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Original Research Article

The Aortic Team Model for the Management of the Distal Arch, Descending Thoracic and Thoracoabdominal Aorta: Appraisal at 3 Years

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Aorta (Stamford)

Abstract

Background This study aimed to assess feasibility, logistical challenges, and clinical outcomes associated with the implementation of an Aortic Team model for the management of distal arch, descending thoracic and thoracoabdominal aortic disease.

Methods An Aortic Team care pathway was implemented in November 2019. Working as a unit, two cardiac surgeons, two vascular surgeons, an interventional radiologist, a cardiologist, and an anesthesiologist collectively determined care decisions via multispecialty presence at an Aortic Clinic. Cardiac and vascular surgeons operated in tandem for open procedures. Interventional radiology participated alongside cardiac and vascular for endovascular procedures. Cardiology aided in medical therapies for heritable and degenerative disease, and had a lead role for genetics and high-risk pregnancy referrals. The model spanned three hospitals. Clinical outcomes at 3 years were assessed.

Results There were 35 descending thoracic and thoracoabdominal surgeries and 77 thoracic endovascular aortic repairs. Endoarch devices were used in 7 cases (Gore Thoracic Branch Endoprosthesis, 4, Terumo RelayBranch, 3) and an endothoracoabdominal device in 4 cases (Cook Zenith t-branch). The Aortic Clinic acquired 456 patients, with yearly increases (54 patients [year 1], 181 patients [year 2], 221 patients [year 3]). For surgery, mortality was 8.6% (3/35), permanent paralysis 5.7% (2/35), stroke 8.6% (3/35), permanent dialysis 0%, and reinterventions 8.6% (3/35). For endovascular cases, mortality was 3.9% (3/77), permanent paralysis 3.9% (3/77), stroke 5.2% (4/77), permanent dialysis 1.3% (1/77), and reinterventions 16.9% (13/77).

Keywords
- aorta
- thoracoabdominal
- thoracic endovascular repair
- multidisciplinary
- interdisciplinary

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Conclusion An Aortic Team model is feasible and ensures all treatment options are considered. Conventional open thoracoabdominal procedures showed acceptable outcomes. Endoarch technology shows early promise.

Introduction

Treatment of aortic pathologies within the aortic arch, descending thoracic and thoracoabdominal aorta draws upon the expertise of several specialties, with synergistic and overlapping skillsets. Cardiac surgery, vascular surgery, interventional radiology, and cardiology, each have specialists with a vested interest in the care of this patient population[1] (►**Fig. 1**). Although aortic disease has historically followed siloed care pathways, with referral to other specialties as deemed necessary, certain factors limit the utility of this approach for providing best patient care in the present era. Endovascular therapy, adopted to varying degrees across the invested specialties (and to varying degrees by specialists within each specialty), has revolutionized aortic care and plays an integral role in the contemporary management of thoracic aortic disease.[2,3] The endovascular footprint continues to expand in scope. Fenestrated and branched endovascular devices are used with increasing frequency to treat thoracoabdominal aortic disease.[4] Experience with total endovascular aortic arch technology is also increasing.[5,6] Case volumes with these improving technologies are certain to steadily increase in the near future. Despite these advancements, open surgery for the descending thoracic and thoracoabdominal aorta provides excellent results in high-volume aortic centers and remains first-line therapy in select patient cohorts.[7–9] In-step with these advancements, the medical sphere has had expansive knowledge growth, with genetic and biomechanical research providing necessary, and increasingly complex nuance to the preventative medical management of aortic disease.[10,11]

Siloed care pathways deter specialists from referring to specialties with overlapping skills who offer alternative treatment options for consideration. In addition, because of the overlap in expertise, patients with the same aortic condition may be referred to different specialties and be treated in a different manner based on the referral patterns and focused expertise of the specialist receiving the referral. In a multispecialty team approach, however, skillset overlap can be leveraged to promote collaboration among specialties. This approach also promotes centralized referral, facilitating a contribution by all aortic experts to the decision-making prior to an intervention. Ultimately, it standardizes care practices for complex disease within a given catchment area.

In recognition of the shortcomings of siloed care for treatment decisions in complex aortic patients, a collaborative multidisciplinary Aortic Team model was developed within the Libin Cardiovascular Institute at the University of Calgary (Calgary, Alberta, Canada). This Aortic Team model was created with a primary objective to ensure collaborative decision-making across aortic specialties to optimize best care practices. We describe the development of this Aortic Team model, provide 3-year outcomes data, and discuss future implications.

Materials and Methods

Aortic Team

Development

In November 2019, the existing siloed care model for treatment of the distal arch, descending thoracic and thoracoabdominal aorta at the University of Calgary was restructured by engaged team members to create an interdisciplinary Aortic Team model. The previous siloed model consisted of a two-hospital construct, with vascular surgery at one hospital and cardiac surgery at another hospital. Cross-specialty interaction for aortic management was rare. Two separate interventional radiology groups provided care at the two hospitals and worked solely with the surgeons at their designated hospital. Cardiology provided care at both hospitals (►**Fig. 2A**). The catchment area of these hospitals served over 2 million people, encompassing all of southern Alberta and parts of the adjoining provinces of British Columbia and Saskatchewan. All complex aortic disease within the catchment area was managed by these two hospitals.

The restructured interdisciplinary Aortic Team model, locally known as the Calgary Aortic Program, brought together two cardiac surgeons, two vascular surgeons, an interventional radiologist, and a cardiologist to lead the initiative. All members had prior dedicated aortic training at high-volume aortic centers. Focus was placed on the distal aortic arch, descending thoracic and thoracoabdominal aorta. At the program's inception, an interdisciplinary Aortic Clinic was implemented at a third hospital. This "neutral site" was purposely chosen for the creation of the clinic, to promote the building of a collaborative program anew. This facilitated equal input by all invested specialists with respect to management strategies (►**Fig. 2B**). A priori, it was determined that a cardiac and vascular surgeon would work in tandem within the clinic, assess patients, and determine best treatment options (medical, endovascular, or surgical). Cardiology, in the same clinic space, would run an aortopathy clinic in tandem with the surgical clinic, having fluid cross-referrals and direct patient assessments together as needed. Interventional radiology would be debriefed on complex cases at weekly rounds, with open dialogue for input and opinions toward treatment options. An encrypted messaging portal shared by the aortic team members was also utilized. The clinic would serve as a hub for interdisciplinary decision-making on complex aortic cases, facilitate long-term imaging

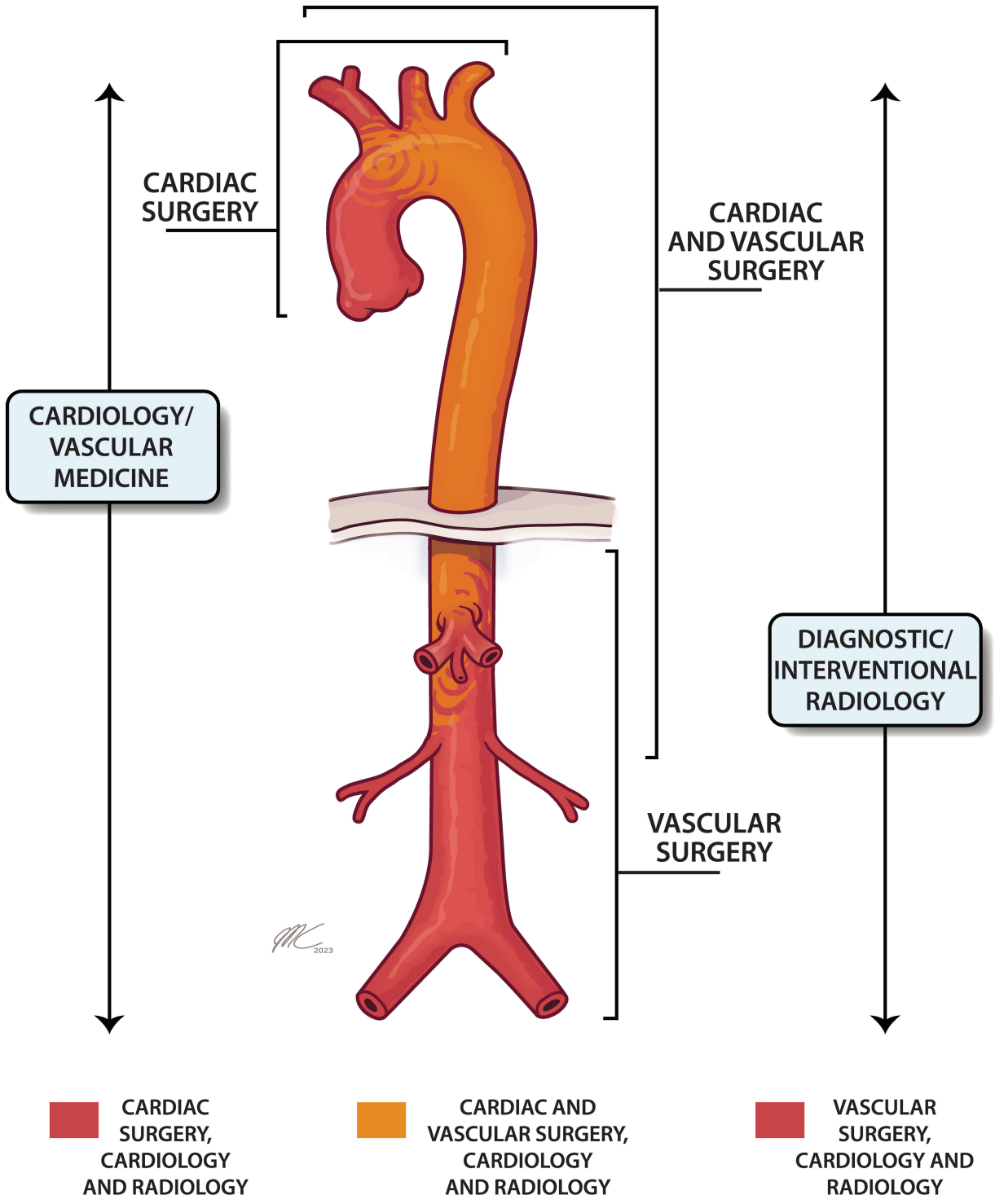
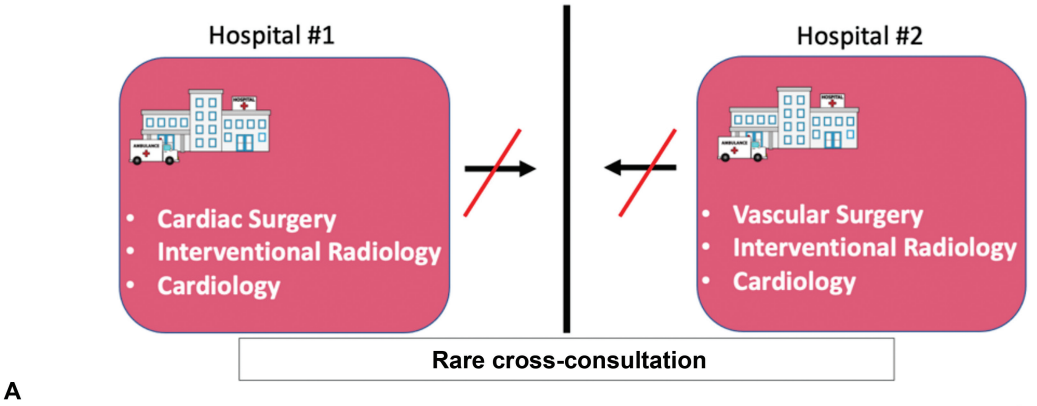
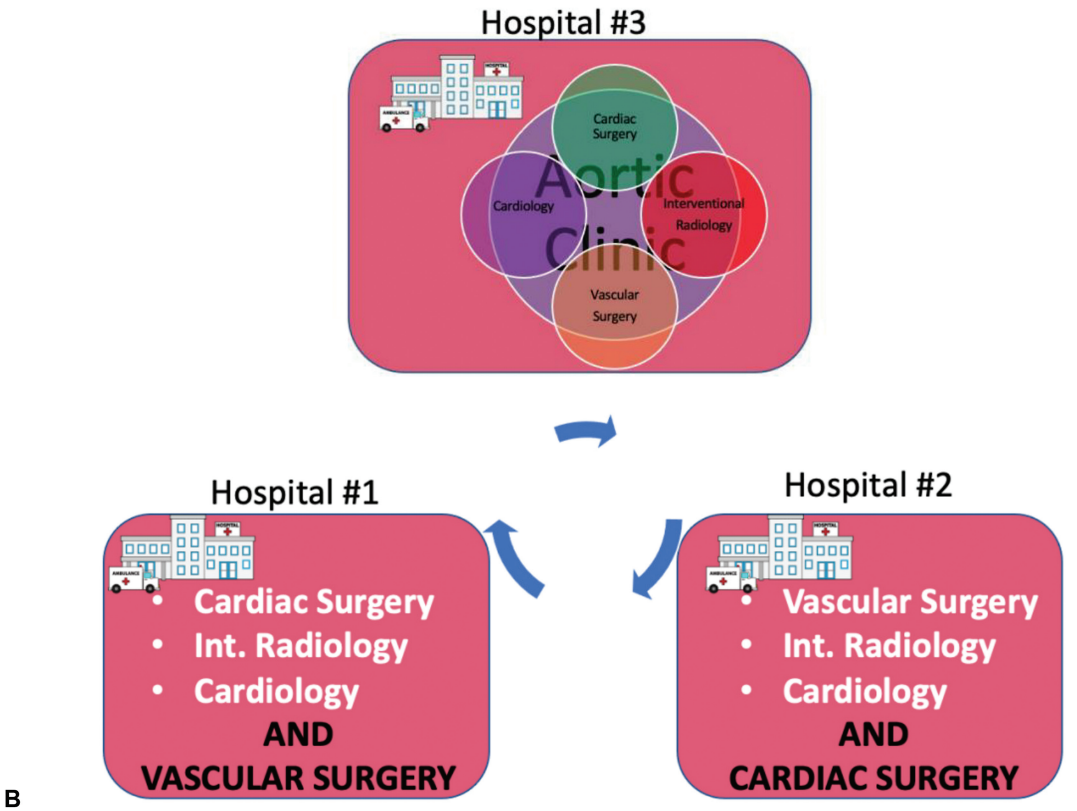


Fig. 1 Depiction of the overlap across specialties invested in the management aorta disease, highlighting areas where interdisciplinary treatment strategies may be of value.

surveillance, and be a single point of care entry site for primary care and other specialty referrals. Also a priori, it was further agreed that a cardiac and vascular surgeon would operate in tandem for all open distal arch, descending thoracic and thoracoabdominal cases. For elective endovascular cases, interventional radiology was actively involved alongside cardiac and vascular surgeons. Open cases were discussed and performed with an experienced cardiac anesthesiologist having perioperative training from a high-volume aortic center. A formal preoperative assessment within the dedicated cardiac anesthesia preadmission clinic was also carried forth. The model was developed over a period of several months through discussions with members across the respective specialties to ensure full support.



A



B

Fig. 2 (A) Siloed care model. Limited cross-consultation. (B) Collaborative Interdisciplinary Decision Making and Tandem Treatment Model.

Three-Year Outcomes Assessment

A review of the Aortic Team model from its inception in November 2019 out to January 2023 (38 months) was completed. Clinical outcomes were assessed for all open surgical and endovascular cases referred to the aortic team for the distal arch, descending thoracic and thoracoabdominal aorta. Aortic clinic volumes were tabulated on an annual basis. The study was approved by the Conjoint Health Research Ethics Board at the University of Calgary (REB22-0868. Approved September 6, 2022). Individual patient consent was waived. Preoperative, intraoperative, and postoperative data collection was through the Alberta Health Services Data Analytics department, with a query for all open (thoracotomy or thoracoabdominal) and endovascular thoracic aortic procedures in the time interval of interest performed by aortic team members. Data were further cross-referenced and supplemented with a review of the aortic clinics internal database. Categorical data are presented with numbers and percentiles. Continuous data are presented as a median with the interquartile range.

Open and Endovascular Techniques

Open surgery for the descending thoracic aorta and extent I, II, and III thoracoabdominal procedures were performed

with deep hypothermic circulatory arrest at 18°C or left heart bypass and permissive hypothermia at 34°C. Deep hypothermic circulatory arrest was preferentially used for focal aortic arch or short-segment descending thoracic pathologies, or when the aorta was not suitable for cross-clamping. Left heart bypass was preferentially used for more extensive aortic operations requiring more surgical resection. A general anesthetic, single lung ventilation with placement of a double-lumen endotracheal tube and transesophageal echocardiography were used for all cases. A standard posterolateral thoracotomy or thoracoabdominal incision paramedian to the umbilicus was used. The fourth, fifth, or sixth intercostal space was entered, depending on the aortic segments involved and this was extended across the costal margin, where appropriate. A retroperitoneal approach was utilized for access to the abdominal aorta. For deep hypothermic circulatory arrest, a left groin cutdown and femoral–femoral cardiopulmonary bypass was used. After completion of the proximal anastomosis, the arterial circuit was configured such that proximal perfusion was immediately reinstituted through a side limb of the aortic graft. For left heart bypass, the left femoral artery was used for inflow, with either direct cannulation or with an 8-mm graft sewn to the vessel. The left inferior pulmonary vein was cannulated for outflow. A centrifugal pump and an oxygenator were incorporated into of the left heart bypass circuit. Heparin was administered to maintain an activated clotting time of 250 seconds or more. Shed blood from the operative field was collected into a cell-saver and immediately directed to a Belmont Rapid Infuser (Belmont Medical Technologies, Billerica, MA) to facilitate immediate reinfusion of the unwashed blood back to the patient through a 15F cannula placed in the right internal jugular vein.[12] A multibranched thoracoabdominal graft was used whenever there was perivisceral vessel involvement, allowing for end-to-end separate anastomoses. Intercostals between T10 and T12 were routinely reimplanted. A spinal drain and neuromonitoring with both somatosensory and motor evoked potentials were routinely used for thoracoabdominal procedures. Extent IV thoracoabdominal procedures also employed a retroperitoneal approach, but a clamp and sew technique was used with a supraceliac clamp. Continuous cold crystalloid renal perfusion at 4°C was used for all thoracoabdominal procedures when the renals were involved.

For endovascular cases, a general anesthetic and transesophageal echocardiography were used. Percutaneous femoral access was routine, with cutdowns reserved for cases at higher risk of vascular complications. Adenosine-induced transient asystole or permissive hypotension with venous inflow occlusion were used when necessary for precise positioning at device deployment.[13] Spinal drains were used for all cases where endovascular coverage below T8 was anticipated. For double-branched aortic arch endografts with antegrade inner branch configuration (RelayBranch, Terumo Aortic, Sunrise, FL), bilateral carotid cutdowns were used.[14] For single-branched aortic arch endografts having a retrograde inner branch configuration (Thoracic Branched Endograft, W.L. Gore, Newark, DE), percutaneous axillary to femoral artery through and through wire access was utilized. Complicated Type B aortic dissections and uncomplicated Type B aortic dissections with high-risk features,[2] when anatomically suitable, underwent endovascular therapy during the acute or subacute phase.

Results

Results are summarized in ►**Fig. 3**. From its inception, the Aortic Clinic had a year-over-year incremental referral

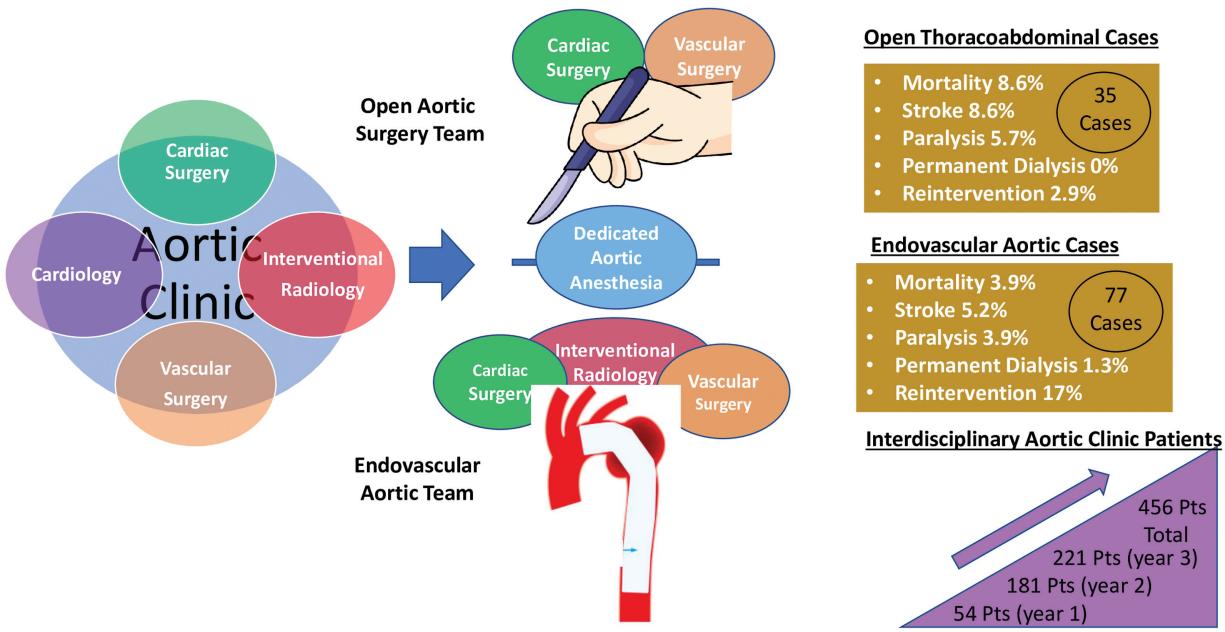


Fig. 3 Visual depiction of clinic development and 3-year results for aortic team management strategy. Pts, patients.

Table 1 Patient demographics

Variables	Open surgery		Endovascular therapy	
n	35 cases		77 cases	
Age (mean, range)	58 (16–73)		66 (20–92)	
Male	22	63%	51	66%
Diabetes	5	14%	14	18%
Hypertension	28	80%	54	70%
Prior stroke	7	20%	8	10%
Chronic obstructive pulmonary disease	14	40%	13	17%
Dyslipidemia	20	57%	12	16%
Chronic kidney disease	2	6%	11	14%
Prior ascending aortic surgery	13	37%	–	–
Heritable thoracic aortic disease	5	14%	–	–

increase from 54 patients in year 1, 181 patients in year 2, and 221 patients in year 3, for a cumulative total of 456 patients. One hundred and twelve patients underwent invasive treatment, either as scheduled cases that had been referred and assessed at the Aortic Clinic or as emergent/urgent cases having direct hospital admission. There were 35 open surgical cases and 77 endovascular cases. Patient demographics are listed in ►**Table 1**. The underlying diagnosis and treatment strategies (open surgery or endovascular therapy) are listed in ►**Table 2**. Both cohorts were predominantly male with a high prevalence of hypertension. There were clear differences across the surgery and endovascular cohorts, both in risk profile and the underlying indications for treatment. The surgical cohort had more obstructive pulmonary disease, history of stroke and dyslipidemia whereas the endovascular cohort had more acuity, more kidney disease, and diabetes. The surgery cohort predominantly had aneurysmal disease (20/35; 57%), followed by subacute or chronic aortic dissection (12/35; 34%), and also included two cases of aortic coarctation (2/35; 6%). Conversely, the predominant indication for endovascular therapy was aortic dissection (47/77; 61%), with a hyperacute or acute presentation in 40% of cases. The remaining endovascular cases were for aneurysmal disease (29/77; 38%) and a single case of aortic coarctation (1/77; 1%). In the surgical cohort, two-thirds of the cases were thoracoabdominal procedures (23/35; 66%), with just over half being Extent I to III (12/23; 52%) and the remaining being Extent IV (11/23; 48%). In the endovascular cohort there were seven endoarch cases, with four deployments in zone 0 (three Terumo RelayBranch endoprostheses and one Gore TBE endoprosthesis), one deployment in zone 1, and two deployments in zone 2 (all three Gore TBE endoprostheses). There were also four endothoracoabdominal device deployments (Cook Zenith t-branch endoprosthesis).

Clinical outcomes are listed in ►**Table 3**. Hospital mortality, stroke, and permanent paralysis was 8.6, 8.6, and 5.7%, respectively, in the surgical cohort and 3.9, 5.2, and 3.9%, respectively, in the endovascular cohort. Two patients in the surgical cohort required temporary dialysis but none required permanent dialysis. In the endovascular cohort, permanent dialysis was required in one patient having suffered malperfusion in the face of an acute Type B aortic dissection. Less reinterventions were required in the surgical cohort (3/35; 8.6%) relative to the endovascular cohort (13/77; 16.9%); however, both length of stay in the intensive care unit (median; 6 vs. 2 d) and the overall hospital stay (median; 15 vs. 6 d) were longer in the surgical cohort. There were no major adverse events the endoarch cases. One endothoracoabdominal patient suffered a cerebrovascular event.

Discussion

The argument in favor of an interdisciplinary Aortic Team to collectively determine how best to treat complex pathology of the aortic arch, descending thoracic and thoracoabdominal aorta is a compelling one. These patients have high-risk pathology. In many situations, the best treatment for aortic disease in this area can be controversial, dependent on both patient factors and the expertise of the specialist assessing the patient. Decisions can be nuanced and discordant viewpoints across specialists are not uncommon.[15,16] Moreover, the modest skillset overlap across specialties can be problematic, with siloed specialists tending to overreach their abilities to determine the value of an alternative treatment option for which their respective training may not be optimized. The recent American Heart Association guidelines on aortic disease management as well as a recent European expert consensus on aortic arch pathology each gave a Class I indication to use of multidisciplinary aortic teams.[2,17] A recent Canadian Clinical Practice Update has also endorsed the need for an Aortic Team model and collaborative decision pathways for aortic care.[18] Still, despite the theoretic practicality of an Aortic Team and its potential value for patient care, reports to the formal development of an Aortic Team and clinical results derived from such a model are sparse.

The current study provides a comprehensive and descriptive assessment of the development of an Aortic Team model with clinical outcome data at 3 years. There are several key findings. First, a team model to care with multiple specialties

Table 2 Diagnosis and treatment strategies

Etiology, types of procedures, and approach				
Variables	**Open surgery**		**Endovascular interventions**	
n	35 cases		77 cases	
Etiology:				
Aneurysm	20	57%	29	38%
Dissection	13	37%	47	61%
Acute	0	0%	19	40%
Subacute	2	15%	11	23%
Chronic	11	85%	17	36%
Coarctation	2	6%	1	1%
TEVAR explant	3	9%		
Procedure:				
Descending thoracic	12	34%		
Thoracoabdominal	23	66%		
Extent I	6	26%		
Extent II	2	9%		
Extent III	4	17%		
Extent IV	11	48%		
Hybrid	5	45%		
Approach:				
Left heart bypass	12	34%		
Deep hypothermic circulatory arrest	12	34%		
Neither adjunct	11	31%		
Neuroadjuncts:				
SSEP/MEP	16	46%		
Cerebrospinal fluid drain	26	74%	50	65%

Abbreviations: MEP, motor-evoked potential; TEVAR, thoracic endovascular aortic repair; SSEP, somatosensory-evoked potential.

Table 3 Clinical outcomes

Variables	Open surgery		Endovascular therapy	
n	35 cases		77 cases	
Mortality	3	8.6%	3	3.9%
Stroke	3	8.6%	4	5.2%
Permanent paralysis	2	5.7%	3	3.9%
Permanent dialysis	0	0%	1	1.3%
Any reinterventions	3	8.6%	13	16.9%
Length of intensive care unit stay (days)	6 (median)	4–12 (IQR)	2 (median)	1–4 (IQR)
Length of hospital stay (days)	15 (median)	10–31 (IQR)	6 (median)	4–13 (IQR)

Abbreviation: IQR, interquartile range.

coordinating their individual practices to facilitate collaborative decision-making is both feasible and sustainable. Though logistical challenges exist, they are not insurmountable. Scheduling for multispecialty presence both within the operating rooms, and clinics, requires support from senior hospital administrators to be successful. Our experience has the heightened complexity of requiring coordinated coverage across multiple hospitals. We had to integrate the presence of the two surgical specialties (cardiac and vascular) into each historically siloed hospital to provide

collaborative aortic care. We also leveraged the use of a third hospital to create our aortic clinic, as we felt strongly, for us, building the clinic in partnership at a new site from the outset was the best way to promote partnership across the four specialties. For medical centers where all necessary specialties are present at a single hospital, the process would be further streamlined. It is our opinion that the benefits derived from the Aortic Team model, most importantly for the patients, but also for the involved physicians, far outweigh any of the logistical inconveniences relative to the alternative siloed care model. The difficult but pertinent necessity to balance a program's commitment to complex open thoracoabdominal surgery, as well as more conservative medical management strategies, while also embracing new innovative technologies in an objective manner is best achieved in a team construct. Centralized referral to an aortic team mitigates bias in the clinical decision-making process and the collective presence within a multispecialty aortic clinic further fosters this ideal. Moreover, a centralized clinic for the four specialties assures patients are not lost to follow-up and long-term surveillance needs are met. This has been most notable for chronic Type B dissections and residual chronic Type A dissections postemergent acute type A surgical repair. It is often this patient population where complex redo open surgery or endovascular or hybrid procedures warrant discussion and collaboration. These patients are now referred for long-term follow-up within the Aortic Clinic.

Our 3-year results support the above assertions. With respect to open surgery, we averaged just under 12 open cases per year with acceptable outcomes. Our expectation based on increasing patient referrals to the aortic clinic on a yearly basis, is that the open surgical cohort will continue to expand. This, despite a team enthusiasm toward novel endovascular therapies at our institution. The model has fostered accelerated adoption and experience with endoarch technologies that continues to increase.[19] Industry has mandated our collaborative approach to access "first in Canada" endoarch technology to ensure optimal outcomes. Several devices have been piloted at our institution prior to the anticipated widespread dissemination to the Canadian market.[19]

Finally, a commitment to an aortic team lends itself well to progressive collaboration and promotes allied interdependent partnerships. These integrated workings facilitate cross-pollination, enhance subspecialty training in complex team-based aortic care, and can potentially evolve such that true "aortic specialists" are the lasting end product for the future.[20]

Though we have focused on the distal arch, descending thoracic and thoracoabdominal aorta, this is a moving target that may broaden with time. At present, most proximal aortic disease is managed by cardiac surgeons and cardiologists, while most infrarenal abdominal aortic disease is managed by vascular surgeons and vascular medicine. Though there are exceptions to every rule, for the most part, we feel the area where there is most crossover of specialty care, where cardiac surgeons, vascular surgeons, cardiologists, and interventional radiologists are all within the same space, is within the aortic segments of which we have focused. The aorta is too fluid for precise cutoffs, but broadly speaking, collaboration on varied treatment options derives the most value at the aortic arch, descending thoracic and thoracoabdominal aorta.

A limitation to this study is the lack of a control group for comparison. Though it is sensical to assume collaborative decision-making is more likely to identify the better treatment strategy for a patient more often than a siloed approach, this is difficult to prove. To achieve this within the framework of this study would have required an analysis of siloed decision-making preprogram relative to team decision-making post-program, measured against benchmark aortic guidelines to assess variance, and then compare outcomes. Given the retrospective nature of the study, this becomes an untenable task, as you cannot with confidence know why decisions for patients in the past tense may have veered from benchmark guidelines. Efforts to manufacture comparisons in this scenario would be susceptible to substantial bias. That our clinicians have changed over time, the technology available for treatment has changed, and our collective experience increased, only further complicates such an analysis. The shortcomings of historical controls to assess decision-making and clinical judgement over time limits the value of this method for comparisons.[21] Proper analysis of decision-making requires a prospective study design. And indeed, a recent prospective cohort study looking at vascular patients did show a clinically significant impact for multidisciplinary decision-making relative to decisions being made by a single physician.[22]

Generalizability of our experience is another potential limitation. In a single-payer universal health care model as is utilized in Canada, we have been able to leverage the use of three hospitals without the barriers that would present themselves in a competitive, for-profit privatized hospital system. The development of the aortic clinic at a third hospital was cost neutral. The third hospital had underutilized clinic space and all hospitals are government funded. Still, though we leveraged a third hospital because it was available, if a hospital has all required specialties practicing at their hospital, the concept of a collaborative aortic team can still be realized within a privatized model of care.

Conclusion

Our 3-year experience supports that an Aortic Team model is a feasible construct and an effective way to ensure all treatment options are considered for complex disease of the distal arch, descending thoracic and thoracoabdominal aorta. Conventional open thoracoabdominal procedures showed acceptable outcomes. The rollout and utilization of endoarch technology within the confines of an interdisciplinary aortic team has shown early promise.

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Conflict of Interest
None declared.

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References

1 McClure RS, Berry RF, Dagenais F, et al. The many care models to treat thoracic aortic disease in Canada: a nationwide survey of cardiac surgeons, cardiologists, interventional radiologists, and vascular surgeons. CJC Open 2021;3(06):787–800
2 Isselbacher EM, Preventza O, Hamilton Black J III, et al. 2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease: A Report of the American Heart Association/American College of Cardiology Joint Committee on Clinical Practice Guidelines. Circulation 2022;146(24):e334–e482
3 Upchurch GR Jr, Escobar GA, Azizzadeh A, et al. Society for Vascular Surgery clinical practice guidelines of thoracic endovascular aortic repair for descending thoracic aortic aneurysms. J Vasc Surg 2021;73(1S):55S–83S
4 Tenorio ER, Dias-Neto MF, Lima GBB, Estrera AL, Oderich GS. Endovascular repair for thoracoabdominal aortic aneurysms: current status and future challenges. Ann Cardiothorac Surg 2021;10(06):744–767
5 Basha AM, Moore RD, Rommens KL, Herget EJ, McClure RS. A systematic review of total endovascular aortic arch repair: a promising technology. Can J Cardiol 2023;39(01):49–56
6 Nana P, Spanos K, Dakis K, Giannoukas A, Kölbel T, Haulon S. Systematic review on customized and non-customized device techniques for the endovascular repair of the aortic arch. J Endovasc Ther 2022:15266028221133701
7 Lau C, Soletti G Jr, Weinsaft JW, et al. Risk profile and operative outcomes in Marfan syndrome versus non-Marfan patients undergoing thoracoabdominal aortic aneurysm repair. J Thorac Cardiovasc Surg 2023;166(06):15481557.e2
8 Coselli JS, LeMaire SA, Preventza O, et al. Outcomes of 3309 thoracoabdominal aortic aneurysm repairs. J Thorac Cardiovasc Surg 2016;151(05):1323–1337
9 Tong MZ, Eagleton MJ, Roselli EE, et al. Outcomes of open versus endovascular repair of descending thoracic and thoracoabdominal aortic aneurysms. Ann Thorac Surg 2022;113(04):1144–1152
10 Chou E, Pirruccello JP, Ellinor PT, Lindsay ME. Genetics and mechanisms of thoracic aortic disease. Nat Rev Cardiol 2023;20(03):168–180
11 Gregory AJ, Di Martino ES, Fedak PWM, Dobson GM. Aortic biomechanics and clinical applications. Anesthesiology 2022;137(03):351–363
12 Kiser KA, Tanaka A, Sandhu HK, et al. Extensive cell salvage and postoperative outcomes following thoracoabdominal and descending aortic repair. J Thorac Cardiovasc Surg 2022;163(03):914–921.e1
13 Lee WA, Martin TD, Gravenstein N. Partial right atrial inflow occlusion for controlled systemic hypotension during thoracic endovascular aortic repair. J Vasc Surg 2008;48(02):494–498
14 McClure RS, Rommens KL, Herget EJ, Halliwell O, Moore RD. Zone 0 aortic arch reconstruction using the RelayBranch thoracic stent graft. CJC Open 2021;3(10):1307–1309
15 Chiu P, Sailer AM, Baiocchi M, et al. Impact of discordant views in the management of descending thoracic aortic aneurysm. Semin Thorac Cardiovasc Surg 2017;29(03):283–291
16 Rudarakanchana N, Reeves BC, Bicknell CD, Heatley FM, Cheshire NJ, Powell JT. Treatment decisions for descending thoracic aneurysm: preferences for thoracic endovascular aneurysm repair or surveillance in a discrete choice experiment. Eur J Vasc Endovasc Surg 2014;48(01):13–22
17 Czerny M, Schmidli J, Adler S, et al; EACTS/ESVS scientific document group. Current options and recommendations for the treatment of thoracic aortic pathologies involving the aortic arch: an expert consensus document of the European Association for Cardio-Thoracic surgery (EACTS) and the European Society for Vascular Surgery (ESVS). Eur J Cardiothorac Surg 2019;55(01):133–162
18 McClure RS, Lindsay TF, Keir M, et al. The aortic team model and collaborative decision pathways for the management of complex aortic disease: clinical practice update from the Canadian Cardiovascular Society / Canadian Society of Cardiac Surgeons / Canadian Society for Vascular Surgery / Canadian Association for Interventional Radiology. Can J Cardiol 2023;39(11):1484–1498
19 Rockley M, Rommens KL, McClure RS, Herget EJ, Smith HN, Moore RD. Aortic arch endovascular branch and fenestrated repair: Initial Canadian experience with novel technology. J Vasc Surg Cases Innov Tech 2023;9(04):101274
20 Field ML, Kuduvalli M, Torella F, Lip GYH. Aortovascular medicine: what is it? J R Soc Med 2021;114(10):467–469
21 Miller DC. Another meiosis in the specialty of cardiovascular and thoracic surgery: birth of the purebred “thoracic aortic surgeon”? J Am Coll Cardiol 2014;63(17):1804–1806
22 Prouse G, Robaldo A, van den Berg JC, Ettorre L, Mongelli F, Giovannacci L. Impact of multidisciplinary team meetings on decision making in vascular surgery: a prospective observational study. Eur J Vasc Endovasc Surg 2023;66(01):130–135

