

Are We There Yet? Emerging Milestones in Aortic Dissection Care

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By land, by sea, by air, and by foot, I have hauled my sons into the wilds on adventures. But nothing can match the “off-the-road” sublime vistas of the North Slope of Alaska’s Brooks Range, with inquisitive caribou and grizzlies visiting camp and howling wolves hunting moose in the valleys, or walking around the African bush and coming to face a suspicious lion, querulous elephant, irritable rhinoceros, or cantankerous buffalo. These are the dangers and thrills of being off the road. On long road trips when my sons were young, I admit to partaking of the finer delights of roadside fast food distributors. One particularly irritating toy from a kids’ meal would ask a frequent question automated to frustrate parents: “Are we there yet?” To pass the time and keep them occupied, my wife and I tried to distract them with games, like doing calculations from milestones.

Do we have milestones in the treatment of aortic dissection? Are we off the road, or are we even close to “there yet,” as suggested by the article by Reutersberg and colleagues¹ from the Munich Aortic Center, published in this issue of the *Journal of the American Heart Association (JAHA)*? In 1979, when I was a trainee in cardiology, I had a large, young patient in severe distress in the cardiology intensive care unit, with hypotension, increased jugular venous pressure, and distant heart sounds. Recall that at that time we had neither bedside echocardiography nor computed tomography. As I watched from the foot of the bed, the scene neuroimprinted in my mind. The cardiac surgeon opened a subxiphoid pericardial incision to relieve the tamponade, whereupon the patient sustained a free rupture and died. Since then, I have witnessed our frustrations in managing patients with acute dissection clinically, at mortality and morbidity meetings, and in medical journals.^{2–9}

What milestones can we point to on this sometimes frustrating journey? (1) Use of anti-impulse medications, such as β blockers, combined with nitroprusside or clonidine to reduce dP/dt and hypertension, allowing patients to be stabilized for potentially definitive care, such as surgery or endografting⁶; (2) better imaging by ECG-gated computed tomography, magnetic resonance imaging, transthoracic echocardiogram, and transesophageal echocardiogram^{5,6}; (3) rapid transfer of patients by helicopter or fixed-wing ambulance to teams at centers of excellence, although this may result in sicker or unsalvageable patients being transferred; (4) earlier detection of potential pending disasters, such as an aortic root or ascending aorta diameter of >5.0 cm or an indexed aortic cross-sectional area/height ratio of >10 , although, frustratingly, many patients dissect at a diameter of <5.0 cm, particularly those with Marfan syndrome^{6–8,10}; (5) better understanding of connective tissue disorders, genetic mutations, and bicuspid valves as risk factors for aortic dissection^{5–7,9}; (6) quicker transfer of patients to operating rooms for surgery,⁶ including transferring patients with a serious suspicion of aortic dissection, even if the outside computed tomographic scan is of poor quality and not ECG gated, and performing an intraoperative transesophageal echocardiogram before opening the chest; and sewing a side graft onto the subclavian/axillary artery before opening the chest to enable “sucker bypass” if the aorta ruptures on relieving tamponade; and (7) improvements in surgical care.^{2,5,6,8–15}

Nearly 20 years ago, International Registry of Acute Aortic Dissection authors reported that mortality for acute ascending aortic dissection at multiple centers was 27.4% (type A and B extents).⁹ Subsequently, they reported a decline to 18% for type A and no change for type B.⁸ Meanwhile, expert surgeons, like Stanley Crawford in Houston, TX, were achieving 6% mortality for type B descending aortic repairs by 1984 and 5% mortality for type A repairs by 1986.¹⁵ At the 2018 American Association for Thoracic Surgery meeting, I was asked to give a talk entitled, “How to Achieve a $<5\%$ Mortality Rate for Acute Aortic Dissection Repair.” We did not reach that milestone. Mortality was 8.1% for ascending or hemiarch emergency repairs for type A and 9.7% when the total arch was included.

In earlier reports, our group noted that use of the subclavian artery with a side graft for arterial inflow for

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deep hypothermic arrest (a technique pioneered by Crawford for left-ventricular assist devices) was associated with reduced stroke.¹⁶ Subsequently, a subgroup analysis of Cleveland Clinic (Cleveland, OH) acute aortic dissection repair data,¹¹ presented at the 2018 American Association for Thoracic Surgery meeting, and an analysis of Society of Thoracic Surgeons' data, presented at the 2018 Western Thoracic Surgical Association meeting, confirmed an association with reduced stroke and, in the Society of Thoracic Surgeons' study, reduced death with subclavian/axillary cannulation. For chronic dissection, 0.8% mortality and stroke can be achieved.¹⁷ For prophylactic bicuspid valve surgery, 0.25% mortality is also possible.¹² Our group has performed root reimplantation in 870 patients, with a mortality of 0.17% for prophylactic repairs, emphasizing the much worse results with acute dissection versus elective procedures.

Why then, in the article by Reutersberg and colleagues,¹ the increase in mortality for their type A aortic dissection definition (namely, those involving repair of the ascending aorta), but no significant increase in mortality for type B? For type B repairs, the authors report a 9.3% mortality. This is important because, based on the administrative data they used, type B is classified as ONLY those patients in whom the aorta was repaired beyond the left subclavian artery, mostly by thoracic endovascular aortic repair (TEVAR) (92%), with a 6.7% occurrence of paraplegia/spinal infarction and only a 0.3% occurrence of stroke (table 3 in the article by Reutersberg and colleagues¹). These results are a milestone for 5622 repairs of acute, subacute, or chronic descending aortic and thoracoabdominal dissection.

Previously, including in the American Heart Association/American College of Cardiology Guidelines,⁶ TEVAR was recommended (class I, level C) for acute type B dissections only if pain was ongoing or complications arose.⁵ The INSTEAD (Investigation of Stent Grafts in Aortic Dissection) trial showed that early mortality was higher for subacute dissection treated with TEVAR, but on later follow-up, the Kaplan-Meier survival curves crossed¹⁸; hence, there was enthusiasm for broader use of TEVAR in settings other than acute dissection with complications. However, despite this change to lower-risk patients, results have not improved. A restricted mean survival time analysis would show when this survival difference became significantly important. Alternatively, the pioneering TEVAR series recently updated from Stanford University (Stanford, CA) showed late survival may be better with open surgery versus TEVAR.¹⁹ Clearly, vascular surgeons in Germany have embraced TEVAR for all types and extents of aortic dissection, but less so in Britain, where the National Institute for Health and Care Excellence has restricted both TEVAR and EVAR. In the United States, TEVAR technology is freely available.

Why, then, the disappointing results for their type A dissection, coded as procedures including the ascending aorta?¹ Is this an issue of timing (acute aortic dissection), coding, type extent, or increasing use of ascending aorta or arch stenting? A third of the patients did not undergo cardiopulmonary bypass; hence, the procedure had to be done "off pump," and most likely by endovascular methods, although the authors did not have this information from the administrative data (table 2 in the article by Reutersberg and colleagues¹). When stenting for true type B dissections, often the stent has to be extended into the arch, covering commonly the left subclavian artery and varying extents of the arch. Because of "bird beaking" of the proximal stent, additional stents have to be placed into the ascending aorta to cover the ridge produced by bird beaking.⁵ Thus, stents into the arch extent may be for true type B extent dissections. It is also likely that there may have been a small number of true type A extent dissections with ascending aortic stents placed because the patients were turned down for conventional open aortic surgery. Nevertheless, this is rare. In a large series of 39 endovascular repairs of the ascending aorta from our group, Roselli and colleagues reported 13% mortality and 10% stroke, one of the best in the literature.²⁰ Considering that, in the report by Reutersberg and colleagues,¹ these stents were used in the ascending aorta and arch without cardiopulmonary bypass, but classified as type A, use of motor-evoked potentials and spinal catheters, 20% mortality, 12% occurrence of acute paraplegia/spinal infarction, and 25% dialysis all make sense. More accurately, these were true type B extent dissections, and, except for ascending aortic dissection, they should have been classified as type B. The low occurrence of stroke in both groups (1% for type A and 0.3% for type B) also raises concerns about the accuracy of the coding and administrative data collection.

Only 5.7% of patients (n=857, table 2 in the article by Reutersberg and colleagues¹) underwent "hybrid" procedures, combining open surgery, presumably arch surgery, and stenting. This is important because German cardiac surgeons have been at the forefront of the so-called frozen elephant trunk procedure, whereby an open repair is supplemented with a stent in the descending aorta to try to prevent later aneurysm formation, or arch elephant trunk stenting. In the GERAADA (German Registry for Acute Aortic Dissection Type A),²¹ which notably does not include chronic dissection, mortality was 16.9% and neurologic dysfunction was 9.5%. From the report by Reutersberg and colleagues,¹ we cannot determine whether the outcomes were for the two thirds of patients in whom procedures were done "on pump," or how the proportion of acute dissection versus chronic dissection, or hybrid procedures, influenced outcome. Chinese and European surgeons, however, have adopted an even more

aggressive elephant trunk class IV/V procedure, with total replacement of the arch and stenting of the graft for dissections.¹⁴ This type of more extensive repair is also referred to as a hybrid procedure.

In summary, does the article by Reutersberg and colleagues¹ describe a thrilling milestone or a risky off-the-road detour attributable to more endovascular stenting for aortic dissection? All we can say definitively is that irrespective of the age of the aortic dissection, if patients are treated with TEVAR only for the descending aorta (their type B), results are reasonable, but if these patients have mostly chronic dissection, results could be better with open surgery at centers of excellence. It would appear that arch stenting or stents to the ascending aorta (one third of their type A) carry considerable risk of death and paralysis. However, we do not know exactly how many patients underwent such stenting. Nevertheless, if these were patients who would have otherwise died and were turned down for conventional open surgery, then 4 of 5 were probably saved, which is not an unreasonable outcome.

In the past 60 years, there have been many significant milestones in improved aortic dissection care, but as long as humans have hearts and aortas, debate will continue about which road to take, whether conventional surgery or the more thrilling off-the-road procedure. A prospective randomized trial is unlikely because of acuity and variability. If humans still exist in 1000 years, as Stephen Hawking, Bill Gates, and Elon Musk doubt, maybe a human brain hooked to “deep-learning” artificial intelligence networks (because of better creativity and less power use of 14 W, hence heat production) and artificially maintained without a heart or aorta will be immune to aortic dissection. In the meantime, we should determine optimal timing for elective intervention because of its excellent results compared with emergency repairs. Blood markers or markers in the aorta that signal impending aortic doom, such as metalloproteinase activity on magnetic resonance imaging, may help in patient selection. On the road to treating or preventing aortic dissection, scientists will undoubtedly emerge with a vision for future milestones.

Disclosures

None.

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