International Journal of
Science Inventions Today
www.ijsit.com
ISSN 2319-5436
Review Article

CATHERIZATION STRATEGIES IN TYPE A AORTIC DISSECTION

Asfandyar Khan[1], Zhengwen Lei[1*], Aimen Khan[2] , Shaheryar Khan[2], Afrasiyab Khan[3] and Yaoguang Feng[1]

[1]*The First Affiliated Hospital, Department of Cardiothoracic Surgery, Hengyang Medical School, University of South China, Hengyang, Hunan, 421001, China*

[2]*Hengyang Medical College, University of South China, Hengyang, Hunan, 421001, China*

[3]*The Affiliated Nanhua Hospital, Department of General Surgery, Hengyang Medical School, University of South China, Hengyang, Hunan, 421001, China*

Aortic dissection is a potentially critical break in the lining of the main arterial out flow from the heart. Acute type A aortic dissection (ATAAD) is a disastrous condition that can be lethal if not treated immediately. The urgency of the problem does not allow for the epidemiological studies like RCTs which are crucial in establishing causation. The establishment of an international registry and improved understanding of molecular biology and genetics of aortic disease have, however, led to substantial advances in the understanding of this disease [1].

Magnetically guided catheters for super selective vascular catherization were developed in the 1960s based on the para operational device (POD) this device used either an external static magnetic and field gradients or an alternating magnetic field to propel and steer a tiny magnetic particle, such as a magnetic catheter tip, intravascularly through tortuous arteries [2].

Catheter based cardiovascular interventions served as textbook examples of cognitive and psychomotor activities in highly uncertain and difficult to predict environments, which are particularly susceptible to cognitive errors and illusions due to following reasons [3].

- ❖ All interventional actions are indirectly mediated by catheters that are tough to control over distances and often highly tortuous vascular pathways
- ❖ Direct vision of the target sires is impossible, it is mostly mediated by X rays which can cause imperfections and geometric illusions.
- ❖ Biomechanical response of living tissues, mostly vascular walls, to interventional actions are often hard to predict, being controlled by different known and mostly unknown variables.
- ❖ Mechanical properties of the high technology instrumentation are only inconsiderably revealed by

industry, allowing only limited insights and understanding of ongoing interactions between tissues and catheters including poor predictability of possibilities of their outcomes.

- ❖ Catheter skills are mostly understood, updated teaching curricula is required
- ❖ Cognitive skills required to master catheter based cardiovascular interventions are largely unexplored and unknown.

The current accepted guidelines of open surgical repair for acute type A aortic dissection include resection of the primary entry tear, replacement of the ascending aorta and hemiarch with an open distal anastomosis, resuspension of the aortic valve, and obliteration of the false lumen of the aortic root. Ideally, the goal is to prevent the rupture of the aorta, aortic regurgitation, and coronary ischemia, and to restore antegrade preferential perfusion of the true lumens [4].

Acute type A aortic dissection (ATAAD) is typically characterized by sudden onset of "tearing" chest pain that may radiate to the neck, jaw, or back. There is often a feeling of impending doom associated with shortness of breath, nausea, sweating, or syncope. Involvement of major vessels of the head and neck means patients may present with neurological symptoms similar to those of a stroke, whereas, rarely, patients may be asymptomatic [5].

The diagnosis of AADA is challenging because of its varied clinical presentation and because the differential diagnosis includes more common conditions such as myocardial infarction. Management involves complex surgery, perioperative intensive care, and long-term surveillance to detect late dissection-related complications [6].

The complication of acute type A acute aortic dissection (ATAAD) is malperfusion. When compared to the conventional HCA/sACP technique, the ABO technique alleviates renal and hepatic injury in ATAAD surgery. ABO allows arch repair to be performed at a higher temperature and with a shorter circulatory arrest time than HCA/sACP. It was found that ABO did not reduce adverse outcomes, such as in-hospital mortality, post-operative stroke, dialysis, liver dysfunction, paraplegia, and prolonged ventilation requiring tracheostomy, for patients with lower body malperfusion [7].

Hemiarch replacement (HAR) involves replacing the proximal aortic arch to the level of the brachiocephalic artery without replacement and reimplantation of the major arch branches. Total-arch replacement (TAR) involves replacing the major head and neck vessels as well. Total arch repair was associated with greater risks of mortality and permanent neurologic injury compared with Hemiarch repair in acute DeBakey type I or III-D aortic dissection [8].

The en bloc technique (EBT) and the separated graft technique (SGT) are currently being used as a method of arch vessels reimplantation during aortic arch reconstructions. Major vessels can be replaced altogether as an “en-bloc,” whereby the aortic vessels are sutured altogether to the prosthesis replacing the aortic arch. Alternatively replacing the proximal parts of the aortic vessels and suturing the aortic vessel grafts to the aortic arch graft [9].

The basic operative technique mainly consists of HAR via transapical cannulation and the adventitial inversion technique. The false lumen was obliterated distally using the adventitial inversion technique and proximally by applying glue between the intima and adventitia. The advantages of transapical cannulation are the quick establishment of cardiopulmonary bypass and secure true lumen perfusion [5].

Although the application of total arch replacement (TAR) combined with frozen elephant trunk (FET) technique in acute DeBakey type I aortic dissection (ADIAD) is still controversial, then also it has evolved itself as an accepted choice for patients with aortic disease involving the aortic arch and supra-arch branches (including ADIAD) [10]. In some patients with dilated or jeopardized descending aorta or with connective tissue disease and a significant probability of aneurismal evolution requiring further reoperations, the technique of "Elephant trunk" may be quite useful [11]. However, this technique is an extended, complex, time-consuming and skill-demanding surgical strategy.

The potential benefits of extended arch surgery in patients with ATAAD are to [12].

❖ Resect primary intimal tears beyond the ascending aorta
❖ Resect or exclude re-entry tears in the distal aorta
❖ Facilitate re-expansion of the distal true lumen
❖ Promote false lumen obliteration.

Deep hypothermic circulatory arrest (DHCA) seems to be necessary, and therefore different strategies of cerebral perfusion (unilateral/bilateral and ante grade/retrograde cerebral perfusion) are developed [13].

Despite modern developments, the mortality of ATAAD has remained at 17% to 26% in the International Registry of Acute Aortic Dissections registry over the last decade or so. It might be argued that acute salvage is strongly influenced by the presence and extent of preoperative complications such as shock and organ mal-perfusion [14].

In pediatric cases also there are no serious allergic reactions related to cardiac catheterization, but some minor allergic reactions can occur. Most of them are urticarial eruptions. The urticaria can occurred during partial exchange transfusion done during catheterization of an infant with coarctation of the aorta, congestive heart failure, and anemia. It can also be a result of exposure to intravenous diphenhydramine hydrochloride [15].

Various studies suggests that recent changes in both the type of procedures performed and the patient groups treated have had a major impact on the complication profile of the modern catheterization procedures.

The introduction of a variety of new devices for the treatment of coronary arterial disease, including atherectomy catheters, metallic stems and circulatory support devices has necessitated the use of both large caliber guiding catheters and arterial sheaths, and intensive periprocedural anticoagulant and librinolytic therapy. The hazards associated with the use of these new devices include a potentially greater risk of arterial injury at the access site. Previous studies have reported the incidence of arterial complications after diagnostic cardiac catheterization and percutaneous transluminal coronary angioplasty [16].

AADA can present with shock, haemodynamic stability, or hypertensive emergency. Invasive hemodynamic monitoring is mandatory. In cases of different blood pressures in the arms, dual arterial blood pressure monitoring may be necessary; medication should be based on the arterial blood pressure site that best reflects true luminal perfusion. When hypertension is present, reliable blood pressure control is required. In order to reduce left ventricular pressure, beta-blockers (such as esmolol) or combined antagonists (labetalol) are the first choice [17].

It may also be necessary to take other antihypertensives, such as glyceryl trinitrate, sodium nitroprusside, urapidil or clonidine.

In addition to relieving pain, opiates also assist in controlling blood pressure. When a patient is in an unstable state, cannulation and ventilation may be necessary, but should be delayed until the operating room, because cannulation may have a rapid effect on hemodynamic [18].

Complication rates for diagnostic catheterization generally continue to meet or exceed the previously proposed standards; the active performance of newer therapeutic procedures has increased the overall rates for mortality, myocardial infarction, cardiac perforation and vascular injury [19].

Standards for laboratory proficiency thus need to be continually re-evaluated, taking new procedures and changing patient groups into account. Evaluation of individual laboratories should focus not just on overall complications but on the complications for each type of procedure performed, with consideration of the patient group treated [20].

Type-A aortic dissection (ATAAD) is a highly deadly cardiovascular emergency. Acute surgical treatment is indicated for all patients, except for those who are moribund or severely co morbid. Surgical and perioperative procedures vary depending on the presentation and aortic pathology. Despite the considerable morbidity and mortality, both early and medium-term outcomes are improving [21].

Acute type A aortic dissection remains a strenuous surgical emergency associated with high mortality and morbidity even with the advances in the last few decades. Current evidence indicates that the dissection process commonly extends through the arch in most patients and that an aortic arch repair is warranted [22].

With the advancement in endovascular techniques, it will be easier to extend into the arch and the ascending aorta in the future; however, it is debatable whether they can compete with the outcome of conventional surgery. The value of registries in documenting outcome is also very important and can play a major role by expanding and incorporating long-term outcomes, and to provide reliable information not just on survival and major neurological complications but also about functional outcomes in survivors after AADA.

For patients with acute DeBakey type I aortic dissection, surgical treatment of arterial cannulation perfusion via cardiopulmonary bypass is essential. However, there has been controversy over how to choose the optimal perfusion cannulation strategy to ensure good perfusion of various organs and reduce the risk of poor perfusion. At present, the common extracorporeal bypass perfusion strategies include transfemoral artery, axillary artery, ascending aorta, innominate artery and axillary-femoral combined cannulation perfusion strategies. However, due to the fact that different patients have different aortic anatomical characteristics and blood flow patterns during cardiopulmonary bypass, different cannulation strategies have different advantages and disadvantages. Therefore, each patient with Dabakey type I aortic dissection should be comprehensively evaluated and a perfusion cannulation strategy suitable for different patients should be developed to reduce the incidence of perfusion adverse events such as false perfusion, intraoperative aortic rupture, intraoperative tissue and organ perfusion, and intraoperative death. The different perfusion cannula strategies are briefly described below.

Femoral artery cannulation (FAC):

Transfemoral artery catheterization, the most commonly used perfusion modality, is ideal for patients with preoperative haemodynamic instability, and may improve renal blood supply and reduce the incidence of postoperative renal damage compared with other perfusion catheters [23]. Transfemoral cannula perfusion is recommended if the preoperative aortic CTA shows dissection involving the left and right renal arteries and renal insufficiency. However, studies have shown that retrograde perfusion through femoral artery cannula may lead to cerebral embolism and poor perfusion of vital organs [24]. Femoral artery catheter perfusion is associated with higher mortality and stroke rates than axillary artery catheterization [25]. May be associated with the risk of plaque detachment and falseluminal perfusion during retrograde perfusion. Therefore, this method of cannula perfusion is not recommended for patients with severe atherosclerosis of the femoral artery, common iliac artery, and thoracic and abdominal aorta.

Right axillary artery cannulation (RAAC):

Transaxillary artery cannula requires a transverse incision of 5 to 8 cm of skin under the right clavicle (6-10 cm from the middle of the sternum), free out of the axillary artery, and suture the graft for later use. Because dissection false lumen involvement, atherosclerosis and plaque formation less often occur in the axillary artery, and perfusion through the right axillary artery cannula is anterograde perfusion, it is more in line with physiological characteristics, can avoid retrograde embolism and further expansion of the dissection range [26, 27, 28], and has a better cerebral protective effect [29, 30]. Therefore, the right axillary artery can be used as one of the sites of extracorporeal bypass perfusion cannula. In 2014, the European Society of Cardiology made transaxillary artery cannula perfusion the preferred strategy for surgical cannulation for DeBakey type I aortic dissection [31]. However, there is also a risk of vascular and brachial plexus injury with the right axillary artery cannula, and it takes about 20 minutes to free and suture. Subclavian artery is promptly involved by dissection false lumen, and axillary artery cannulation can lead to risks of retrograde carotid artery false lumen dissection and poor cerebral perfusion [32].

Ascending aortic cannula perfusion strategy (AAC):

The ascending supra-aortic cannula perfusion strategy has the advantages of anterograde perfusion and simple operation, which can simulate the blood circulation path under physiological conditions to the greatest extent, and can better protect the perfusion of patient tissues and organs; This strategy also has its drawbacks, as the process of perfusion catheter insertion may lead to further separation or tearing of the aorta wall at the insertion site. In addition, if the perfusion catheter is inserted into the false lumen of the aorta, perfusion may lead to poor perfusion of tissues and organs, such as poor cerebral perfusion and poor renal perfusion. Therefore, ascending aortic cannula perfusion requires that the aorta has a normal wall sufficient to support the cannula procedure. Some scholars recommend the use of transesophageal echocardiography intraoperatively to determine whether the perfusion catheter enters the true lumen; Intraoperative perfusion pressure is monitored to determine whether the perfusion catheter has entered the true lumen, if it does not, the perfusion pressure will increase. Ascending aortic catheter perfusion has been shown in the literature to be safe and effective.

Innominate cannulation perfusion strategy (IAC):

Innominate artery catheter perfusion is one of the most widely used perfusion strategies in type A aortic dissection, especially when emergency situations require rapid establishment of cardiopulmonary bypass. With the advantages of saving time and easy operation, the literature shows that innominating artery cannula is a safe method of cannulation perfusion. Zhong Hui et al. confirmed that the innominate artery cannulation strategy is also a safe and effective cannulation strategy in cardiopulmonary bypass surgery in infants and young children. In the process of application, some scholars have found that this perfusion strategy also has its limitations, and when the conditions of the right axillary artery and the left common carotid artery are not good, poor perfusion of tissues and organs may occur.

Common carotid artery cannulation perfusion strategy (CAC):

Urbanski proposed in 2006 to establish extracorporeal bypass perfusion through the common carotid artery. This method of cannulation has the advantages of simple technical operation, wide arterial diameter, and short establishment cycle time, especially suitable for obese patients. The literature shows that bilateral common carotid artery perfusion has better brain protection effect than unilateral common carotid artery perfusion, and the incidence of nerve injury in postoperative patients is lower. When atherosclerosis occurs in the arteries, the choice of common carotid artery cannula may lead to cerebral embolism, so patients with poor common carotid artery conditions should not choose this perfusion strategy.

REFERENCES

1. C. A. Nienaber and R. E. Clough, “Management of acute aortic dissection,” Lancet, vol. 385, no. 9970, pp. 800–811, 2015, doi: 10. 1016/ S0140- 6736(14)61005-9.
2. J. Diamond, C. Bateman, and J. Laws, “Cancer Registrar Training Guide Pennsylvania Cancer Registry Registries,” 2020.
3. L. M. Kern MJ, Sorajja P, “Cardiac catheterization handbook.,” in Elsevier Health Sciences, 2016.
4. G. Matalanis and S. Ip, “A new paradigm in the management of acute type A aortic dissection: Total aortic repair,” J. Thorac. Cardiovasc. Surg., vol. 157, no. 1, pp. 3–11, 2019, doi: 10.1016/j.jtcvs.2018.08.118.

5. L. J. Saw, M. S. Lim-Cooke, B. Woodward, A. Othman, and A. Harky, “The surgical management of acute type A aortic dissection: Current options and future trends,” J. Card. Surg., vol. 35, no. 9, pp. 2286–2296, 2020, doi: 10.1111/jocs.14733.
6. T. Krüger et al., “Acute aortic dissection type A,” Br. J. Surg., vol. 99, no. 10, pp. 1331–1344, 2012, doi: 10.1002/bjs.8840.
7. G. Tong et al., “Aortic Balloon Occlusion Technique Does Not Improve Peri-Operative Outcomes for Acute Type A Acute Aortic Dissection Patients With Lower Body Malperfusion,” Front. Cardiovasc. Med., vol. 9, no. March, pp. 1–7, 2022, doi: 10.3389/fcvm.2022.835896.
8. J. B. Kim et al., “Total arch repair versus hemiarch repair in the management of acute DeBakey type I aortic dissection,” Eur. J. Cardio-thoracic Surg., vol. 40, no. 4, pp. 881–887, 2011, doi: 10.1016/j.ejcts.2010.12.035.
9. M. Di Eusanio et al., “Separate grafts or en bloc anastomosis for arch vessels reimplantation to the aortic arch,” Ann. Thorac. Surg., vol. 77, no. 6, pp. 2021–2028, 2004, doi: 10.1016/j.athoracsur.2003.10.094.
10. K. Shen et al., “Total Arch Replacement With Frozen Elephant Trunk Using a NEW ‘Brain-Heart-First’ Strategy for Acute DeBakey Type I Aortic Dissection Can Be Performed Under Mild Hypothermia (≥30°C) With Satisfactory Outcomes,” Front. Cardiovasc. Med., vol. 9, no. February, pp. 1–7, 2022, doi: 10.3389/fcvm.2022.806822.
11. J. Bachet, “Open repair techniques in the aortic arch are still superior,” Ann. Cardiothorac. Surg., vol. 7, no. 3, pp. 328–345, 2018, doi: 10. 21037/ acs.2018.05.05.
12. H. N. Smith et al., “Classification and outcomes of extended arch repair for acute Type A aortic dissection: A systematic review and meta-analysis,” Interact. Cardiovasc. Thorac. Surg., vol. 24, no. 3, pp. 450–459, 2017, doi: 10.1093/icvts/ivw355.
13. M. L. Morton J Kern, Paul Sorajja, The cardiac Catheterization Handbook, vol. 6. 2012. doi: 10.1093/ejcts/ezt359.
14. C. Olsson, C. G. Hillebrant, J. Liska, U. Lockowandt, P. Eriksson, and A. Franco-Cereceda, “Mortality in acute type A aortic dissection: Validation of the Penn classification,” Ann. Thorac. Surg., vol. 92, no. 4, pp. 1376–1382, 2011, doi: 10.1016/j.athoracsur.2011.05.011.
15. P. Stanger, M. A. Heymann, H. Tarnoff, J. I. Hoffman, and A. M. Rudolph, “Complications of cardiac catheterization of neonates, infants, and children. A three year study,” Circulation, vol. 50, no. 3, pp. 595–608, 1974, doi: 10.1161/01.CIR.50.3.595.
16. D. W. M. Muller, K. J. Shamir, S. G. Ellis, and E. J. Topol, “Peripheral vascular complications after conventional and complex percutaneous coronary interventional procedures,” Am. J. Cardiol., vol. 69, no. 1, pp. 63–68, 1992, doi: 10.1016/0002-9149(92)90677-Q.
17. M. Carl et al., “S3 Guidelines for intensive care of cardiac surgery patients. Hemodynamic monitoring and cardiocirculatory system,” Zeitschrift fur Herz-, Thorax- und Gefasschirurgie, vol. 24, no. 5, pp. 294–310, 2010, doi: 10.1007/s00398-010-0790-1.

18. R. Erbel et al., “Diagnosis and management of aortic dissection: Recommendations of the Task Force on Aortic Dissection, European Society of Cardiology,” Eur. Heart J., vol. 22, no. 18, pp. 1642–1681, 2001, doi: 10.1053/euhj.2001.2782.
19. R. M. Wyman, R. D. Safian, V. Portway, J. J. Skillman, R. G. Mckay, and D. S. Baim, “Current complications of diagnostic and therapeutic cardiac catheterization,” J. Am. Coll. Cardiol., vol. 12, no. 6, pp. 1400–1406, 1988, doi: 10.1016/S0735-1097(88)80002-0.
20. B. Chandrasekar et al., “Complications of cardiac catheterization in the current era: A single-center experience,” Catheter. Cardiovasc. Interv., vol. 52, no. 3, pp. 289–295, 2001, doi: 10.1002/ccd.1067.
21. T. Gudbjartsson et al., “Acute type A aortic dissection–a review,” Scand. Cardiovasc. J., vol. 54, no. 1, pp. 1–13, 2020, doi: 10.1080/ 14017431. 2019.1660401.
22. S. S. Poon, T. Theologou, D. Harrington, M. Kuduvalli, A. Oo, and M. Field, “Hemiarch versus total aortic arch replacement in acute type A dissection: A systematic review and meta-analysis,” Ann. Cardiothorac. Surg., vol. 5, no. 3, pp. 156–173, 2016, doi: 10.21037/acs.2016.05.06.
23. Ram E, Krupik Y, Lipey A, et al. Is Axillary Better Than Femoral Artery Cannulation in Repair of Acute Type A Aortic Dissection?. Innovations (Phila). 2019;14(2):124-133. doi:10.1177/1556984519836879
24. Goldstein LJ, Davies RR, Rizzo JA, et al. Stroke in surgery of the thoracic aorta: incidence, impact, etiology, and prevention. J Thorac Cardiovasc Surg. 2001;122(5):935-945. doi:10.1067/mtc.2001.117276
25. Peterson MD, Mazine A, El-Hamamsy I, et al. Knowledge, attitudes, and practice preferences of Canadian cardiac surgeons toward the management of acute type A aortic dissection. J Thorac Cardiovasc Surg. 2015;150(4):824-31.e315. doi:10.1016/j.jtcvs.20
26. Gulbins H，Pritisanac A，Ennker J. Axillary versus femoral cannulation for aortic surgery: Enough evidence for a general recommendation ［J］? Ann Thorac Surg，2007，83(3) : 1219—1224.
27. Moizumi Y，Motoyoshi N，Sakuma K，et al . Axillary artery cannulation improves operative results for acute type a aortic dissection ［J］. Ann Thorac Surg，2005，80(1) : 77 —83.
28. Strauch JT，Spielvogel D，Lauten A，et al . Axillary artery cannulation: Ｒoutine use in ascending aorta and aortic arch replacement ［J］. Ann Thorac Surg，2004，78(1) : 103—108
29. Wong DR, Coselli JS, Palmero L, et al. Axillary artery cannulation in surgery for acute or subacute ascending aortic dissections. Ann Thorac Surg. 2010;90(3):731-737. doi:10.1016/j.athoracsur.2010.04.059
30. Benedetto U, Mohamed H, Vitulli P, Petrou M. Axillary versus femoral arterial cannulation in type A acute aortic dissection: evidence from a meta-analysis of comparative studies and adjusted risk estimates. Eur J Cardiothorac Surg. 2015;48(6):953-959.
31. Erbel R, Aboyans V, Boileau C, et al. Wytyczne ESC dotyczące rozpoznawania i leczenia chorób aorty w 2014 roku [2014 ESC Guidelines on the diagnosis and treatment of aortic diseases]. Kardiol Pol. 2014;72(12):1169-1252. doi:10.5603/KP.2014.0225

32. Moizumi Y, Motoyoshi N, Sakuma K, et al. Axillary artery cannulation improves operative results for acute type a aortic dissection. Ann Thorac Surg 2005;80:77-83.