb ischemia, while one other was with acute respiratory failure. One patient had previous cardiac surgery for aortic valve disease.

Surgery was performed through a median sternotomy. Cardiopulmonary bypass was initiated by femoral artery and right atrial cannulation, and then mean arterial pressure was lowered below 60 mmHg prior to the aortic cannulation. A single pledgetted 4—0 polypropylene mattress suture was placed at the left lateral side of the ascending aorta adjacent to pulmonary artery, and a 16—20 Fr. heparin-coated flexible thin-walled cannula (Flexmate cannulae: TOYOBO Ltd., Osaka, Japan; or Fem-Flex II arterial cannulae: Edwards Life Sciences Research Medical, Midvale, UT) was inserted into the aorta using the Seldinger technique, and antegrade systemic perfusion was performed. Epiaortic ultrasonography (Diagnostic Ultrasound System; Prosound SSD-3500 and Linear Array Probe; UST-5534T-7.5: Aloka Co. Ltd., Tokyo, Japan) was also used as a guide for cannulation in six cases. Cardiopulmonary bypass was performed at a flow rate of 2.1 L/(min/m²).

At first, open distal anastomosis was performed with woven Dacron one branch graft (Boston Scientific Corp., Natick, MA) and with felt strip supports. At the end of distal repair, a brief period of retrograde brain perfusion, as well as retrograde perfusion from femoral artery, was performed to flush out atheromatous debris. And then antegrade systemic perfusion was re-started through the side branch of the graft, and after blood cardioplegia was administered directly into the coronary ostia, proximal repair was subsequently performed. Aorta was not clamped throughout the operation, and clamps were only used for prosthetic graft. Aortic valve resuspension was performed in 10 cases. Gelatin–resorcin–formalin biological glue (Caridal S.A., Saint-Etienne, France) was used for proximal anastomosis in 18 cases.

3. Results

Ascending aorta cannulation was safely performed in all cases (Fig. 1), and there was no case that required switching of cannulation site. The adventitia of the dissected aorta was firm enough to support the aortic cannula inserted by Seldinger technique with staged dilators, and there was no case of complicated local massive hemorrhage at the cannulation site. Mean arterial pressure during aortic cannulation was 46.9 ± 8.9 mmHg. No malperfusion or apparent thromboembolism due to ascending aortic cannulation was observed during cardiopulmonary bypass.

Operative time was 252.8 ± 42.6 min. The time from skin incision to initiation of cardiopulmonary bypass was 29.9 ± 7.7 min. The duration of deep hypothermic circulatory arrest was 24.8 ± 4.9 min, while that of cardiopulmonary bypass was 122.5 ± 26.9 min. The time elapsed from initiation of cardiopulmonary bypass to deep hypothermic circulatory arrest was a mean of 25.9 ± 5.0 min.

There was one in-hospital death (1/32 = 3.1%) due to postoperative duodenal bleeding. Nine patients required prolonged ventilation for more than 4 days, including three patients with pneumonia. Three patients had complicated acute renal failure and one patient (the case of in-hospital death) required hemodialysis. And there was one case of pulmonary embolism. There were two cerebral infarctions (2/32 = 6.3%); one case of preoperative cerebral infarction and one of transient postoperative cerebral infarction. The patient with transient neurologic dysfunction recovered by the time of discharge. The patient with permanent neurologic dysfunction, who underwent emergent operation due to rupture and shock, had presented neurological deficit preoperatively. These patients with neurological complications were the cases of true-channel cannulation. Twenty-nine patients (29/32 = 90.6%) were discharged in New York Heart Association class I, and have been followed with periodic chest CT uneventfully at the outpatient clinic for a mean of 17.4 ± 11.9 months.

The epiaortic ultrasound-guided Seldinger technique was useful for aortic cannulation along with color Doppler imaging, which provided information about the true lumen antegrade perfusion (Fig. 2).

![Fig. 1. The dissected ascending aorta was cannulated at its lesser curvature adjacent to the pulmonary artery by the Seldinger technique (arrow). RV, right ventricle; Ao, ascending aorta.](image1)

![Fig. 2. Long-axis view of ascending aorta by epiaortic ultrasound. (A) Apical location of the cannula (arrow) is located within the true lumen. (B) Antegrade perfusion via true lumen was subsequently confirmed by color Doppler imaging (right: cranial side). T, true lumen; F, false lumen.](image2)
The apical location of the cannula was within the true lumen in 28 patients (Fig. 3) and inside the perfused false lumen in 4. However, no neurological disorder, malperfusion, or subsequent extension of the false lumen occurred in the latter four cases. In these cases, large intimal tear adjacent to the cannula was observed during circulatory arrest.

Structural disruption at the pulmonary artery side of ascending aorta seemed to be related to the frequency of false-channel cannulation. Patients without disruption of left lateral side of the ascending aorta in at least two slices on preoperative CT were frequent (24/32 = 75.0%), and among such patients, apical catheter location was in the false channel in one. In contrast, eight patients (8/32 = 25.0%) had a structural disruption at the lesser curvature of ascending aorta, and among these patients, apical location of the cannula in the false channel was noted in three.

Enhanced images of the chest CT demonstrated thrombosis of the false channel in 16 cases, although there was no case of false-channel cannulation in this group. Thus, no cerebral or other type of thromboembolism was observed in these cases.

Postoperative CT demonstrated no subsequent extension of the false lumen due to ascending aortic cannulation.

4. Discussion

Although the idea of cannulating ascending aorta of type A aortic dissection was reported about three decades ago [10,11], direct cannulation to ascending aorta for type A aortic dissection has only been performed reluctantly as a bail-out procedure through transection of the aorta in case of retrograde malperfusion [12]. Because of poor outcome, direct cannulation to the ascending aorta has been avoided by surgeons for type A dissections, and has not been reported positively [13].

However, recently, a few successful attempts have been made to establish antegrade perfusion via ascending aorta primarily for type A dissections [7—9]. Provided that it is safe, ascending aorta cannulation may have a great advantage because of the technical simplicity, especially in the situations of hemodynamic instability. And prompt establishment of antegrade systemic perfusion may also be of benefit [14—16]. The obtained results indicated that this technique could be performed safely under ultrasound-guided Seldinger technique. Quick establishment of antegrade perfusion through the ascending aorta resulted in shorter duration of initiating antegrade systemic perfusion and of core cooling, and consequently lead to reduction in the duration of cardiopulmonary bypass and of surgery, which may have contributed to the low mortality and morbidity.

One of the essential conditions for safe cannulation appeared to be decompression of the aorta, by femoral artery inflow in advance. It enabled subsequent safe aortic cannulation by the Seldinger technique. Otherwise, cannulating the expanded ascending aorta may tear the adventitia and the tear may lead to massive local hemorrhage. And also, it is necessary to avoid aortic clamping during the operation, which may increase the risk of malperfusion.

In addition, epiaortic ultrasonographic guidance may be also indispensable for reliable true-channel cannulation. Epiaortic ultrasound is a simple method to obtain information of ascending aorta and proximal arch [17]. It instantly provides information on the location of intimal tear, intimal flap, true and false channels, and the guidewire and the cannula. And during cannulation, it is easy to visualize thrombosed false lumen where color Doppler signal is absent. After aortic cannulation, it also provides information about the perfusion flow dynamics inside the dissected aorta by color Doppler imaging.

In case of false lumen cannulation, there may be a concern about malperfusion, thromboembolism, and subsequent extension of the false lumen. Actually, postoperative neurological complication was observed in patients with true-channel cannulation. In the patients with perfused false lumen cannulation, no neurological disorder or other complication occurred. Assumably, the large intimal tears located adjacent to the cannula within the ascending aorta and arch may have acted as a channel communicating flow between the false and true lumens and, along with bi-arterial inflows, consequently prevented malperfusion. However, the safety of this procedure may be represented by the reliability of true channel perfusion via ascending aorta. Routine application of epiaortic ultrasonographic guidance combined with Seldinger technique could eliminate false-channel cannulation.
Despite a lot of reports advocating the advantage of antegrade selective brain perfusion, our preference for brain protection has been deep hypothermic circulatory arrest for the emergency operations of acute type A dissection when a circulatory arrest time of less than 30 min is anticipated, on the basis of the papers supporting the adequacy of deep hypothermic circulatory arrest within half hour [18—21]. We prefer to avoid technical complexity and manipulation of arch vessels as well as sacrificing surgical visibility in the emergency operations of acute type A dissection.

The limitation of this study is that comparison with femoral and axillary artery cannulations was not performed. The surgical results of this study may be influenced not only by this procedure but also by patient’s preoperative status, age, and risk factors for cardiovascular diseases. Epiaortic ultrasound examinations were not performed in all cases.

In conclusion, antegrade perfusion via the dissected ascending aorta was successfully performed with low mortality and morbidity. With ultrasound-guided Seldinger technique, ascending aorta may have a sufficient potential as an alternative arterial inflow, which could be applied promptly for the establishment of cardiopulmonary bypass in patients with type A aortic dissection.

References


Editorial comment

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In an original article published in the present issue of the journal, Inoue and co-workers [1] describe and advocate the use of a rather sophisticated and complex method of arterial return of the cardiopulmonary bypass (CPB), associating several modes of cannulation and, in particular, direct cannulation of the ascending aorta, during surgery of acute type A dissection. Their experience is a variation of the experience obtained with a similar technique by the group from Hannover (Germany) and published a few years ago [2].

According to the authors, the rationale for developing and using such a technique is based on two straightforward goals: simplicity and safety.

Although the experience reported herein is limited, one may observe that the results obtained have been as excellent as the hospital mortality was reduced to 3% and the rate of neurological complications did not exceed 6.5%. No case of malperfusion or thrombo-embolism induced by the technique of cannulation and perfusion was observed. One could admit, thus, that the authors have achieved their goals.