Basic Approaches for the Surgical Management of Acute Type A Aortic Dissection: Safe Management Strategies for the General Cardiac Surgeon

Tirone E. David

Surgery for acute type A aortic dissection is associated with high operative mortality and morbidity largely because of its heterogeneity in pathology, pathophysiology and clinical presentation. Many patients die before reaching an emergency room whereas others walk in a doctors' office complaining of vague chest discomfort or other symptom and are found to have acute type A aortic dissections. The dissection may involve only the ascending aorta in some cases whereas in most patients the entry tear is in the proximal ascending aorta and the false lumen extends down to the thoracic, abdominal and even femoral arteries causing various degrees of organ malperfusion. The faster the diagnosis is made and the faster the patient can be taken to the operating the better for the patient, and probably for the surgeon too. The mortality of acute type A aortic dissection during the first 24 h is very high and referring these patients to an aortic center may be inappropriate because whatever might be gained in operative mortality if the operation is performed by an experienced aortic surgeon the overall mortality might be higher by delaying surgery. In addition, even experienced aortic surgeons find challenging to operate on certain patients with acute type A aortic dissection. Thus, the general cardiac surgeon working somewhere distant from an "aortic center" is probably the best person to save the patient's life. This is an operation that every cardiac surgeon should be able to perform, and if it is planned and executed well, the mortality and morbidity rates can be reduced.

This chapter was written with the "general cardiac surgeon" in mind, the one who sees only a few patients with acute type A dissection each year. Based on my

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T. E. David (✉)
University of Toronto, Toronto, ON, Canada
e-mail: tirone.david@uhn.ca

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lifetime experience working in a teaching hospital, I will be describing techniques that I know that are reproducible if only followed correctly and performed with care and attention to the details I will enumerate. Although I already mentioned, I firmly believe that prompt diagnosis and immediate surgery are crucial in this disease, and the sooner you can get the patient on the operating table, the better the operative and long-term outcomes will be.

The Hemodynamically Unstable Patient

Hemodynamic instability after acute type A aortic dissection occurs because acute myocardial ischemia due to the dissection or ruptured of the false lumen into the pericardial cavity with consequent pericardial tamponade or rupture into the chest of abdominal cavities. It is difficult and sometimes impossible to save the patient with acute rupture of the false lumen in the pleural or abdominal cavity. However, it is relatively common to have to operate on patients with myocardial ischemia or pericardial tamponade. Patients with acute type A dissection and myocardial ischemia may have been treated by emergency room doctors with drugs such as ticagrelol which immensely increases the risk of massive postoperative bleeding. I have operated on only two such patients and one died as consequence of massive blood transfusion after a correctly and expeditiously performed operation for acute type A dissection.

An arterial line on the right radial or brachial artery, a central venous line, and a good peripheral IV are indispensable in hemodynamically unstable patients. Although transcutaneous cannulation of the femoral vessels can be performed, I believe you should start the operation by making an incision in the inguinal area and expose the anterior wall of the femoral vein and common femoral artery. If the femoral artery has evidence of a false lumen, mobilize this vessel circumferentially and put tapes around it. If there is no dissection, simply put a purse string suture on the anterior wall of the common femoral artery. A purse string suture should also be place on the femoral vein. Next, go to the chest and do a full median-sternotomy. If the hemodynamic instability is due to tamponade the pericardial cavity will be tense and blue. Don't open it because if you do there is a risk of a hypertensive crisis and the aorta may blow up and make things messy. Give heparin and insert perfusion cannulas in the femoral vessels using the Seldinger technique. If the femoral artery has a false lumen, clamp it and open it transversely and insert a cannular into the true lumen. Both the arterial and venous cardiopulmonary bypass lines should have a second arm of tubing 80–100 cm long in case you need another venous cannula to completely drain the right side of the heart, or another arterial cannula. Go on bypass and start to cool the patient. Make a small incision in the pericardium and begin to drain the fluid slowly. Alert the anesthetist of possible hypertension and reduce the doses of inotropes and vasopressors. The rupture that caused the tamponade is often sealed and there is no active bleeding in most patients. If this is the case, carry on and you may want to insert a cannula in the right atrium for better venous

drainage. The heart is not likely to fibrillate very soon if left undisturbed because it is the last organ to receive cold blood when blood is pumped into a femoral artery. However, if the heart is ischemic because of occlusion of the right coronary artery by the dissection and/or if there is severe aortic insufficiency, the heart may fibrillate sooner than you hope. Regardless, it is safer to insert a vent into the right superior pulmonary vein and gently advance it into the left ventricle. In addition, you should do two more things while the patient is being cooled: insert a cardioplegia cannula into the coronary sinus and put a tape around the superior vena cava. If the heart begins to fibrillate but the left ventricle is not distending, wait until the nasopharyngeal temperature reaches 20–22 °C. If the ventricle is distending, apply suction on the ventricular vent and increase the pump flow into the femoral cannula. Uncommonly, the aortic insufficiency is so severe that perfusion pressure cannot be maintained or the heart remains distended and requires more than an occasional manual squeeze to decompress it. In this case, reduce the pump flow to 1 l/min and apply a large clamp on the proximal half of the ascending aorta, as close to the sinotubular junction as possible without much dissection (you will have to clamp part of the pulmonary artery too), and gently increase the pump flow. When the heart is empty give 1–2 l of cold blood cardioplegia into the coronary sinus. You may also want to use some topical cooling by placing ice over a sponge on top of the right ventricle.

When the target temperature is reached, snare the superior vena cava and wait for 30 s before stopping the pump (venous hypertension prevents air from entering the cerebral circulation). Transect the ascending aorta at its mid-portion and incise its anterior wall (false and true lumens) up to the level of the innominate artery. Visually inspect the intima of the aortic arch for any tear, and if there is none, cut the ascending aorta a few millimeters below the level of the innominate artery.

If you did not have to clamp the aorta because of severe aortic insufficiency, now is the time to give retrograde blood cardioplegia (the perfusionist has to know in advance that cardioplegia will be given during circulatory arrest).

Choose a tubular Dacron graft that fits inside the true lumen of the arch, usually 26–30 mm in diameter, depending of the size of the patient and aorta. Dacron grafts manufacturers make large straight grafts with a side arm (8–10 mm) that can be used for antegrade perfusion. Next, suture the Dacron graft 5–7 mm inside the intima on the posterior wall of the aortic arch with a horizontal mattress suture of 4–0 polypropylene buttressed on a 4–5 mm wide strip of Teflon felt on the adventitia. The needle should be the thinnest you can find. Begin to suture the graft into the posterior wall of the arch by making sure that the graft lies at least 5–7 mm inside the dissected intima of the aortic arch. Every bite should be through the intima first, 3–4 mm apart from each other, and 5–7 mm into the arch and in the graft. Once you reach the innominate artery, take the second arm of the suture and begin to sew the anterior wall of the graft inside the intima with the same precision that you sutured the posterior wall. Never pull the suture against the intima; pull it always against the graft to prevent tears in the intima along the suture line. I do not think you should use French glue or BioGlue® (Cryolife, Kennesaw, GA) but other experienced surgeons believe that it makes the anastomosis more hemostatic. If you are going to use glue, do so

sparingly and only in between the dissected layers along the first centimeter where you are going to suture the graft. Fibrin glue can also be used to "glue" the layers together before suturing the graft and it does not cause tissue necrosis like the others do. Next, remove the arterial femoral cannula and insert into the Dacron graft, 1 cm from the distal anastomosis by making a small transverse cut in the graft (smaller than the size of the arterial cannula) and placing two 4-0 polypropylene sutures, one on each end of the cut to secure the cannula, and later to close the hole in the graft. Conversely, if you have large Dacron grafts with a side arm for perfusion, insert the cannula into the perfusion limb of the graft. Start antegrade perfusion with an open graft and carefully de-air the aortic arch. Clamp the Dacron graft close to the new arterial cannula or perfusion limb of the graft and increase perfusion pressure. Release the tape on the superior vena cava and re-establish full cardiopulmonary bypass. The distal anastomosis seldom leaks if performed as described. If it does, place extra stitches but reduce the pump flow to 1 l/min while you are putting the stitches and tying them. When the anastomosis is perfect, begin to re-warm the patient. Figure 1 illustrates the sequence of the technique described above.

I have had a few patients in whom the ascending aorta was bleeding actively when I opened the pericardium and I had to exsanguinate the patient into the venous reservoir, clamp the aorta above the rupture and re-establish full cardiopulmonary bypass before proceeding with the operation as described above. Those patients did not always survive surgery.

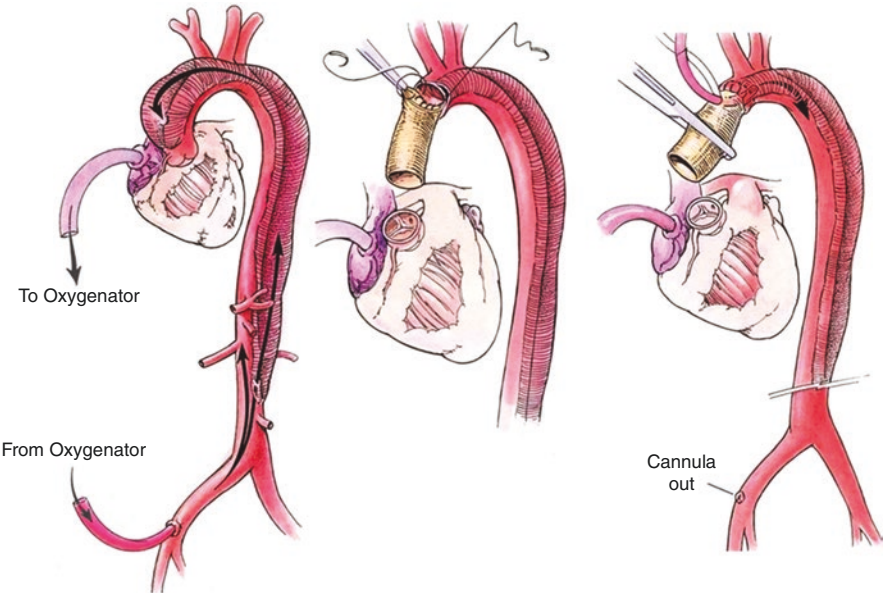

Fig. 1 Femoral artery perfusion reverses the flow in the false lumen and aortic clamping should be avoided to reduce the risk of malperfusion. The distal anastomosis should be performed under circulatory arrest. The femoral cannula should be removed and inserted into the Dacron graft for antegrade perfusion after completion of the distal anastomosis or connected to a perfusion branch already sewn to the Dacron graft

Clamping the aorta just below the takeoff of the innominate artery in acute type A aortic dissection should be avoided when arterial blood is pumped in the femoral artery because it can increase the risk of malperfusion and cause multiple ruptures of the false lumen (Fig. 1).

It is generally believed that it is important to resect the primary tear in type A aortic dissection. Luckily, in most patients the tear starts just above the sinotubular junction in the greater curvature of the ascending aorta. However, the primary tear can be in the aortic arch and resection can be complicated because it may require replacement of the entire aortic arch, and sometimes even replacement of the proximal parts of the brachiocephalic arteries. This is not an operation for a "general cardiac surgeon". I believe that the safest thing for you to do is to replace the ascending aorta as described above and leave the tear in the aortic arch unless you can resect the tear without detaching the brachiocephalic vessels from the aortic arch and descending thoracic aorta. You should do your best to save the patient's life and if further surgery is needed in the future, so be it, and it is certainly much better than death or a devastating stroke if you try to replace the aortic arch and brachiocephalic arteries in this acute setting.

The Hemodynamically Stable Patient

In the hemodynamically stable patient with acute type A aortic dissection you can take a bit more time and do things differently. You should have two monitoring arterial lines, one on each arm, and perhaps even a third one in a femoral artery (all this to control malperfusion during cardiopulmonary bypass). If you know how to expose the right axillary artery, this is the ideal vessel to use as arterial return during cardiopulmonary bypass unless there is a complex arch dissection with tears that extend into the right subclavian artery which his uncommon but when it does you should not use it for arterial return. The right axillary artery should be mobilized for a length of 25–30 mm and elastic vessel loops passed around it proximally and distally or you also can use fine vascular clamps. A tubular graft of 6 or 8 mm (Dacron or Gore-Tex) should be sutured to it in an end-to-side fashion and used for arterial return (Fig. 2). You do not have to give heparin to perform this anastomosis because there are plenty collaterals around the axillary artery. Once the anastomosis is completed, release the distal vessel loop first and let some blood out. Occlude the vessel distally and release the proximal vessel loop for a fraction of second. Clamp the graft a few millimeters from the anastomosis and release both vessel loops. Make sure the anastomosis is intact. The blood pressure in the right radial artery should return to normal after releasing the vessel loops.

Do a full median-sternotomy, open the pericardium and give heparin. Connect the arterial line to the axillary artery graft (Fig. 2). This line should have a second limb of tubing 80–100 cm for another arterial cannula if needed. Use the right atrium for venous drainage. Go on cardiopulmonary bypass and began to cool the patient. If the mean arterial pressure in the right arm is greater than 15–20 mmHg

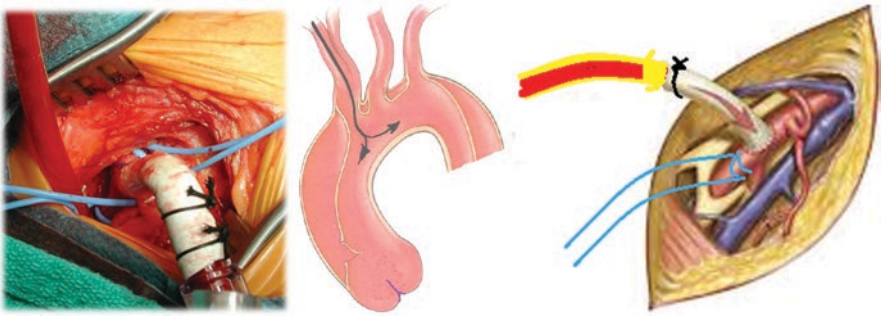

Fig. 2 Axillary artery perfusion may prevent malperfusion because blood is pumped into the true lumen. With this type of arterial return during cardiopulmonary bypass the ascending aorta may be clamped without increasing the risk of malperfusion

than in the left arm, gently snare the distal vessel loop on the axillary artery until the mean pressures are similar. If the arterial resistance in the pump head is too high to deliver the calculated blood flow, you need to insert a second arterial cannula, probably in the femoral artery. Insert a left ventricular vent through the right superior pulmonary vein. You can now clamp the ascending aorta 1–2 cm below the takeoff of the innominate artery and wait for a few seconds to make sure the blood pressure remains the same in both arms. Transect the aorta and give cardioplegia either directly into the coronary arteries or retrograde into the coronary sinus.

Carefully dissect the aortic arch and brachiocephalic arteries. Start by detaching the pericardial reflection around the distal ascending aorta, then the innominate vein, and finally the three brachiocephalic arteries. When the nasopharyngeal temperature is 25 °C and the rectal is below 30 °C (the rectal temperature will not drop as fast as the nasopharyngeal because cold blood is being pumped into the axillary artery) you can reduce the flow to 10 ml/kg/min, clamp all three bachiocephalic vessels, remove the aortic clamp and cut the ascending aorta (true and false lumens) immediately below the level of the innominate artery. Suture a tubular Dacron graft to the aortic arch as described above for the hemodynamically unstable patient. Once this anastomosis is completed you may to use the axillary artery for antegrade perfusion or insert a new arterial cannula into the Dacron graft as described above. If the anastomosis is intact, begin to re-warm the patient.

If you are unfamiliar with axillary artery anatomy or this artery is too small to supply blood to the entire body, you may use the femoral artery for cardiopulmonary bypass and conduct the operation as we described for the hemodynamically unstable patient but avoid clamping the aorta to reduce the risk of malperfusion and further expand the false lumen.

The Patient with Malperfusion

Malperfusion of one or more organs (heart, brain, mesenteric, renal and peripheral arteries) was associated with higher operative mortality in all three large registries on acute type A aortic dissection (International Registry on Acute Aortic Dissection, German Registry for Acute Aortic Dissection Type A, and the Nordic Consortium for Acute Type A Aortic Dissection). Malperfusion of at least one organ occurs in approximately one-third of all patients. The best approach to manage these patients remains controversial and it ranges from immediate surgery and repair of the proximal aorta to force the blood into the true lumen to percutaneous intervention with fenestration and stenting of the descending thoracic aorta and delay repair of the proximal aorta. What should the general cardiac surgeon do when a patient presents with life threatening malperfusion? If the patient has mesenteric ischemia and profound lactic acidosis, surgery may be futile. If resources for percutaneous intervention are available, fenestration and stenting can be considered. If the patient has myocardial, cerebral, renal or peripheral malperfusion and has no serious co-morbidities, I believe immediate surgery with cardiopulmonary bypass with at least two arterial cannulas (axillary and femoral) or one central cannula into the true lumen (if you can do this safely) is probably the safest approach. If malperfusion persists after proximal aortic repair which restored flow into the true lumen, a separate procedure may be necessary and this may involve transcatheter interventions such as fenestration and stenting of large and medium size arteries or an extra-anatomic bypass such as axillary artery to femoral artery bypass for lower limb ischemia. Patients with persistent malperfusion after proximal aortic repair usually succumb postoperatively in spite all available therapies.

The Patient with Aortic Arch Tear

The aortic arch can be the primary site of an aortic tear and the dissection can propagate distally (antegrade false lumen) or proximally (retrograde false lumen) or in both directions. Patients with antegrade aortic arch dissection can be managed medically initially as if they had Type B aortic dissection, however, if the dissection extends proximally the risk of rupture into the pericardial cavity appears to be similar to Type A and surgery with total arch replacement and probably and descending thoracic aortic stent should be done. These types of operations are in the domain of experienced aortic surgeons and referral to an aortic center may be the best for the patient.

The Aortic Root

Once the distal anastomosis is completed attention is turned to the aortic root. Transect the false and true lumens 5–7 mm above the sinotubular junction. Gently suspend the three commissures of the aortic valve and inspect the cusps. If they are normal or near normal, an attempt should be made to save them. Next, inspect the aortic sinuses and the extensiveness of the dissection. If it involves only the non-coronary aortic sinus and part of the right (the most common finding in acute type A dissection), and the sinuses are not aneurysmal, they can be preserved. I don't believe you should use BioGlue® (I prefer to use fibrin glue to seal the intima with the adventitia) but many surgeons disagree with me. If you are going to use glue do so sparingly to minimize tissue necrosis and false aneurysms later on. Suspend the three commissures and approximate them until the three cusps touch each other. Measure the diameter of the imaginary circle that include all three commisures and use a Dacron graft of this size to repair the root. In one end of the graft make three equidistant marks (approximately at 120° from each other), unless the inter-commissural distances are grossly different (the left cusp is usually the smallest of the three and so is its inter-commissural distance). Using three horizontal mattress sutures (4-0 polypropylene with a fine needle) secure the Dacron inside the aortic root immediately above each commissure using the marks made in the end of the graft as reference points. Buttress these sutures on a strip of Teflon felt on the adventitia of the aortic root. As with the distal anastomosis, carefully suture the Dacron graft to the aortic root using the same principles (the bites should be 3–4 mm apart and 5–7 mm into the aortic wall and Dacron graft, and the needle is always passed from the inside to the outside of the aortic root). Once this anastomosis is completed, inject blood cardioplegia under pressure inside graft by clamping its distal part. This maneuver tests the integrity of the proximal anastomosis and aortic valve competence. In my experience, if the ventricle does not distend while cardioplegia is given and the ventricular vent is not on suction there must be none or less than mild aortic insufficiency.

If the aortic sinuses are aneurysmal or extensively dissected but the cusps are normal, an aortic valve-sparing operation can be performed. Reimplantation of the aortic valve in a tubular Dacron graft has been shown to provide excellent long-term results in patients with acute type A aortic dissection that need aortic root repair. Aortic valve sparing operations are complex procedures and usually out of the domain of the general cardiac surgeon and I believe that an aortic root replacement is probably safer in this setting. Depending on the patients' age you may use a mechanical or a tissue valve.

Finally, if the aortic sinuses are relatively normal with minimal dissection but the aortic cusps are diseased, replace the aortic valve, leave the coronary arteries where they are, and suture a graft in the supra-coronary position.

If the dissection involved the orifice of the right coronary artery but the intima of this artery is intact, there is no need to bypass it as elimination of the false lumen alone should re-establish normal flow. If there is an intimal tear around the orifice of the right coronary artery or its intima is damaged, it is safer to tie it off and bypass it with a saphenous vein graft 1 or 2 cm from its origin. Remember that suturing a vein graft into collagen impregnated Dacron can cause ostio-stenosis of the vein due to pannus. Thus, if the vein has a small caliber (<4 mm), it is safer to sew a patch of vein graft on the Dacron graft (a circular patch 1–1.5 cm^2 is adequate) and the saphenous vein graft onto the vein patch.

Trim the distal and proximal Dacron grafts and suture them together. Remember that the total length of the ascending aorta graft should be only 4–5 cm. Thus, both the distal and the proximal grafts should be relatively short to prevent kinking of the graft. De-air the heart and unclamp the distal graft. Reperfuse the heart and when the rectal temperature is around 36 °C discontinue bypass. If things are stable and you have a cannula into the aortic graft, remove it before reversing the heparin and put it into the right atrium in the place of the venous cannula. Tie the sutures that you placed to secure the cannula in the graft and run a fine polypropylene suture for hemostasis. Obviously, this is not necessary if you used a Dacron graft with a perfusing branch. Give protamine and make sure hemostasis is perfect. Transfusion of platelets and other clotting factors are often needed in acute type A aortic dissection because most of these patients develop coagulopathy.

Do this operation as described and your patient will have a 90% chance to go home alive and without neurological deficit. Unfortunately you will lose some patients mostly because of malperfusion, which remains an unresolved problem in surgery for acute type A aortic dissection.

Postoperative Care

Most surgically treated patients with acute type A aortic dissection require more than one day in the intensive care unit. In addition to the routine postoperative care for patients who undergo surgery on cardiopulmonary bypass they need close surveillance for malperfusion and may need further intervention if the malperfusion is life-threatening.

Antihypertensive agents, particularly betablockers, are extremely important to prevent or retard the expansion of the false lumen. A CT angiogram is advisable before discharge from hospital to determine patency, extension and diameter of the false lumen. These patients need lifelong surveillance of the false lumen with periodical images of the entire thoracic and abdominal aorta as well as echocardiography of the aortic root.

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