

Alternative cannulation techniques in surgical repair for acute type A aortic dissection

Senol Yavuz

Department of Cardiovascular Surgery, Bursa Yuksek Ihtisas Training and Research Hospital, Bursa, Turkey

Eur Res J 2016;2(1):1-6

In this issue of the *European Research Journal*, Yalcin *et al.* [1] reported an experience with ascending aorta cannulation for surgical repair in a case with acute type A aortic dissection (AAAD). This presentation raises many questions that should be answered by the authors. They reported direct true lumen cannulation of the ascending aorta under visual control but this technique has not clearly been explained in detail. How was the aortic cannula introduced? What was arterial systolic pressure before procedure? Was venous exsanguination from the right atrium performed? The answers to these questions have not been explicitly stated in the text. Another very important issue is cerebral protection. There is also no an information about protection of the brain during the open distal anastomosis. The technique has not satisfactorily been discussed. Despite all these shortcomings, the authors are to be congratulated on their successful dissection repair with this technique and for bringing it to our attention. I would also like to share additional comments on alternative cannulation techniques for arterial inflow in these complicated patients.

AAAD is one of the life-threatening cardiovascular conditions and associated with an increased risk of mortality and morbidity. It requires immediate surgical intervention to avoid catastrophic complications such as aortic rupture or organ malperfusion (brain or visceral). The most important stages for succesful surgical treatment of AAAD include the excision of the primary entry tear in the aorta, the elimination of aortic valve insufficiency, and the establishment of the

true lumen flow to correct the distal malperfusion [2].

The best arterial cannulation site for a prompt induction of CPB in surgical repair of AAAD remains controversial [3]. The most important objective for the arterial cannulation in this lethal condition is to allow antegrade blood flow through the true lumen. The choice of arterial inflow site is influenced by many factors including hemodynamic instability (cardiac tamponade or shock), the presence of malperfusion, the extent of dissection, possible involvement of the cannulation site, peripheral vascular disease, a history of stroke, the patient's age or the preference of the surgeon.

Many different inflow sites for arterial cannulation have been described. Possible access points for cannulation include the femoral artery, the axillary artery, the brachial artery, the innominate artery, the carotid artery, the subclavian artery, the ascending aorta, the transverse arch of the aorta, and the left ventricular apex. Each cannulation site has both the advantages and disadvantages [3].

In current cardiovascular practice, the femoral arteries and the axillary arteries are the most commonly used cannulation sites for repair of AAAD. Excellent results have been reported with these arterial inflow sites [4-6]. Femoral artery cannulation is the standard cannulation technique and allows for the rapid institution of CPB in hemodynamically unstable patients with AAAD. However, it has disadvantages of retrograde arterial perfusion such as an increased risk of retrograde cerebral embolization due to atherosclerotic debris or thrombus in the descending

Address for correspondence:

Senol Yavuz, MD, Bursa Yuksek Ihtisas Training and Research Hospital, Department of Cardiovascular Surgery, 16330 Bursa, Turkey

E-mail: dr.syavuz@hotmail.com

Received: 29.02.2016; Accepted: 03.03.2016; Published Online: 04.03.2016

aortic lumen, stroke, critical organ malperfusion, false lumen enlargement, and the elevation of a dissected intimal flap [3]. Other complications of this technique are lower extremity ischemia, neurologic injury, lymphorrhea, and wound infection. Access site for femoral arterial cannulation is not suitable in the presence of atherosclerosis of the femoral vessels, severe peripheral occlusive disease, aorto-iliac aneurysms, and distal extension of the aortic dissection. In a retrospective study, Fusco *et al.* [4] cannulated the femoral artery for arterial access in 79 patients with AAA. They reported that this cannulation technique is associated with a low malperfusion rate of 2.5%. The authors conclude that femoral artery cannulation is an appropriate choice and provides satisfactory postoperative outcomes.

The technique allowing antegrade perfusion is a good option, particularly in patients with AAA. In contrast to femoral cannulation, axillary artery cannulation is a widely used approach for antegrade arterial perfusion to prevent cerebral and visceral complications in surgical repair of AAA [5]. It also allows safely the extended utilization in aortic surgery and complex cardiac procedures [6]. The advantages of this cannulation technique include antegrade perfusion of the true lumen in aortic dissection, elimination of the risk of retrograde embolization, low risk of malperfusion, and the possibility to apply antegrade cerebral perfusion. However, the disadvantages of this approach are the necessity for an additional skin incision, and the possible small caliber of the axillary artery. Therefore, this technique is presumably more time consuming, especially in obese patients, and not always free from risk [7]. Although rare in experienced hands, it also has potential complications such as brachial plexus injury, axillary artery damage, axillary artery thrombosis, arm ischemia, lymphocele, and local wound infection [6]. This cannulation is not suitable in patients with hemodynamic instability. The patients with dissection extending into the innominate artery or the subclavian artery also have a risk of retrograde carotid dissection resulting in cerebral malperfusion [3]. The right axillary artery is rarely affected by the dissection process and may be cannulated either directly or interposing a vascular graft. In our institute we mostly prefer direct right axillary cannulation in patients with AAA. In a study with direct axillary artery cannulation, we found no major complications regarding this technique [5]. Therefore, we think that

this cannulation procedure is easy to establish and may safely be used for arterial access in AAA [3, 5].

The carotid artery may also be proposed for selected patients, as another possible alternative site for cannulation. Urbanski *et al.* [8] performed right carotid artery cannulation in 100 patients, including 27 with AAA. This procedure offers the possibility of antegrade arterial flow during CPB and selective cerebral perfusion during aortic arch repair. However, it also carries the risk of cerebral malperfusion and local complications related to cannulation site. Innominate artery cannulation is also the preferred alternative cannulation technique for antegrade perfusion. This cannulation technique has a larger arterial access. It also does provide more central flow, does carry a low risk of neurological complications, and does not require an additional skin incision during surgery. Preventza *et al.* [9] cannulated the innominate artery with a side-graft in 263 patients undergoing the proximal aortic surgery. In their study, 27 (10.3%) patients had acute or subacute Type I aortic dissection. The mortality rate was 4.9% and postoperative stroke was 3.4% [9].

Ascending aorta cannulation, also referred to as central cannulation, is a challenging alternative technique for arterial cannulation in the complicated situations such as hemodynamic instability or when other cannulation options are not suitable for patients with AAA [3, 10, 11]. It provides an advantage of antegrade perfusion but has the risk of the false lumen cannulation, which might lead to aortic rupture, or malperfusion [11]. This cannulation technique includes direct cannulation of the dissected ascending aorta [12-14] or transapical cannulation of the ascending aorta [10]. This technique is not recommended as the first cannulation option. Direct ascending aorta cannulation may be performed by the Seldinger technique (a guide-wire technique) under ultrasonographic guidance [12, 15-19] or direct true lumen cannulation of the dissected ascending aorta under direct visual control [20, 21].

Ascending aorta cannulation using the Seldinger technique is an attractive option for arterial inflow into the true lumen of the dissected ascending aorta to avoid malperfusion and retrograde embolization [19]. In this technique, a perfusion cannula through the guide-wire is inserted easily and safely into the true lumen of the aorta from the non-dissected portion of the aortic wall just beside the pulmonary artery under direct epiaortic ultrasound guidance [12, 19]. Yamada

et al. [19] did not use the purse-string suture for cannula fixation in the aorta to avoid hemorrhage. Ascending aorta cannulation is an appropriate option for rapid establishment of antegrade perfusion in hemodynamically unstable patients with AAAD [11, 12, 17, 18].

Reece *et al.* [15] applied the Seldinger technique for cannula insertion for surgical repair in 24 patients with AAAD. The eligible cannulation site was identified by transesophageal echocardiography and computed tomography. In their study, they did not utilize purse-string suture and the cannula was firmly held in position by hand during the cooling phase. They reported that there was no malperfusion in this series [15]. In addition to the femoral artery, Inoue *et al.* [12] routinely cannulated the ascending aorta using the Seldinger technique, also by epiaortic ultrasound guidance (6 patients), for arterial inflow in 32 patients with AAAD. The aortic perfusion cannula was introduced after aortic decompression by starting CPB with femoral arterial cannulation. Their technique was extremely complicated. CPB perfusion was retrogradely started by the femoral artery and then mean arterial pressure was reduced below 60 mmHg prior to the ascending aorta cannulation. Antegrade systemic perfusion was performed by aortic cannulation. These authors used purse-string suture for cannula fixation. In their study, the rate of false lumen cannulation was 12.5%, but they had satisfactory results with no clinical end-organ malperfusion [12].

Recently, Taguchi *et al.* [18] also used similarly a hybrid technique in 29 patients as described by Inoue *et al.* [12] with starting femoral arterial cannulation (retrograde flow) followed by ascending aorta cannulation (antegrade flow) using the Seldinger technique for cannula insertion. In both studies, reversing the blood flow before the repair can lead to adverse effects. The authors reported that all insertions (guide-wire or cannula) using this technique were only guided by transesophageal echocardiography. The authors also conclude that the proposed skills for this cannulation are careful evaluation of needle insertion site, feeling the resistance of needle insertion twice, and security of guide-wire in the aorta [18].

Ascending aorta cannulation is not an appropriate option in patients with thrombosed false lumen or intramural hematoma [15, 18]. In these situations, thrombosed false lumen dilatation during the insertion procedure is associated with possibility of complications such as disastrous thromboembolism.

In patients with circumferential dissection of the entire ascending aorta, the false lumen constitutes a large portion of the aortic lumen. Therefore, this technique may be difficult to enter the true lumen [19]. The risks related to cannulation of the dissected ascending aorta are false lumen cannulation, potential malperfusion, extension of the dissection, and aortic complete rupture as a result of tearing the fragile aortic wall. Therefore, Seldinger technique should be applied to the diseased aorta very gently [17, 18]. Ascending aorta cannulation has some advantages such as a low risk of malperfusion and retrograde cerebral embolism, ease of rapid induction of antegrade perfusion in hemodynamically unstable situations, and suitability in dissections extending into the innominate artery [18].

In a recent study of 14 cases, Gobolos *et al.* [17] reported an innovative ultrasound-guided direct true lumen cannulation on the concavity of the aortic arch at the level of Botallo's ligament by Seldinger technique. With their technique there was no need for purse-string suture for cannula fixation in the aorta. The cannula was attached to the skin incision with a suture. In this study, there were no operative mortality and permanent neurological deficits.

Direct cannulation of the dissected ascending aorta in 122 patients with AAAD was presented by Hannover group [13]. In contrast to other groups, their technique includes direct approach to the the aorta (conventional cannulation) in a less dissected or non-dissected area. This cannulation site was identified by preoperative computed tomography and intraoperative transesophageal echocardiography. They cannulated the ascending aorta at the site of the minimal distances of the dissected layers and used double purse-string sutures for cannula fixation. They showed that this technique is a safe option with malperfusion in 3 (2.5%) patients, aortic rupture in 1 (0.8%) patient, and hospital mortality in 18 (15%) patients [13].

Direct true lumen cannulation of the ascending aorta is another valid means as antegrade perfusion route in surgical repair of AAAD. This technique particularly may be recommended in patients with circumferential ascending aortic dissection, narrowed true lumen at the aorta, and the true lumen located on the posterior aspect of the aorta. Prevention of bleeding around the aortic cannula is provided either with a cross-clamp or with a snare passed around the aorta. The most important drawbacks of this cannulation technique is the possibility of rupture risk

of the aorta in this area during the separation between the adventitial layers of the ascending aorta and the pulmonary artery. Jakob *et al.* [20], in 2007, reported an experience with direct cannulation of the ascending aorta in 8 patients with AAAD. The technique consists of venous exsanguination, direct true lumen cannulation of the ascending aorta under direct vision (arterial systolic pressure at that time is 30 mmHg or less), controlled de-airing, followed by standard CPB after proximal aortic clamping. This technique process completes in less than ninety minutes [20]. Conzelman *et al.* [21] also reported their experience with 29 patients with AAAD using a similar technique as described by Jakob *et al.* [20]. The authors described that the ascending aorta was completely transected after venous exsanguination and the aortic true lumen was identified. An arterial cannula was directly inserted into the true lumen under direct visual control. Lastly, the arterial cannula was anchored with a ligature. In their report, the only minor technical difference was usage of the snare around the ascending aorta to fix cannula and to prevent bleeding around the cannula. There was no hospital mortality and temporary hemiplegia occurred in 4 (14%) patients. The authors conclude that direct true lumen cannulation is an encouraging technique with good results [21].

Tiwari *et al.* [22] reviewing 14 publications (the best evidence topic) compared ascending aorta cannulation and peripheral arterial cannulation for surgical repair of AAAD. The authors determined that central cannulation has a lower mortality rate but a higher stroke rate. They conclude that direct true lumen cannulation is a promising cannulation technique for quick and easy institution of CPB [22]. In contrast, artery cannulation was a remarkable choice according to all results when compared with central cannulation. Reece *et al.* [15] compared retrospectively the results of ascending aorta cannulation (n=24) versus peripheral arterial cannulation (n=46). They demonstrated that the peripheral cannulation group had a higher 30-day mortality rate than the central cannulation group (19.5% versus 4.2%; $p < 0.05$) [15]. From their experience of 235 patients on long-term survival, Kamiya *et al.* [23] analyzed the results of ascending aorta cannulation (82 patients) and femoral artery cannulation (153 patients) for AAAD. Although the 30-day mortality rate was lower in the aortic cannulation group (14% versus 23% in the femoral group), the difference was not statistically significant

($p = 0.07$). In this study, they also reported that the cannulation technique had no impact on long-term survival [23]. Suzuki *et al.* [16] compared central cannulation (n=26) and peripheral cannulation (n=51). In their study, an arterial cannula was inserted using the Seldinger technique under ultrasound guidance. The mortality rate was 4% in the central group and 8% in the peripheral group ($p = 0.45$). They showed that direct central cannulation has equal or superior clinical outcomes when compared to the peripheral cannulation.

In a recent study of 117 patients, Klotz *et al.* [11] analyzed the outcome after initial femoral arterial cannulation (53.1%) versus the central cannulation (46.9%) for AAAD in the last 10 years. In this study, there was no significant difference in term of the 30-day mortality and postoperative cerebral infarction between the cannulation groups (20% vs 17% , $p = 0.699$ in the central cannulation and 13% vs 9% , $p = 0.449$ in the peripheral cannulation). They reported similar results with both cannulation techniques for surgical repair of AAAD.

Wada *et al.* [24] retrospectively analyzed two different central cannulation techniques including direct ascending aorta cannulation (n=20) using the Seldinger technique and transapical aortic cannulation (n=6). They reported that excellent early results could be obtained by these cannulation techniques. There is no single best cannulation techniques. Therefore, the technique should be selected according to each patient's individual characteristics.

In ascending aorta cannulation, the relationship of the true and false lumens in the ascending aorta play an important role. In a study of 88 patients, Frederick *et al.* [14] classified three levels of distinct dissection anatomy. These anatomic variants affect the strategy of cannulation. A detailed examination of the preoperative computed tomographic angiogram shows the relationship of the true and false lumens in the ascending aorta and arch. This correlation is verified by visual inspection and intraoperative transesophageal echocardiography. The true lumen is localized anteriorly in the ascending aorta at Level 1, the true lumen is posterior and the false lumen is anterior at Level 2, and there is a free-floating ascending aortic true lumen at Level 3 [14]. The authors successfully underwent ascending aorta cannulation using the Seldinger technique guided by preoperative computed tomographic angiographic study and intraoperative transesophageal echocardiographic examination to assess guide-wire

access to the aortic true lumen [14].

Transapical aortic cannulation for establishing CPB is also a remarkable technique. The arterial cannula is inserted through an apical ventriculotomy (1 cm hole) into the left ventricle and then across the aortic valve directly into the true lumen of the ascending aorta guided by transesophageal echocardiography. Transapical aortic cannulation has some advantages including easy and fast procedure, adequate antegrade perfusion, and possible true lumen perfusion with low risk of cerebral embolization and organ malperfusion [10]. The disadvantages of this technique is the prolonged CPB time and the inability to additional procedures during cooling phase. This cannulation technique is not suitable in patients with severe aortic stenosis or undergoing redo median sternotomy. Another serious problem related to this technique is bleeding from cannulation site at the left ventricular apex. This problem might be overcome by performing simple stab-wound cannulation and closing the incision with interrupted sutures with pledgets. In a large cohort of 138 patients, including 129 patients with AAAD, Wada *et al.* [10] showed the safety and usefulness of transapical aortic cannulation for establishing CPB in surgical repair of AAAD. They reported good results without malperfusion events, but the hospital mortality rate was 18.8% (26 patients). In their study, these deaths were due to organ ischemia from malperfusion existing before the operation [10]. The cause of these deaths was the presence of preoperative malperfusion resulting in the organ ischemia.

As a cardiovascular surgeon, we must be familiar with alternative cannulation techniques in surgical repair for AAAD. It should be kept in mind that ascending aorta cannulation technique could be applied to provide antegrade flow for well-selected patients. It is more appropriate to wait the results confirmed by further studies in a larger group of patients for a general recommendation related to the best arterial cannulation technique in this complicated pathology.

Competing interests

The authors declare that they have no competing interests with respect to the authorship and/or publication of this article.

References

- [1] Yalcin M, Godekmerdan E, Tayfur KD, Urkmez M, Yazman S, Bademci S. Ascending aortic cannulation in acute type A aortic dissection: a frightening but lifesaving procedure. *Eur Res J.* 2016 Mar;2(1):74-6.
- [2] Grabenwoger M, Weiss G. Type A aortic dissection: the extent of surgical intervention. *Ann Cardiothorac Surg.* 2013 Mar;2(2):212-5.
- [3] Yavuz S. eComment. what is the best arterial cannulation site in a complicated patient with acute type A aortic dissection? *Interact CardioVasc Thorac Surg.* 2008 Feb;7(1):134-5.
- [4] Fusco DS, Shaw RK, Tranquilli MT, Kopf GS, Elefteriades JA. Femoral cannulation is safe for type A dissection repair. *Ann Thorac Surg.* 2004 Oct;78(4):1285-9.
- [5] Yavuz S, Goncu MT, Turk T. Axillary artery cannulation for arterial inflow in patients with acute dissection of the ascending aorta. *Eur J Cardiothorac Surg.* 2002 Aug;22(2):313-5.
- [6] Yavuz S, Toktas F, Yumun G, Turk T. eComment. Extended utilization of axillary cannulation as arterial access for cardiopulmonary bypass. *Interact CardioVasc Thorac Surg.* 2013 Jun;16(6):759.
- [7] Schachner T, Nagiller J, Zimmer A, Laufer G, Bonatti J. Technical problems and complications of axillary artery cannulation. *Eur J Cardiothorac Surg.* 2005 Apr;27(4):634-7.
- [8] Urbanski PP, Lenos A, Lindemann Y, Weigang E, Zacher M, Diegeler A. Carotid artery cannulation in aortic surgery. *J Thorac Cardiovasc Surg.* 2006 Dec;132(6):1398-403.
- [9] Preventza O, Garcia A, Tuluca A, Henry M, Cooley DA, Simpson K, et al. Innominate artery cannulation for proximal aortic surgery: outcomes and neurological events in 263 patients. *Eur J Cardiothorac Surg.* 2015 Dec;48(6):937-42; discussion 942.
- [10] Wada S, Yamamoto S, Honda J, Hiramoto A, Wada H, Hosoda Y. Transapical aortic cannulation for cardiopulmonary bypass in type A aortic dissection operations. *J Thorac Cardiovasc Surg.* 2006 Aug;132(2):369-72.
- [11] Klotz S, Heuermann K, Hanke T, Petersen M, Sievers HH. Outcome with peripheral versus central cannulation in acute type A dissection. *Interact Cardiovasc Thorac Surg.* 2015 Jun;20(6):749-53; discussion 754.
- [12] Inoue Y, Ueda T, Taguchi S, Kashima I, Koizumi K, Takahashi R, et al. Ascending aorta cannulation in acute type A aortic dissection. *Eur J Cardiothorac Surg.* 2007 Jun;31(6):976-9; discussion 979-81.
- [13] Khaladj N, Shrestha M, Peterss S, Strueber M, Karck M, Pichlmaier M, et al. Ascending aortic cannulation in acute aortic dissection type A: the Hannover experience. *Eur J Cardiothorac Surg.* 2008 Oct;34(4):792-6; discussion 796.
- [14] Frederick JR, Yang E, Trubelja A, Desai ND, Szeto WY, Pochettino A, et al. Ascending aortic cannulation in acute type A dissection repair. *Ann Thorac Surg.* 2013 May;95(5):1808-11.
- [15] Reece TB, Tribble CG, Smith RL, Singh RR, Stiles BM, Peeler BP, et al. Central cannulation is safe in acute aortic dissection repair. *J Thoracic Cardiovasc Surg.* 2007 Feb;133(2):428-34.
- [16] Suzuki T, Asai T, Matsubayashi K, Kambara A, Kinoshita T, Hiramatsu N, et al. Safety and efficacy of central cannulation through ascending aorta for type A aortic dissection. *Interact Cardiovasc Thorac Surg.* 2010 Jul;11(1):34-7.
- [17] Gobolos L, Ugocsai P, Foltan M, Philipp A, Thrum A, Miskolczi S, et al. Central cannulation by Seldinger technique: a reliable method in ascending aorta and aortic arch replacement. *Med Sci Monit.* 2014 Nov 22;20:2386-93.
- [18] Taguchi S, Mori A, Suzuki R, Ishida O. Simplicity, skills, and pitfalls of ascending aortic cannulation for type A aortic dissection. *J Cardiothorac Surg.* 2013 Jun 26;8:161.
- [19] Yamada T, Yamazato A. Central cannulation for type A acute aortic dissection. *Interact Cardiovasc Thorac Surg.* 2003 Jun;2(2):175-7.
- [20] Jakob H, Tsagakis K, Szabo A, Wiese I, Thielmann M, Herold U. Rapid and safe direct cannulation of the true lumen of the ascending aorta in acute type A aortic dissection. *J Thorac Cardiovasc Surg.* 2007

Jul;134(1):244-5.

[21] Conzelmann LO, Kayhan N, Mehlhorn U, Weigang E, Dahm M, Vahl CF. Reevaluation of direct true lumen cannulation in surgery for acute type A aortic dissection. *Ann Thorac Surg.* 2009 Apr;87(4):1182-6.

[22] Tiwari KK, Murzi M, Bevilacqua S, Glauber M. Which cannulation (ascending aortic cannulation or peripheral arterial cannulation) is better for acute type A aortic dissection surgery? *Interact CardioVasc Thorac Surg.* 2010 May;10(5):797-802.

[23] Kamiya H, Kallenbach K, Halmer D, Ozsoz M, Ilg K, Lichtenberg A, et al. Comparison of ascending aorta versus femoral artery cannulation for acute aortic dissection type A. *Circulation.* 2009 Sep 15;120(11 Suppl):S282-6.

[24] Wada H, Matsumura H, Minematsu N, Amako M, Nishimi M, Tashiro T. Direct and transapical central cannulation for acute type a aortic dissection. *Ann Vasc Dis.* 2014;7(3):286-91.