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Long-term outcomes in thoracic aortic surgery: 11 year single centre experience

Edward Staniforth[1], Iakovos Ttofi[2], Jasmina Ttofi[2], Vanitha Perinparajah[2], Rohit Vijjhalwar[1], Raman Uberoi[3], Ediri Sideso[4], Shirish Dubey[5,6] and George Krasopoulos[2,7*]

Abstract

Objectives Thoracic aortic aneurysms and dissections provide a complex surgical cohort termed thoracic aortic surgery. Regular follow-up at specialist clinics with cross-sectional imaging is recommended. Identifying risk factors that lead to re-operations as well as the requirement for and appropriate length of follow-up remain points of debate.

Methods Patients undergoing thoracic aortic surgery performed at a single centre from January 2012 to December 2022 were retrospectively reviewed. The clinical information, operative details, histological reports, post-operative outcomes and follow up were collected from electronic patient records. Statistical analysis was performed using Microsoft Excel and R Studio.

Results 409 patients met the inclusion criteria for the study with a median follow-up of 3.8 years (IQR 1.6–7.6). The prevalence of all cause re-operations was 10.8% ($n=44$). The median time to re-operation was 1.8 years. 68% of the reoperations occurred within the first 5 years. Multi and univariate logistic regression identified young age, arteritis and/or aortitis as the main risk factors associated with increased risk of re-operation. Connective tissue disease and systemic inflammatory diseases approached but didn't meet statistical significance. Bicuspid aortic valve pathology was associated with reduced risk of re-operation.

Conclusions Patients undergoing thoracic aortic surgery have a high rate of re-operation. The first 5 years represent a high-risk period and follow-up with cross-sectional imaging during that time by specialist aortic services is essential. Patient with aortitis remain at high risk and should be treated by appropriate by specialist aortic services with subspecialty interest and expertise on treating patients with aortitis.

Keywords Cardiac surgery, Aorta, Aortic aneurysm, Type a aortic dissection, Follow-up

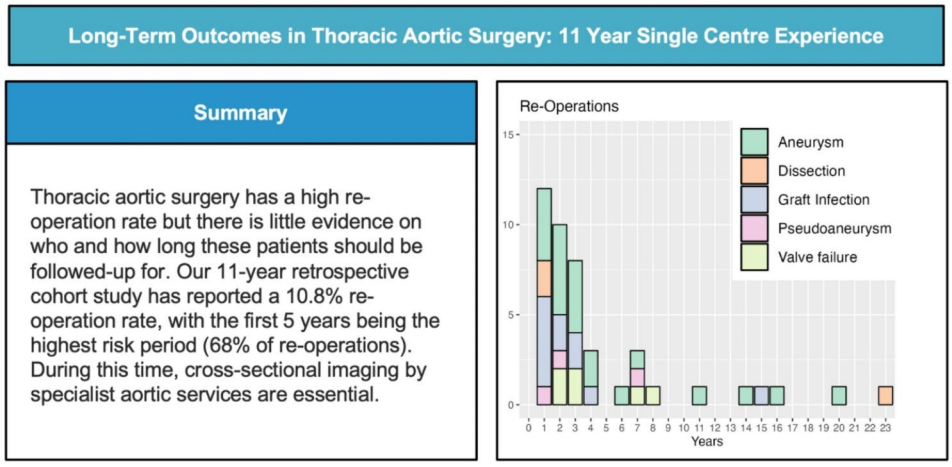
Introduction/Background

Thoracic aortic aneurysms and Type-A aortic dissections (TAAD) provide a complex surgical cohort which is often termed thoracic aortic surgery. Thoracic aortic surgery depends on the extent of the pathology and can be limited to isolated segments, such as an interpositional graft in the ascending aorta at the time of an aortic dissection repair, to near total replacement of the thoracic aorta with a frozen elephant trunk. The incidence of thoracic aortic surgery is increasing globally as healthcare screening and investigations detect more aortic aneurysms and dissections [1] and it is often associated with significant morbidity and mortality [2–5] despite reported improvements over recent years (United Kingdom (UK) data: 11.6% in 2002/3 to 8.9% in 2015/16 for elective [6] and 20.2% in 2013-14 to 17.2% in 2021−22 [7] for mainly TAAD repairs.

*Correspondence:
George Krasopoulos
george.krasopoulos@ouh.nhs.uk

Full list of author information is available at the end of the article

Graphical Abstract



Reporting outcomes in thoracic aortic surgery is challenging due to the range of procedures performed. There is an increasing drive to centralise complex aortic surgery in tertiary centres to create high volume units [8] and deliver a specialist aortic service to TAAD, aiming to achieve a reduction to observed mortality for TAAD by 50% [9]. The Society for Cardiac Surgery reports regularly on the outcomes of cardiac surgery [6]. Furthermore, cardiac surgery in the UK is independently reviewed by the National Adult Cardiac Surgery Audit which analyses both unit and surgeon specific outcomes in cardiac surgery [10]. However, long term outcomes are not reported, mainly because long term follow-up in the UK is often scattered between cardiothoracic centres and local cardiology units. As a consequence, there no consensus on who and how long these patients should typically be followed up for.

We performed a single centre, retrospective, cross sectional study over an 11-year period of patients who underwent thoracic aortic surgery. The primary outcome was to investigate the risks and timing to re-operation in thoracic aortic surgery to provide evidence for an appropriate length of follow-up. The secondary outcome was to identify risk factors associated with re-operations and identify high risk patients that would benefit for enhanced follow-up.

Methods

Ethical statement

This study was carried out in accordance with the Declaration of Helsinki. All patients included in this study provided written informed consented to the use of their data in clinical audits and research. Human ethics was not required. This study was approved by Oxford University Hospitals NHS Foundation Trust (Audit Number: 8036).

Study design

This is a retrospective cohort study of all thoracic aortic operations performed at a single centre over an 11-year period. The primary aim was to investigate the long-term risk of re-operations in thoracic aortic surgery. The secondary aim was to use logistic regression to identify risk factors for re-operation.

Inclusion criteria

The inclusion criteria for this study were all aortic operations of the thoracic aorta performed by cardiac surgeons. Thoracic aortic operations are defined as operations which replaced segments of the aorta, which in our dataset were operations replacing the root, ascending, and/or arch of the aorta. This dataset did not include patient that underwent thoracoabdominal or abdominal aortic operations. Patients whose initial aortic pathology was due to an infective aetiology, such as infective endocarditis and aortic root abscesses were excluded. Patients that may have had infected grafts, requiring redo operation were included in the analysis. We excluded patients with incomplete histological reports and cardiovascular risk factors to allow regression analysis.

Data collection and sorting

We reviewed all thoracic aortic operations performed at Oxford University Hospitals NHS Foundation Trust, United Kingdom, between 1/1/2012 and 31/12/2022 with data prospectively stored on the unit's database. Data were extracted only for patients who had consented

Table 1 Indications for re-operations, separated by indication for initial operation

Indication for Re-Operation	All-Group *N*=44	Aneurysm *n* = 27[1]	TAAD *n* = 17[1]
Aortic Valve Failure (Native or Replacement)	6 (14%)	6 (22%)	0 (0%)
Graft Infection	11 (25%)	8 (30%)	3 (18%)
Pseudoaneurysm	3 (6.8%)	1 (3.7%)	2 (12%)
Aneurysm	21 (48%)	12 (44%)	9 (53%)
Dissection	3 (6.8%)	0 (0%)	3 (18%)

[1]n (%), TAAD = Type A Aortic Dissection

Table 2 Demographics of patient undergoing thoracic aortic surgery

Patient Demographics	*N* = 409
Age	63 (52, 72)[1]
Sex (Male)	277 (68%)
BMI	26.8 (23.9, 30.9)[1]
Hypercholesterolemia	136 (33%)
Diabetes	17 (4.2%)
Hypertension	277 (68%)
Smoking Status	
Current Smoker	40 (9.8%)
Previous Smoker	132 (32%)
Never Smoker	237 (58%)
Previous Cardiac Surgery	26 (6.4%)
Bicuspid Aortic Valve	153 (37%)
Previous Type B Dissection	8 (2.0%)
Connective Tissue Disease	27 (6.6%)
Arteritis	10 (2.4%)
Aortitis	46 (11%)
Systemic Inflammatory Condition	15 (3.7%)
Previous Chemotherapy or Radiotherapy	4 (1.0%)

[1]Median (IQR); n (%)

the use of their information for audit and research. The database contained the patient's age at surgery, date of operation and cardiovascular risk factors. Over the period from January to March 2023, medical notes were reviewed using the local electronic patient record system. The following information was collected: intra-operative details, the major indication for surgery, past medical history, aortic valve type, presence or absence of infective endocarditis, histological report and post-operative outcomes including requirement for further surgery.

Re-operations included all patients who had a re-operation after being discharged from the initial event and beyond the initial 30 postoperative days (recorded as a second event), patients who were listed for a re-operation based on the same principles, but at the point of data collection had not yet received it, and patients who required a reoperation but were medically unfit. Re-operations in the immediate post-operative period, due to post-operative bleeding, as well as re-operations for wound infections and/or sternal wire removal were excluded from the analysis. The cause of the re-operation is summarised in Table 1. Pseudoaneurysms were defined as locally contained haematomas of the aorta or anastomotic leaks, based upon radiological reporting and intra-operative findings.

Sorting was performed to ensure patient demographics, summarised in Table 2, were correct. Arteritis was defined as a previous rheumatological diagnosis of arteritis in another vascular bed which included Giant Cell Arteritis, Takayasu's arteritis and ANCA positive vasculitis [11]. Aortitis was defined when the histology sample taken at the time of the operation from the resected segment of aorta demonstrated aortitis [12]. Other inflammatory conditions included inflammatory and autoimmune diseases which are associated with an increased risk of cardiovascular events such as Crohn's disease, polymyalgia rheumatica, systemic lupus erythematous and rheumatoid arthritis [13]. Connective tissue diseases included Marfan's Syndrome, Loez-Dietz Syndrome and hereditary thoracic aortic disease. Patients were classified as diabetic if they were on oral hypoglycaemic medication and/or insulin. Hypertension was classified as: when patients were already under treatment for hypertension or if the blood pressure was recorded as >140mmHg/90mmHg on more than one occasion prior to surgery. Smoking status was grouped as current, previous, or never smoker.

Follow-up time was defined as the time between the initial operation to the point of data collection or death. Patients out our centre were routinely seen in cardiac surgery clinic for 1–5 years. Afterwards, they were seen if they re-presented for a re-operation at out centre. If a patient received an operation at another centre, we received a letter from that institution to update us of the changes. Patient notes were meticulously reviewed to ensure re-operations at other centres weren't missed.

Seven patients underwent thoracic aortic surgery prior to 2012 but received further aortic surgery within the time frame we investigated. This cohort was included as they provide valuable information on long term outcomes in thoracic aortic surgery. Their age and date of operation was corrected for their first operation. If only the year of the previous surgery was only available, then it was recorded as the first of June of the year given.

Statistical analysis

Statistical analysis was performed on Microsoft Excel and R using RStudio (Version 2022.07.2).

Variables were checked for normality. Descriptive statistics were employed to summarised patient demographics and indications for re-operations.

Logistic regression was used to investigate risk factors for all cause re-operations and specifically for aneurysms, dissection graft infections and pseudoaneurysms. Prior

to running logistic regression, predictors were included if they were present in more than 2.5% of the patients to ensure the features truly explain the dataset. Variables were grouped as necessary. Residual diagnostic regression testing was conducted for the primary outcomes. Linearity of continuous variables with the outcomes was assessed using fractional polynomials and collinearity between variable was assessed by the variance inflation factor (VIF).

Results

Patient demographics

Between 2012 and 2022, 690 procedures logged as thoracic aortic operations were performed on 678 patients on the hospital database. On review of the medical records, 612 patients were confirmed to have undergone thoracic aortic surgery (423 aneurysms, 189 TAADs). 8 patients were excluded due to infective aetiologies, 72 due to a lack of aortic histology report and 123 were removed due to incomplete dataset of cardiovascular risk factors.

409 patients met the inclusion criteria and their preoperative, intraoperative and postoperative follow-up data were included into the study, as per protocol. The demographics of the patients included are summarised in Table 2. Patients undergoing thoracic aortic surgery were more likely to be male (67%). The dataset included patients with connective tissue disease such as Marfan's syndrome and Loez-Dietz syndrome, as well as patients with arteritis, aortitis and systemic inflammatory conditions which are associated with aortic aneurysms and dissections [14]. The median follow-up time was 3.8 years (IQR 1.6–7.6) and the longest follow-up was 29.6 years, including patient who had first time and redo procedures. The major indication for initial surgery was aortic aneurysms (71%) and the median age at operation was 63 with a negative skew. At the point of data collection, 88.9% (n=363) of patients were alive.

Table 3 Mortality adjusted for length of follow-up and indication for operation

Follow-Up Time	All-Group Mortality	Aneurysm Mortality	TAAD Mortality
28 Day Mortality	3.9% (n=16/409)	2.1% (n=6/289)	8.3% (n=10/120)
1 Year Mortality	8.1% (n=29/358)	4.8% (n= 12/250)	15.7% (n=17/108)
2 Year Mortality	9.7% (n=30/308)	6.5% (n=14/214)	17.0% (n=16/94)
3 Year Mortality	10.1% (n=26/258)	6.1% (n=11/179)	19.0% (n=15/79)
4 Year Mortality	11.7% (n=24/206)	5.6% (n=8/143)	25.4% (n=16/63)
5 Year Mortality	14.3% (n=22/154)	5.5% (n=6/110)	36.4% (n=16/44)
6 Year Mortality	15.0% (n=16/107)	6.4% (n=5/78)	37.9% (n=11/29)
7 Year Mortality	17.3% (n=14/81)	8.8% (n=5/57)	37.5% (n=9/24)
8 Year Mortality	18.2% (n=12/66)	8.3% (n=4/48)	44.4% (n=8/18)

TAAD = Type A Aortic Dissection

Survival

Patients undergoing thoracic aortic surgery were at high risk of mortality of up to 18.2% at 8 years post-surgery (Table 3). Most deaths occurred within the first year (1 year adjusted mortality=8.1%, n=29/358). As expected, mortality is higher in aortic dissections in comparison to aneurysms (non-statistically significant) (Fig. 1a; Table 3).

Re-operations

Patients undergoing thoracic aortic surgery in our unit had a 10.8% risk for reoperation (n=44/409). Aortic dissections had a higher rate of reoperations at 14.2% in comparison to elective aneurysm repairs (9.3%), but this did not achieve statistical significance (Pearson's Chi-squared test, P=0.2). Kaplan Meier analysis comparing the risk of re-operation by initial operation indication over time also demonstrated a non-statistically significant higher rate of re-operation for aortic dissections. The cause of re-operation varied from aortic valve failure to the development of new aneurysms, pseudoaneurysms and dissection flap extensions which were managed with open and/or endovascular surgery (Table 1). The commonest indication for re-operations in both cohorts is due to new aneurysm formation.

The median time to re-operation was 1.8 years (IQR 1.0-4.4) with 68% (n=30/44) occurring within the first 5 years. Early causes of reoperation outside of the postoperative period were typically graft infections and new aneurysms or pseudoaneurysm formation. As time from the initial operation increased, the development and new aneurysms formation at a non-operated part of the thoracic aorta and valve failures became the predominant indications for re-operation (Fig. 2).

Risk factors for re-operations

Univariate and multivariate logistic regression was performed to investigate the risk factors for all cause re-operations (Table 4). Univariate regression identified arteritis and/or aortitis as significantly associated with increased risk of re-operation, whilst increased age and bicuspid aortic valve were associated with a statistically significant reduction in the rate of re-operation. Connective tissue disease and current smoking approached but did not achieve statistical significance for re-operation. Multivariate regression also identified arteritis and/or aortitis as significantly associated with increased risk of re-operation, whilst increased age and bicuspid

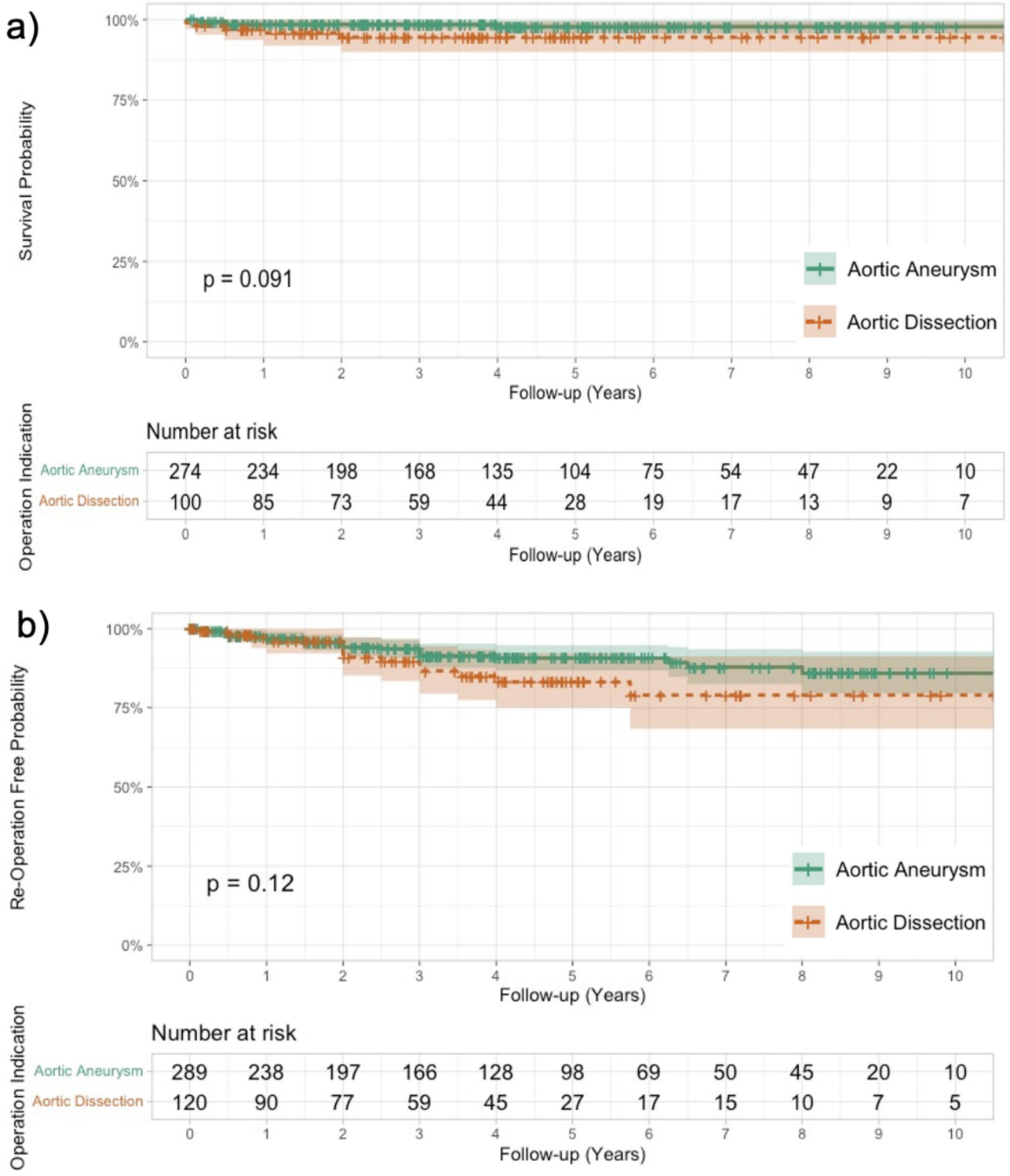


Fig. 1 Kaplan-Meier plots for the (**a**) survival and (**b**) re-operation free probability in thoracic aortic surgery based upon the initial operation. Log-rank test has been used to compare the two groups

aortic valve were associated with a statistically significant reduction. The effect of connective tissue disease was not seen in multivariate regression, likely due to its association with younger age.

Logistic regression analysis was also performed looking at risk factors for re-operations specifically due to new aneurysms, dissection, graft infections and pseudoaneurysms as these would require cross sectional imaging

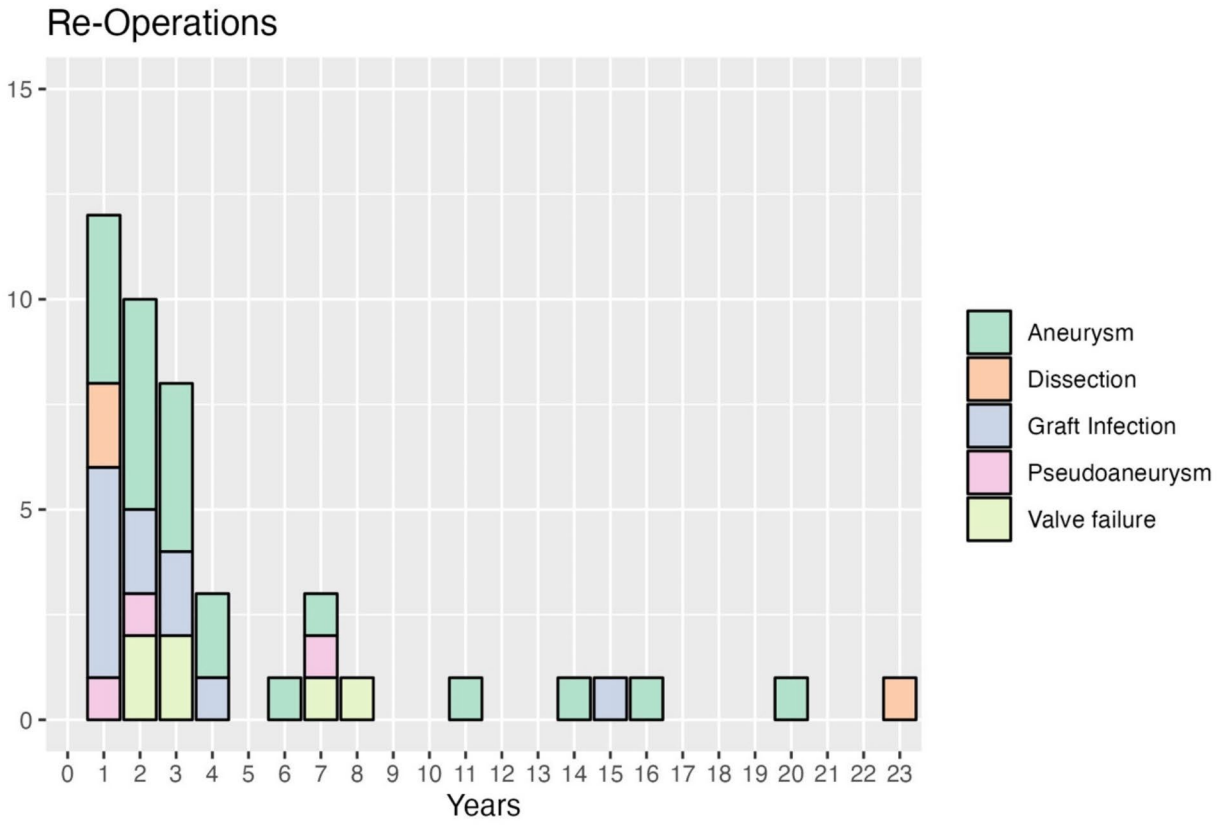


Fig. 2 Graph of re-operations by time (years) and indication

Table 4 Univariate and multivariate logistic regression for predicators of all cause re-operations from thoracic aortic surgery

	Univariate			Multivariate		
Predictor	**OR**[1]	**95% CI**[1]	**p-value**	**OR**[1]	**95% CI**[1]	**p-value**
Increased Age	0.97	0.96, 0.99	**0.012***	0.96	0.93, 0.99	**0.004****
Male	0.73	0.39, 1.42	0.341	0.99	0.48, 2.10	>0.9
BMI	0.97	0.90, 1.04	0.357	0.98	0.91, 1.05	0.6
Hypercholesterolemia	0.56	0.25, 1.13	0.121	0.75	0.31, 1.72	0.5
Hypertension	1.02	0.53, 2.06	0.945	1.64	0.72, 3.90	0.2
Current Smoker	2.31	0.93, 5.19	0.053	1.66	0.60, 4.21	0.3
Previous Smoker	0.77	0.37, 1.50	0.454	1.02	0.46, 2.18	>0.9
Previous Cardiac Surgery	0.68	0.11, 2.39	0.604	0.99	0.15, 3.91	>0.9
Bicuspid Aortic Valve	0.34	0.14, 0.71	**0.007****	0.36	0.14, 0.86	**0.027***
Connective Tissue Disease	2.59	0.90, 6.47	0.054	0.96	0.26, 3.14	>0.9
Arteritis and/or Aortitis	2.79	1.26, 5.82	**0.008****	2.71	1.08, 6.54	**0.029***
Systemic Inflammatory Disease	3.22	0.86, 9.91	0.054	2.75	0.67, 9.59	0.13

[1]OR = Odds Ratio, CI = Confidence Interval, * = $P<0.05$, ** = $P<0.01$

to diagnose (Table 5). Multivariate logistic regression revealed that inflammatory diseases significantly increase the risk of re-operation and bicuspid aortic valve is associated with a significant reduction in the risk of re-operation.

Discussion

Outcomes in thoracic aortic surgery

Thoracic aortic operations provide a complicated surgical cohort, and associated mortality remains high with overall 5-year mortality at 14.3% (lower for aneurysms - higher for TAAD) (Table 3; Fig. 1a). Our unit's all comers 28-day mortality was 3.9% (Table 3), which is much lower than the 8.9% quoted for operations of the ascending

Table 5 Univariate and multivariate logistic regression for predicators of re-operations due to aneurysms, dissections, graft infections and pseudoaneurysms

	Univariate			Multivariate		
Predictor	**OR[1]**	**95% CI[1]**	**p-value**	**OR[1]**	**95% CI[1]**	**p-value**
Increased Age	0.99	0.96, 1.01	0.192	0.97	0.94, 0.99	**0.021***
Male	0.80	0.40, 1.64	0.528	1.24	0.56, 2.86	0.6
BMI	0.99	0.92, 1.06	0.728	0.99	0.92, 1.07	0.9
Hypercholesterolemia	0.60	0.26, 1.25	0.193	0.69	0.27, 1.65	0.4
Hypertension	1.19	0.58, 2.57	0.645	1.43	0.60, 3.64	0.4
Current Smoker	2.83	1.13, 6.44	**0.018***	1.87	0.66, 4.88	0.2
Previous Smoker	0.73	0.33, 1.50	0.411	1.02	0.43, 2.32	>0.9
Previous Cardiac Surgery	0.80	0.13, 2.86	0.772	1.60	0.24, 6.57	0.6
Bicuspid Aortic Valve	0.23	0.08, 0.55	**0.003****	0.20	0.06, 0.55	**0.004****
Connective Tissue Disease	1.24	0.28, 3.78	0.736	0.45	0.09, 1.79	0.3
Arteritis and/or Aortitis	3.47	1.55, 7.39	**0.002****	3.23	1.25, 8.04	**0.013***
Systemic Inflammatory Disease	3.85	1.02, 11.96	**0.027***	2.85	0.68, 10.1	0.12

[1]OR = Odds Ratio, CI = Confidence Interval, * = $P<0.05$, ** = $P<0.01$

aorta in the UK [6] and comparable to some other studies who also reported 93% 5-year survival for elective aortic root replacement [15], 74% 10-year survival for hemi-arch surgery [16] and 20–40% 10-year mortality for TAAD [2, 17–19].

The re-operation rate in out cohort was 10.4% (9.3% for aneurysms and 14.2% for dissections), which is concordant with other reports in the literature [2]. The commonest cause for re-operation in both aortic aneurysms and dissections is due to the development of new aneurysms is other segments of the native aorta (Table 1) with the first 5 years representing a particularly high-risk period. Whilst our dataset was theoretically limited by having a median follow-up of 3.8 years, we included patients who had a thoracic aortic surgery outside of a period we investigated who required a re-intervention within the time frame. The relatively small number of patients who were in the group therefore suggests that the first 5 years is likely correct, but longer follow-up would be required to confirm this. Due to the relatively small size of this cohort, multi-centre collaboration would be important to quantify this risk.

We have identified younger age and arteritis and/or aortitis as statistically associated with an increased risk of re-operations, with current smoking and connective tissue disease approaching but not achieving statistical significance (Table 4). Therefore, patients who had a thoracic aortic aneurysm at a very young age, patients with aortitis/arteritis (especially if the disease remains active despite medical therapy) and those with connective tissue disorder should be under close follow-up and for an extended period. Although there is a general understanding that patient with connective tissue disorder [20, 21] or patients (especially young) with genetic profile that predisposes them to aortic aneurysm formation [22–24] should form a high risk group that require vigorous and probably prolonged follow-up, our results suggest that patients with aortitis/arteritis should also form part of this group of high risk patients.

Interestingly, bicuspid aortic valve in our cohort represented a decreased risk for re-operation, which could be due to the fact that one of the major factors that drive aortic aneurysm formation in bicuspid aortopathy is related to rheology and sheer stress generated by the bicuspid (often stenosed or regurgitant) valve, which is treated at the time of the initial operation [25].

Requirement for a new follow-up pathway

Whilst the causes of re-operation are varied, it is important to ensure patients are monitored for complications that develop silently as these can progress to a catastrophic event such as new aneurysms, dissections, graft infections and pseudoaneurysms. A recent audit in our department identified that most patients in this cohort are followed-up for one year before being discharged to local cardiology services. At our unit we have now setup a complex aortic clinic as part of a local initiative to provide a standardised specialist follow-up for all aortic cases who had a surgical intervention or diagnosed have been diagnosed with an aortic aneurysm and are currently under surveillance. This includes patients with aortitis and other high-risk groups which are reviewed annually with cross sectional imaging.

Cardiac surgery works closely with cardiology who also provide specialist genetic counselling to the appropriate cohort of patients and rheumatology department for patients with aortitis. It is however important to realise that the surgical complications of thoracic aortic surgery likely fall outside of the remits of cardiology and rheumatology. Vascular surgery and interventional radiology are also closely aligned in providing comprehensive and holistic treatment options through multidisciplinary

team meetings and integrated services within out hospital. Additionally, input from geriatric services, aortic specialist anaesthetic colleagues and intensivists are often vital to the decision-making process. We believe this multi-disciplinary approach (which has been rapidly adopted by many aortic centres worldwide [18, 19]) is the best way of managing patients with complex aortic disease. It offers the right environment for clinicians to explore and implement the most appropriate therapies, individualised to patient's needs, genetic profile, urgency, and other patient specific clinical and social circumstances.

Limitations

This is a retrospective cohort study. Due to the limitations associated with retrospective studies, subthreshold events, such as a new small aneurysm, can be hard to detect when regular cross-sectional imaging is not performed in a regimented fashion. In addition, cardiovascular risk factor reporting and histological sampling of the aorta was absent in some patients, which resulted in them being excluded from the analysis. Patient notes were meticulously reviewed to ensure all re-operation were identified, including those performed out of region. It is possible that a small number of re-operations may have been missed.

The dataset contains patients who underwent a wide range of procedures replacing segments of the aorta from isolated ascending aorta to total aortic arch replacement with both aneurysmal and dissection pathologies. It has been assumed that risk factors are common between these pathologies and procedures. Due to the wide range of initial and re-operation, analysis into whether specific types of procedures, beyond the broad classifications discussed were not possible.

The prevalence of connective tissue diseases in our cohort is relatively low. Whilst patients who met the testing criteria from the NHS were screened where possible, this has only become widely available over the later part of the decade and still is not fully implemented in the UK despite the NHS England recommendations.

Conclusions

Patients undergoing thoracic aortic surgery are at risk for re-intervention, which is higher in younger patients, patients with aortic dissections and those with aortitis/arteritis. The first 5 years represent the highest risk-period for reintervention and follow-up during that time by specialist aortic services is essential. We recommend annual review with cross sectional imaging during this period, and possibility decreasing frequency afterwards. Longer term follow-up will be required to validate the exact frequency of follow-up beyond 5 years.

Abbreviations

TAAD	Type A Aortic Dissection
NHS	National Health Service
UK	United Kingdom

Author contributions

E.Staniforth. Conceptualisation, project administration, methodology, investigation, formal analysis, validation, writing-original draft, writing- review and editing. I.T. Conceptualisation, methodology, investigation, writing-review and editing. J.T. Conceptualisation, methodology, investigation, writing- review and editing. V.P. formal analysis, writing – review and editing, R.V. Methodology, formal analysis, validation, writing– review and editing. R.U. writing– review and editing.E.Sideso. writing– review and editing.S.D. Validation, Supervision, Writing – review and editing. G.K. Conceptualisation, project administration, methodology, supervision, writing- review and editing.

Funding

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Data availability

Dataset is available upon request.

Declarations

Human Ethics and Consent to Participate

This study was carried out in accordance with the Declaration of Helsinki. All patients included in this study provided written informed consented to the use of their data in clinical audits and research. Human ethics was not required. This study was approved by Oxford University Hospitals NHS Foundation Trust (Audit Number: 8036).

Competing interests

SD has received advisory fees from Boehringer Ingelheim GmbH and Bristol Myers Squibb and speaker fees from Janssen. GK has received advisory fees, consultancy fees and financial educational support from: Atricure, Terumo-Vascutec, Medistim, Abbott, Medronic, Ethicon - Johnson & Johnson, Artivion, Zimmer & Nuffield Health. He is also the director of Cardiac Surgery GK Ltd. RU has received an educational grant from Terumo Aortic. ES has received consultancy fees and educational grants from Terumo Aortic.

Author details

[1]Oxford University Medical School, Medical Sciences Division, University of Oxford, Oxford, UK
[2]Department of Cardiac Surgery, John Radcliffe Hospital, Oxford University Hospitals NHS Foundation Trust, Oxford, UK
[3]Department of Radiology, John Radcliffe Hospital, Oxford University Hospitals NHS Foundation Trust, Oxford, UK
[4]Department of Vascular Surgery, John Radcliffe Hospital, Oxford University Hospitals NHS Foundation Trust, Oxford, UK
[5]Department of Rheumatology, Oxford University Hospitals, Oxford, UK
[6]Nuffield Department of Musculoskeletal Sciences, University of Oxford, Windmill Road, Oxford, UK
[7]Oxford Heart Centre, Department of Cardiac Surgery, Oxford University Hospitals NHS Foundation Trust, Headley Way, Headington, Oxford OX3 9DU, UK

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References

1. Wang Z, You Y, Yin Z, et al. Burden of aortic aneurysm and its attributable risk factors from 1990 to 2019: an analysis of the global burden of Disease Study 2019. Front Cardiovasc Med. 2022;9:901225.
2. Gariboldi V, Grisoli D, Kerbaul F, et al. Long-term outcomes after repaired acute type a aortic dissections. Interact Cardiovasc Thorac Surg. 2007;6:47–51.
3. Harris KM, Nienaber CA, Peterson MD, et al. Early Mortality in Type A Acute Aortic dissection: insights from the International Registry of Acute Aortic Dissection. JAMA Cardiol. 2022;7:1009–15.

4. Di Eusanio M, Berretta P, Cefarelli M, et al. Long-term outcomes after aortic arch surgery: results of a study involving 623 patients. Eur J Cardiothorac Surg. 2015;48:483–90.
5. Hernandez-Vaquero D, Silva J, Escalera A, et al. Life expectancy after surgery for ascending aortic aneurysm. J Clin Med. 2020;9:615.
6. The Society for Cardiothoracic Surgery in Great Britain and Ireland National Cardiac Surgery Activity and Outcomes. Report 2002–2016. https://scts.org/_userfiles/pages/files/sctscardiacbluebook2020_11_20tnv2.pdf. Accessed 20th May, 2024.
7. NACSA Annual Report. 2023 (Data for the 3 years - from April 2019 to March 2022) Appendix – additional data (including all data from which main report derived). https://www.nicor.org.uk/national-cardiac-audit-programme/previous-reports/adult-cardiac-surgery-1/2023/appendix-of-data-for-2023?layout=default. Accessed 20th May, 2024.
8. Richens David, Cardiothoracic Surgery GIRFT. Report 2018. https://gettingitrightfirsttime.co.uk/wp-content/uploads/2018/04/GIRFT-Cardiothoracic-Report-1.pdf. Accessed March 11, 2024.
9. Bashir M, Shaw M, Field M, et al. Repair of type a dissection-benefits of dissection rota. Annals Cardiothorac Surg. 2016;5:209–15.
10. NACSA 2024 Summary Report. https://www.nicor.org.uk/publications/ncap/cardiac-surgery-audit/2024-6/nacsa-final-report-2022-23/?layout=default. Accessed 20th May, 2024.
11. Pugh D, Grayson P, Basu N, Dhaun N. Aortitis: recent advances, current concepts and future possibilities. Heart. 2021;107:1620–9.
12. Stone JR, Bruneval P, Angelini A, et al. Consensus statement on surgical pathology of the aorta from the Society for Cardiovascular Pathology and the Association for European Cardiovascular Pathology: I. Inflammatory diseases. Cardiovasc Pathol. 2015;24:267–78.
13. Sorriento D, Iaccarino G. Inflammation and Cardiovascular diseases: the most recent findings. Int J Mol Sci. 2019;20:3879.
14. Bossone E, Eagle KA. Epidemiology and management of aortic disease: aortic aneurysms and acute aortic syndromes. Nat Rev Cardiol. 2021;18:331–48.
15. Jahangiri M, Mani K, Acharya M, et al. Early and long-term outcomes of conventional and valve-sparing aortic root replacement. Heart. 2022;108:1858–63.
16. Pearsall C, Blitzer D, Zhao Y et al. Long-term outcome of hemiarch replacement in a proximal aortic aneurysm repair: analysis of over 1000 patients. Eur J Cardiothorac Surg. 2022;62.
17. Jormalainen M, Kesävuori R, Raivio P, et al. Long-term outcomes after ascending aortic replacement and aortic root replacement for type A aortic dissection. Interact Cardiovasc Thorac Surg. 2022;34:453–61.
18. Porto A, Omnes V, Bartoli MA, et al. Reintervention of residual aortic dissection after type A aortic repair: results of a prospective Follow-Up at 5 years. J Clin Med. 2023;12(6):2363. https://doi.org/10.3390/jcm12062363. Published 2023 Mar 18.
19. Gaudry M, Porto A, Guivier-Curien C, et al. Results of a prospective follow-up study after type A aortic dissection repair: a high rate of distal aneurysmal evolution and reinterventions. Eur J Cardiothorac Surg. 2021;61(1):152–9. https://doi.org/10.1093/ejcts/ezab317.
20. Coelho SG, Almeida AG. Marfan syndrome revisited: from genetics to the clinic. Síndrome De Marfan Revisitada – Da genética à clínica. Rev Port Cardiol (Engl Ed). 2020;39(4):215–26. https://doi.org/10.1016/j.repc.2019.09.008.
21. Elendu C, Amaechi DC, Elendu TC, Ibhiedu JO, Torubiri AO, Okoye OK. Comprehensive review of aortic aneurysms, dissections, and cardiovascular complications in connective tissue disorders. Med (Baltim). 2023;102(48):e36499. https://doi.org/10.1097/MD.0000000000036499.
22. Bulut HI, Arjomandi Rad A, Syrengela AA, et al. A Comprehensive Review of Management Strategies for Bicuspid aortic valve (BAV): exploring Epidemiology, Aetiology, Aortopathy, and interventions in light of recent guidelines. J Cardiovasc Dev Dis. 2023;10(9):398. https://doi.org/10.3390/jcdd10090398. Published 2023 Sep 18.
23. Gyftopoulos A, Ziganshin BA, Elefteriades JA, Ochoa Chaar CI. Comparison of genes Associated with thoracic and abdominal aortic aneurysms. Aorta (Stamford). 2023;11(3):125–34. https://doi.org/10.1055/s-0043-57266.
24. Jeoffrey SMH, Kalyanasundaram A, Zafar MA, Ziganshin BA, Elefteriades JA. Genetic overlap of spontaneous dissection of either the thoracic aorta or the coronary arteries. Am J Cardiol. 2023;205:69–74. https://doi.org/10.1016/j.amjcard.2023.07.046.
25. Rooprai J, Boodhwani M, Beauchesne L, et al. Thoracic aortic aneurysm growth in bicuspid aortic valve patients: role of aortic stiffness and pulsatile hemodynamics. J Am Heart Assoc. 2019;8(8):e010885. https://doi.org/10.1161/JAHA.118.010885.

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