Featured Article

Trends in sex-specific differences following aortic arch repair: results from the Canadian Thoracic Aortic Collaborative

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Background: Previous data have shown that sex-related differences exist in aortic arch surgery, with female patients experiencing worse outcomes. Over time, as surgical techniques and strategies have improved, these improvements have benefitted female patients. Using a multicenter national aortic registry from the Canadian Thoracic Aortic Collaborative (CTAC), we aimed to determine the relationship between sex and outcomes following aortic arch repair and to examine how these have changed over time.

Methods: The multicenter prospective CTAC database of all aortic procedures performed under circulatory arrest from participating centers across Canada (n=9) was used. Patients were included who underwent elective or urgent/emergency arch reconstruction under circulatory arrest from 2002 to 2021. The primary composite endpoint was defined as the occurrence of one of the following endpoints: in-hospital mortality, stroke, dialysis-dependent renal failure, deep sternal wound infection, reoperation, or prolonged ventilation of >40 hours. Secondary endpoints included in-hospital mortality, in-hospital stroke, and a modified version of the Society of Thoracic Surgeons-defined composite endpoint for mortality and major morbidity (MMOM).

Results: A total of 2,592 patients who underwent aortic arch repair between 2002 and 2021 (31.4% female and 68.6% male patients). Operative mortality decreased through the study period for female patients. No change in operative mortality was observed in male patients or following elective repair. The composite endpoint improved for female patients over time in both elective and urgent surgery, while for male patients, rates improved for elective surgery and remained stable for urgent. Ultimately, female sex was not an independent predictor of adverse outcomes following aortic arch repair.

Conclusions: Our results are congruent with existing data and are highly encouraging. It shows that multilevel improvements in our approach to aortic arch surgery have helped to serve female patients who were previously disadvantaged.

Keywords: Arch repair; aortic aneurysm; aortic dissection; sex

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Introduction

Important sex-related differences exist in the pathophysiology of thoracic aortic aneurysms and dissections. This translates further into sex-differences with respect to the prevalence, anatomic phenotype, growth rate, and virulence of these disease processes (1,2). Whether these differences then translate into outcome differences amongst male and female patients undergoing thoracic aortic surgery is less well understood. Our group, the Canadian Thoracic Aortic Collaborative (CTAC), previously reported results of our multicenter registry examining outcomes following both urgent and elective aortic arch surgery (3). We found that after multivariable regression analysis, female patients experienced significantly higher rates of death [odds ratio (OR) =1.81] and stroke (OR =1.90) (3). These findings are consistent with the outcomes of the 2004 International Registry of Aortic Dissection (IRAD) study which identified that female patients had significantly higher operative mortality than male patients (32% *vs.* 22%, P=0.01) following type A dissection repair (4). In the elective setting, single-centre studies have observed that female patients are at a significantly increased risk of post-operative complications following thoracic aortic surgery, including respiratory failure, and prolonged intensive care unit (ICU) stay (5-7).

However, the most recent data from IRAD published in 2022 suggest that not only are results for repair of type A dissection much improved in both sexes, but that the outcome gap has significantly decreased (operative mortality 17% in female patients *vs.* 14% in male patients, P=0.04) (8). Recent large national studies of type A aortic dissection from Germany have similarly reported no differences in in-hospital outcomes between the sexes (9). Taken together, these results suggest that sex disparities in outcomes of aortic surgery are improving over time. In a temporal analysis of the CTAC aortic arch registry, operative mortality and other complications were shown to have significantly improved over the past decade (10). Therefore, CTAC set out to re-examine our large national all-comers registry for aortic arch surgery with the our most recent dataset, to better clarify the nuances of sex-related outcome differences and how they have evolved over time.

Methods

Study population

CTAC maintains a multicenter database containing inpatient data from all consecutive aortic procedures performed under circulatory arrest in nine participating centers across Canada. These data are prospectively collected at local sites at the time of surgery and uploaded to the national registry periodically. Ethics approval was obtained locally from institutional review boards at individual participating institutions, with data-sharing agreements with London Health Sciences Centre (REB #119869).

All patients undergoing elective or urgent/emergency arch reconstruction under circulatory arrest from 2002 to 2021 were included in this study. Each center obtained local ethics approval from their respective institutional review boards, and individual informed consent was waived at all centers. All extents of aortic surgery including hemiarch replacements, total arch reconstructions with or without elephant trunk repairs were included if circulatory arrest was used with or without cerebral perfusion techniques. Elective and emergency cases were included, as were cases with concomitant surgery. Circulatory arrest cases not involving aortic repair (i.e., congenital cases, tumor removal, etc.) were excluded. Patients undergoing descending thoracic and thoracoabdominal aortic surgery using circulatory arrest were also excluded. The study population was divided into eight equal groups of consecutive patients: Era 1 spans January 2002 to February 2011, Era 2 spans March 2011 to October 2013, Era 3 spans November 2013 to March 2015, Era 4 spans April 2015 to April 2016, Era 5 spans May 2016 to May 2017, Era 6 spans June 2017 to June 2018, Era 7 spans July 2018 to September 2019, and Era 8 spans October 2019 to March 2021.

Outcomes

Three major outcomes of interest were evaluated: in-hospital mortality, in-hospital stroke, and a modified version of the Society of Thoracic Surgeons-defined composite endpoint for mortality and major morbidity (MMOM). This composite endpoint was defined as the occurrence of one of the following endpoints: in-hospital mortality, stroke, dialysis-dependent renal failure, deep sternal wound infection, reoperation, prolonged ventilation of >40 hours. Transfusion rates for patients undergoing arch reconstruction were also examined.

Statistics

Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range), and categorical variables were expressed as frequencies (%). Factors associated with the outcomes were identified logistic regression models using least absolute shrinkage and selection operator (LASSO) selection methods to identify candidate variables. Variables assessed as potential risk factors included pre-operative baseline characteristics (i.e., age, aortic valve disease, aortic diameter, presence of dissection or rupture, urgent status of surgery, and comorbidities), as well as operative data (extent of aortic reconstruction, concomitant surgeries, surgical times, hypothermic circulatory arrest (HCA) temperatures, HCA times, and cerebral protection strategies). For variables that were not normally distributed (e.g., surgical times), a logarithmic transformation was used. To account for the effect of the individual centers, multivariable analyses using mixed effects regression models with logit link and a random effect of the center were then conducted using variables identified through LASSO (PROC GLIMMIX in SAS 9.4, SAS Institute, Cary, NC, USA). Variables were manually excluded in a backward selection process until all variables in the final model were significant.

Trends in time for mortality in elective and urgent/emergency cases were assessed using mixed-effect regression models with logit link with a random-effect for the center to account for the effect of the individual centers. Two mixed-effect models were built for every variable including either year of surgery as a categorical variable to assess yearly estimates, or date of surgery as a continuous variable to assess a linear trend, if appropriate. For linear trend analyses, values at the beginning and the end of the curve may not exactly correspond to the yearly 2008 or 2018 estimates. Statistical significance was set at α=0.05.

Results

A total of 2,592 patients underwent arch repair between 2002 and 2021 in nine centres across Canada. There were 1,778 male (68.6%) and 814 female (31.4%) patients, and the proportion of female patients did not change throughout the study period (P=0.55). The proportion of patients that underwent surgery for acute aortic dissection or rupture were similar for both the cohort of female (30%) and male (31%) patients.

Baseline characteristics are outlined in *Table 1*. Female patients were older (67±14 *vs.* 62±13 years, P<0.001), and this age difference remained consistent over the study period. Female patients had higher rates of hypertension (P<0.001), cerebrovascular disease (P=0.011), and chronic obstructive pulmonary disease (P<0.001). Male patients

Table 1 Patient baseline characteristics

Characteristic	Overall (n=2,592)	Female (n=814)	Male (n=1,778)	P value
Risk factors				
Age, years	63±13	67±14	62±13	<0.001
Hypertension	1,756 [68]	588 [72]	1,168 [66]	<0.001
Connective tissue disease				0.89
None	2,446 [94]	770 [95]	1,676 [94]	
Suspected	53 [2.0]	15 [1.8]	38 [2.1]	
Confirmed	93 [3.6]	29 [3.6]	64 [3.6]	
Diabetes mellitus	329 [13]	107 [13]	222 [12]	0.64
Dyslipidemia	1153 [44]	366 [45]	787 [44]	0.74
Renal failure	119 [4.6]	36 [4.4]	83 [4.7]	0.78
Cerebrovascular disease	189 [7.3]	75 [9.2]	114 [6.4]	0.011
Peripheral vascular disease	280 [11]	85 [10]	195 [11]	0.69
Coronary artery disease	531 [20]	145 [18]	386 [22]	0.023

Table 1 (*continued*)

Table 1 (*continued*)

Characteristic	Overall (n=2,592)	Female (n=814)	Male (n=1,778)	P value
Ever smoker	1,166 [45]	325 [40]	841 [47]	<0.001
COPD	312 [12]	130 [16]	182 [10]	<0.001
Congestive heart failure	279 [11]	88 [11]	191 [11]	0.96
Prior myocardial infarction	188 [7.3]	53 [6.5]	135 [7.6]	0.32
Prior cardiac surgery	378 [15]	84 [10]	294 [17]	<0.001
Atrial fibrillation	306 [12]	85 [10]	221 [12]	0.15
LVEF, %	56±9	57±8	55±10	<0.001
LVEF, grade				<0.001
LVEF >60%	1,434 [55]	491 [60]	943 [53]	
LVEF 40–60%	1,005 [39]	296 [36]	709 [40]	
LVEF 20–40%	143 [5.5]	27 [3.3]	116 [6.5]	
LVEF <20%	10 [0.39]	0 [0]	10 [0.56]	
Anatomy				
Body mass index, kg/m^2	28±6	27±6	29±5	<0.001
Body surface area, m^2	1.9±0.3	1.7±0.2	2.0±0.2	<0.001
Maximum aortic diameter, mm	51±12	51±13	51±12	0.38
Maximum aortic diameter indexed, mm/m^2	26±7	29±9	25±6	<0.001
Aortic valve anatomy				<0.001
Tricuspid	1,974 [76]	682 [84]	1,292 [73]	
Bicuspid	604 [23]	131 [16]	473 [27]	
Unicuspid	14 [0.54]	1 [0.12]	13 [0.73]	
Aortic stenosis	549 [21]	151 [19]	398 [22]	0.027
Aortic insufficiency	1,119 [43]	354 [43]	765 [43]	0.83
Ascending aorta aneurysm	1,949 [75]	616 [76]	1,333 [75]	0.70
Presentation				
Acute dissection or rupture	799 [31]	244 [30]	555 [31]	0.53
Chronic and acute dissection	1,029 [40]	303 [37]	726 [41]	0.081
Rupture	162 [6.3]	57 [7.0]	105 [5.9]	0.28
Urgency status				0.60
Elective	1,462 [56]	472 [58]	990 [56]	
Urgent (same hospital stay)	279 [11]	79 [10]	200 [11]	
Emergent (<6 h)	782 [30]	241 [30]	541 [30]	
Salvage	69 [2.7]	22 [2.7]	47 [2.6]	
Emergent or salvage	851 [33]	263 [32]	588 [33]	0.70

Values are expressed n [%] for categorial variables or mean ± SD for continuous variables. COPD, chronic obstructive pulmonary disease; LVEF, left ventricular ejection fraction; SD, standard deviation.

had higher rates of previous cardiac surgery (P<0.001) and coronary artery disease (P=0.023). Maximal aortic diameter at the time of surgery decreased over time for the entire cohort (Era 1: 56±13 *vs.* Era 8: 50±11 mm, P<0.001), and this was true for both male (P=0.032) and female patients (P=0.003).

Intraoperatively, both female and male patients received similar rates of hemiarch and total arch replacement (*Table 2*). Male patients had higher rates of aortic root surgery, including Bentall procedures (30% *vs.* 17%, P<0.001) and valve-sparing root replacement (8.3% *vs.* 5.5%, P=0.013). Rates of concomitant surgery were similar between the sexes (female 26% *vs.* male patients 28%, P=0.18). Cardiopulmonary bypass time and myocardial ischemic time were longer for male patients (P<0.001 for both), reflecting the higher rate of root surgery. Duration of HCA was similar for both groups (female 20 min *vs.* male patients 21 min, P=0.43) and this did not change over the study period. Target nadir temperature during the arch repair increased over the study period (entire cohort: Era 1: 19 ℃ *vs.* Era 8: 25 ℃, P<0.001), and this was seen for both male and female patients (P<0.001 for both). Cerebral perfusion strategy shifted from no cerebral perfusion towards antegrade cerebral perfusion over time (P<0.001), and this shift was seen for both male and female patients (P<0.001 for both).

Outcomes for both sexes over the entire study period are reported in *Table 3*. Overall operative mortality was the same for male and female patients (10% *vs.* 10%, P=0.85). For female patients, these rates have decreased from 18% in Era 1 to 7.2% in Era 8 (P=0.011) (*Figure 1A*). This change was largely driven by improved outcomes following urgent surgery (Era 1: 30% *vs.* Era 8: 11%, P=0.01) (*Figure 1B*). Operative mortality did not change over time for elective surgery for female patients (P=0.32). For men, operative mortality did not change over time (P=0.41), whether for elective (P=0.29) or urgent surgery (P=0.59).

The overall perioperative stroke rate across all eras was the same between sexes (11% for female patients and 10% for male patients; P=0.50). There was a significant increase in stroke over time (P=0.021). Stratifying by sex, this change was driven by an increase in stroke rate in male patients undergoing urgent surgery (P=0.009) (*Figure 2A*). The stroke rate for male patients undergoing elective surgery remained stable over time (P=0.26). Overall stroke rate also remained same over time for female patients (P=0.11), with rates being stable for female patients undergoing urgent surgery (P=0.74) and declining over time for female patients undergoing elective arch repair (P=0.03) (*Figure 2B*).

The overall rate of MMOM across the entire study period was also the same between sexes (female 32% *vs.* male patients 32%, P=0.70). MMOM rates significantly improved following elective surgery from 32% in Era 1 to 12% in Era 8 (P<0.001). Stratifying by sex, rates of MMOM improved for female patients (P=0.002) in both the elective (P=0.012) and urgent settings (P=0.026) (*Figure 3A,3B*). MMOM rates were similar over time for male patients (P=0.12); when stratified by urgency of surgery, these rates did improve for elective surgery (P<0.001) (*Figure 3B*), while remaining the same for urgent surgeries (P=0.44). Rates of transfusion were significantly lower for male compared to female patients (72% *vs.* 78%, P=0.001). Transfusion rates improved over time for male patients (P<0.001) but remained static for female patients (P=0.58).

Multivariable logistic regression analysis found that female sex was not an independent predictor of in-hospital mortality, stroke, or MMOM (*Figure 4*). Independent predictors of outcomes are reported in *Table 4*.

Discussion

The most important finding of this study was that the sex disparities in aortic surgery that were previously observed in our multicenter Canadian aortic registry have diminished and resolved over time. Similar to our previous study, female patients were older and had a higher rate of hypertension (3). However, in contrast to our previous study, in-hospital outcomes over the entire study period were the same between sexes and female sex was not an independent predictor of any of the adverse endpoints. Improvements in operative mortality and rates of major complications, specifically in female patients undergoing urgent or emergency aortic arch surgery, drove the equalization of operative outcomes between the sexes.

Contemporary IRAD data also confirmed an era effect similar to what we observed. The sex-related differences in operative mortality for type A dissection {female sex OR =1.40 [95% confidence interval (CI): 1.00–1.98]}, disappeared when only analyzing the second decade of enrollment [female sex OR =0.93 (95% CI: 0.54–1.62)] (8). This shift over time is occurring in the context of multiple studies demonstrating improved outcomes overall for type A dissection, including a large administrative database study

Table 2 Intraoperative differences between sexes

Variable	Overall (n=2,592)	Female (n=814)	Male (n=1,778)	P value
Aortic replacement				
Ascending aorta replacement	2,252 [87]	725 [89]	1,527 [86]	0.026
Aortic arch surgery				0.69
Hemiarch	2,110 [81]	659 [81]	1,451 [82]	
Total arch	482 [19]	155 [19]	327 [18]	
Elephant trunk				0.46
None	2,262 [87]	702 [86]	1560 [88]	
Conventional elephant trunk	119 [4.6]	43 [5.3]	76 [4.3]	
Frozen elephant trunk	211 [8.1]	69 [8.5]	142 [8.0]	
Aortic valve or root surgery				
Aortic valve replacement	497 [19]	173 [21]	324 [18]	0.069
Bentall procedure	670 [26]	137 [17]	533 [30]	<0.001
Ross procedure	9 [0.35]	3 [0.37]	6 [0.34]	0.90
Valve sparing root replacement	192 [7.4]	45 [5.5]	147 [8.3]	0.013
Concomitant surgery				
Any concomitant surgery	711 [27]	209 [26]	502 [28]	0.18
Mitral valve replacement	53 [2.0]	17 [2.1]	36 [2.0]	0.92
Mitral valve repair	53 [2.0]	19 [2.3]	34 [1.9]	0.48
Coronary artery bypass graft	488 [19]	132 [16]	356 [20]	0.021
ASD or VSD closure	36 [1.4]	12 [1.5]	24 [1.3]	0.80
Perfusion				
CPB time, min	176 [131, 231]	160 [120, 210]	183 [136, 237]	<0.001
Myocardial ischemia time, min	100 [66, 142]	87 [57, 127]	105 [72, 150]	<0.001
HCA time, min	21 [13, 32]	20 [14, 31]	21 [13, 33]	0.43
HCA time, categories				0.054
30 min or less	1,854 [72]	608 [75]	1,246 [70]	
Between >30 and <60 min	560 [22]	156 [19]	404 [23]	
60 min or more	178 [6.9]	50 [6.1]	128 [7.2]	
Lowest temperature, Celsius	24 [20, 26]	24 [21, 26]	24 [20, 26]	0.012
Cerebral perfusion strategy				0.60
No cerebral perfusion	369 [14]	116 [14]	253 [14]	
Unilateral antegrade	1,933 [75]	615 [76]	1,318 [74]	
Bilateral antegrade	125 [4.8]	39 [4.8]	86 [4.8]	
Retrograde	165 [6.4]	44 [5.4]	121 [6.8]	

Table 2 (*continued*)

Table 2 (*continued*)

Variable	Overall (n=2,592)	Female (n=814)	Male (n=1,778)	P value
Cerebral perfusion time, min	17 [9, 28]	17 [9, 27]	17 [9, 29]	0.75
Cerebral ischemia time, min	0 [0, 5]	0 [0, 5]	0 [0, 5]	0.74
Cerebral ischemia time 30 min or more	84 [3.2]	18 [2.2]	66 [3.7]	0.045
Transfusion				
Any transfusion	1,920 [74]	636 [78]	1,284 [72]	0.001
Any PRBCs transfused	1,256 [48]	499 [61]	757 [43]	<0.001
Units of PRBCs used in transfused patients	3 [2, 6]	3 [2, 5]	4 [2, 6]	0.10
Any FFP transfused	1,490 [57]	453 [56]	1,037 [58]	0.20
Units of FFP used in transfused patients	4 [2, 7]	4 [2, 6]	4 [2, 8]	<0.001
Any platelets transfused	1,632 [63]	517 [64]	1,115 [63]	0.70
Units of platelets used in transfused patients	8 [2, 10]	5 [2, 10]	8 [3, 10]	0.012
Any cryoprecipitate transfused	495 [19]	135 [17]	360 [20]	0.028

Values expressed as n [%] for categorial variables or median [interquartile range] for continuous variables. ASD, atrial septal defect; VSD, ventricular septal defect; CPB, cardiopulmonary bypass; HCA, hypothermic circulatory arrest; PRBCs, packed red blood cells; FFP, fresh frozen plasma.

Table 3 Outcome differences between sexes

Variable	Overall (n=2,592)	Female (n=814)	Male (n=1,778)	P value
In-hospital mortality	260 [10]	83 [10]	177 [10]	0.85
Cerebrovascular accident	271 [10]	90 [11]	181 [10]	0.50
Cardiac reoperation for bleeding or tamponade	241 [9.3]	64 [7.9]	177 [10]	0.089
Prolonged ventilation (>40 h)	504 [19]	167 [21]	337 [19]	0.35
Dialysis dependent renal failure	151 [5.8]	35 [4.3]	116 [6.5]	0.025
Deep sternal wound infection	17 [0.66]	9 [1.1]	8 [0.45]	0.055
MMOM	827 [32]	264 [32]	563 [32]	0.70
ICU length of stay, day	2.4 [1, 5]	2.7 [1.1, 5]	2.3 [1, 5]	0.30
Hospital length of stay, day	9 [6, 15]	9 [7, 16]	8 [6, 15]	<0.001

Values expressed as n [%] for categorial variables or median [interquartile range] for continuous variables. MMOM, mortality and major morbidity composite endpoint; ICU, intensive care unit.

from Taiwan and the United Kingdom, as well as a smaller but nationwide study from Iceland (11-13).

The proportion of patients undergoing surgery rather than medical management for acute type A dissection is increasing (11,14), and so the improvement is unlikely due to fewer female patients being offered surgery, but rather overall improved surgical technique and outcomes. Female patients had the worst outcomes historically and had the most to gain from the improvements in surgical techniques, which may be the reason why the greatest statistical change is observed in this subgroup. Increasing attention, awareness and focus on sex disparities in cardiovascular surgery may

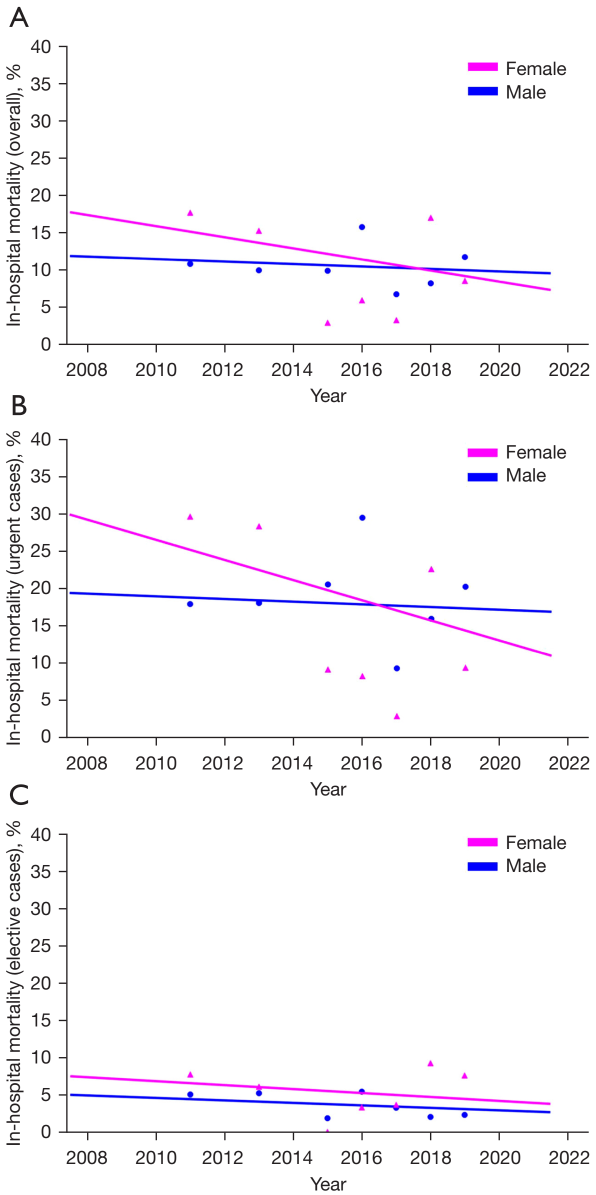

Figure 1 Sex specific trends for overall in-hospital mortality for all surgeries (A), urgent surgeries only (B), and elective surgeries only (C).

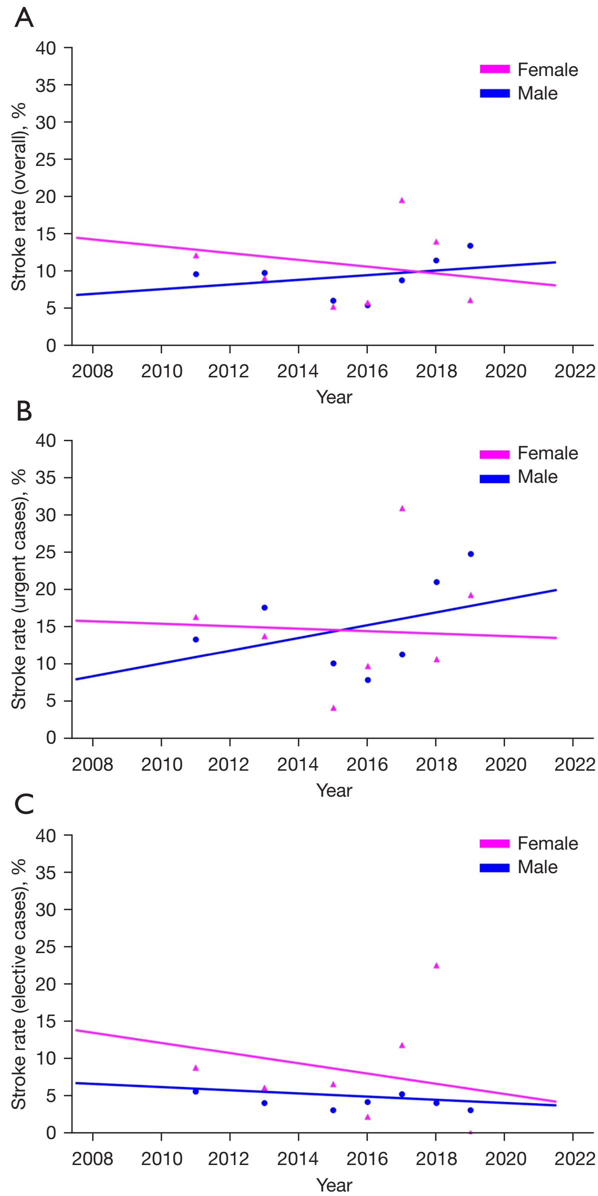

Figure 2 Sex specific trends in stroke rate for all surgeries (A), urgent surgeries (B), and elective surgeries (C)

also have played a role in improving outcomes. Additionally, with ongoing advocacy and a heightened awareness of aortic disease in female patients, perhaps female patients were also presenting earlier in the disease process, although our data registry study lacks clear evidence to support this hypothesis. Notably in our study, adverse events in male patients undergoing elective surgery were low, making it more difficult to capture incremental improvements. Larger datasets have found statistically significant improvements in outcomes for men after surgery for acute type A and B dissection as well (11).

The reasons behind aortic arch surgery becoming safer over time is multifactorial. One aspect is certainly improved adjunctive surgical techniques. Over the same

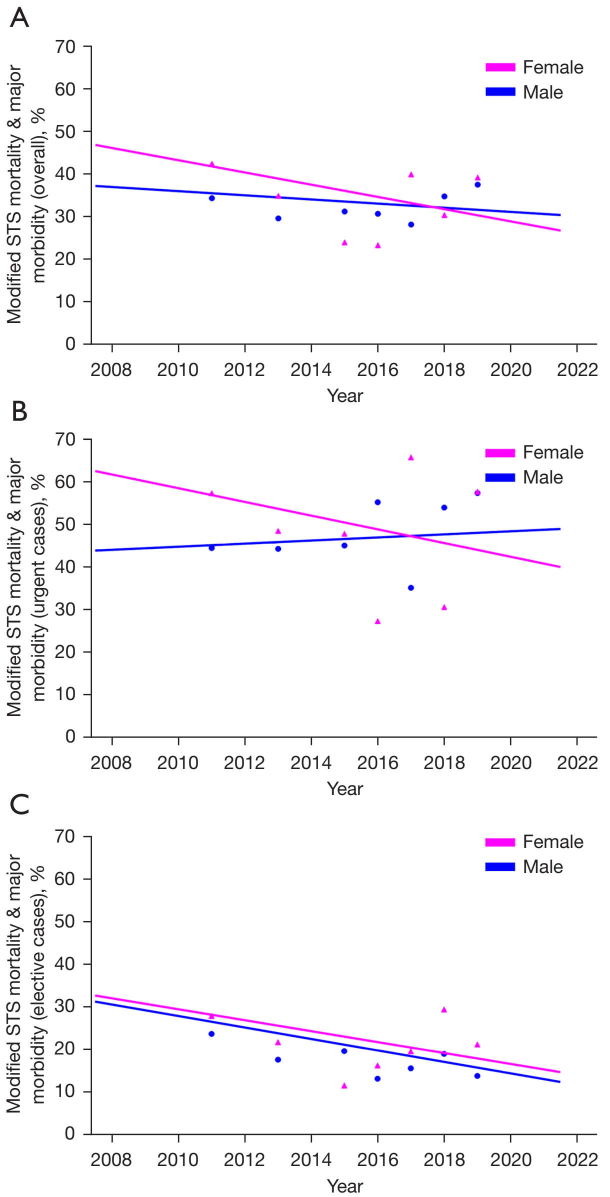

Figure 3 Sex specific trends in the Modified STS MMOM for all surgeries (A), urgent surgeries (B), and elective surgeries (C). STS, Society of Thoracic Surgeons; MMOM, mortality and major morbidity.

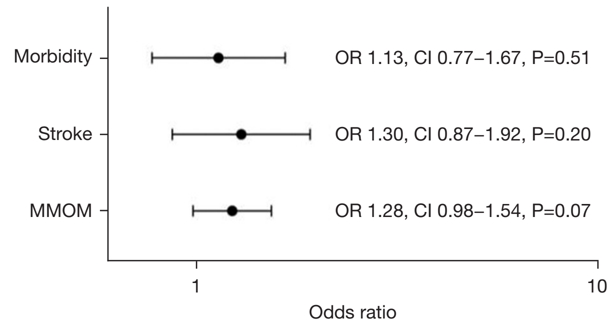

Figure 4 The effect of female sex on outcomes after multivariable analysis. Circular markers represent ORs and error bars represent 95% CIs. MMOM, mortality and major morbidity composite endpoint; OR, odds ratio; CI, confidence interval.

time, we observed a significant increase in the use of moderate hypothermia and antegrade cerebral perfusion. Aortic surgery has become a subspecialty with dedicated fellowship training over the same period, and the concept of aortic teams and dedicated aortic surgeons managing all acute dissections have emerged. The volume-outcome relationships at the hospital- and surgeon-level have been demonstrated (15,16), and further concentration of aortic volume may be the next step in improving outcomes for aortic arch surgery. Lastly, there have been many technological and innovative device advancements, such as hybrid arch devices, which may have contributed to the iterative improvement in patient outcomes, particularly in the urgent patient setting. The main limitation of our study lies in its observational and retrospective nature. The improvement in outcomes were associated with an increase in the use of moderate hypothermia and antegrade cerebral perfusion, but they cannot be directly attributed to them. We were unable to capture other changes in practice over the same time that may also have had a significant impact on outcomes. There may also be variability across centers in terms of methods of data collection and covariate interpretation. Finally, those not undergoing surgery are not captured and so we were unable to study trends in patient selection and sex-specific differences in outcomes of medically treated patients.

It is encouraging that the outcome gap between the sexes for aortic arch surgery previously observed in our multicenter Canadian aortic registry has closed. It serves as an example that improving outcomes for high-risk surgery provides the most benefit for the most vulnerable subgroups, which in this case would be female patients undergoing urgent arch surgery. Future work is still needed in reducing stroke and transfusion rates for both sexes, as trends have not been as favourable over time.

Table 4 Multivariable logistic regression for in-hospital mortality, stroke, and MMOM

Variable	Odds ratio	95% CI	P value
In-hospital mortality			
Age	1.57	1.35–1.83	<0.001
Peripheral vascular disease	1.53	1.07–2.18	0.020
Renal failure	2.18	1.25–3.80	0.006
Cerebrovascular disease	1.64	1.06–2.55	0.027
Left ventricular ejection fraction	0.97	0.96–0.98	<0.001
Acute dissection or rupture	4.37	3.46–5.51	<0.001
Cardiopulmonary bypass time	5.30	3.51–8.01	<0.001
No cerebral perfusion compared to antegrade cerebral perfusion	2.08	1.16–3.74	0.019
Stroke			
Acute dissection or rupture	2.60	2.23–3.03	<0.001
Cardiopulmonary bypass time	1.99	1.29–3.08	0.002
HCA time >60 min compared to <30 min	1.98	1.18–3.33	0.013
MMOM			
Age	1.33	1.21–1.45	<0.001
Hypertension	1.45	1.18–1.80	<0.001
Redo cardiac surgery	1.52	1.19–1.94	<0.001
Acute dissection or rupture	3.71	3.15–4.37	<0.001
Cardiopulmonary bypass time	7.11	4.85–10.41	<0.001
Cerebral ischemia time >30 min	2.57	1.50–4.42	<0.001

MMOM, mortality and major morbidity composite endpoint; CI, confidence interval; HCA, hypothermic circulatory arrest.

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Footnote

Conflicts of Interest: M.O. is partially supported by the Munk Chair in Advanced Therapeutics and the Antonio & Helga DeGasperis Chair in Clinical Trials and Outcomes Research. M.W.A.C. is partially supported by the Ray and Margaret Elliott Chair in Surgical Innovation. The other authors have no conflicts of interest to declare.

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