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RESEARCH PAPER

Preoperative clinical characteristics and 12-month outcomes following operative or non-operative management of asymptomatic aortic aneurysms

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Abstract

Design: An observational cohort study conducted at a tertiary referral center for aortic surgery to describe the medical and surgical characteristics of patients assessed for abdominal aortic aneurysm repair and examine associations with 12-month outcome.
Methods: Patients with aortic aneurysms referred for discussion at the aortic multidisciplinary meeting (MDM). Data were collected via a prospectively maintained clinical database and included aneurysm characteristics, patient demographics, co-morbidities, geriatric syndromes, including frailty, management decision and 12-month mortality, both aneurysm-related and all-cause including cause of death. The operative and non-operative groups were compared statistically.
Results: 621 patients referred to aortic MDM; 292 patients listed for operative management, 141 patients continued on surveillance, 138 patients for non-operative management. There was a higher 12-month mortality rate in the non-operative group compared to the operative group (41% vs 7%, $P = <0.001$). In the non-operative group, 16 patients (29%) died of aneurysm rupture within 12 months, with 39 patients (71%) dying from other medical causes. Non-operatively managed patients were older, more likely to have cardiac and respiratory disease and more likely to be living with frailty, cognitive impairment and functional limitation, compared to the operative group.
Conclusion: This study shows that preoperative geriatric syndromes and increased comorbidity lead to shared decision to non-operatively manage asymptomatic aortic aneurysms. Twelve-month mortality is higher in the non-operative group with

the majority of deaths occurring due to cause other than aneurysm rupture. These findings support the need for preoperative comprehensive geriatric assessment followed by multispecialty discussion and shared decision making.

Keywords: aortic aneurysm repair; comprehensive geriatric assessment; shared decision making; realistic medicine; aortic multidisciplinary meeting; older people

Key points

- Pre-operative medical and surgical characteristics can help guide shared decision making conversations.
- Twelve-month mortality is higher in the non-operative group with the majority of deaths occurring due to medical causes.
- Preoperative CGA followed by multispecialty discussion can guide decision to operate.

Introduction

Abdominal aortic aneurysms occur more frequently as age increases. This older cohort often present with co-existent medical co-morbidities and geriatric syndromes such as frailty or cognitive impairment [1]. The aim of elective aortic aneurysm repair is to prolong life by reducing premature death through aneurysm rupture, while avoiding perioperative complications that may impact negatively on longer term outcomes and quality of life. Decision making around surgical repair therefore needs to consider not only intraoperative risk but also risk of postoperative complications which may have longer term implications such as deteriorating renal function requiring dialysis, worsening cognitive trajectory or increasing dependency necessitating social care provision. Moreover, the decision to operate for an asymptomatic condition such as aortic aneurysm also requires an estimation of life expectancy related to the probability of aneurysm rupture, as well as the probability of death related to underlying comorbidities and geriatric syndromes.

Appraising the benefits and risks of aortic repair to provide realistic choice and support shared decision making can be challenging in the older population who often present with medical and surgical complexity. Informing the process of shared decision making requires data on morbidity and mortality following aneurysm repair, as well as data on possible outcomes without repair including longevity, rates of aneurysm rupture and the associated mortality from rupture. Furthermore, patient reported outcomes such as quality of life following both operative and non-operative aneurysm management, are required to ensure meaningful shared decision making [2, 3]. Due to inherent difficulties in obtaining observational natural history data on untreated aneurysms and the lack of focus on patient reported outcomes, there is limited literature to inform these discussions [4]. However, over recent years, literature has suggested that the estimation of annual rupture rate, particularly in aneurysms less than 6 cm in diameter, may have been over estimated, further emphasizing the need for thorough preoperative assessment in order to identify patients who are most likely to benefit from surgical repair [5–9].

In 2020, the COVID-19 pandemic forced changes to elective aortic aneurysm pathways across the UK and internationally. The UK National Joint Vascular Implementation Board initially proposed that patients with aortic aneurysm diameter 55–60 mm could be delayed for 12 months, and patients with aortic aneurysm diameter 60–70 mm could be delayed for 6 months [10, 11]. The Vascular and Endovascular research network COVER study collaborative reported that thresholds for abdominal aortic aneurysm (aortic aneurysm) repair were raised in the majority of centers; 12% of vascular units limited surgery to aortic aneurysm more than 6.5 cm in maximal diameter, 16% to those above 7 cm, 25% to symptomatic or ruptured aortic aneurysm and 2% to aortic aneurysm suitable for endovascular aortic aneurysm repair only [12]. Despite these significant changes in surgical practice enforced due to the pandemic, there are not yet data describing the rupture rate during this period, or whether permanent changes to surgical practice have occurred. The impact of the COVID-19 pandemic, NICE guidance and the Vascular Society for Great Britain and Ireland's Choosing Wisely program has prompted vascular surgical centers to develop multidisciplinary team meeting (MDM) approaches to ensure the most appropriate patients are being listed for operations [13, 14].

At the vascular hub where this study was undertaken, the aortic pathway has evolved to incorporate a multidisciplinary and multispecialty approach. The Perioperative medicine for Older People undergoing Surgery (POPS) team provides geriatrician delivered preoperative comprehensive geriatric assessment (CGA) and optimization of patients considered for elective aortic aneurysm repair. This CGA approach allows thorough appraisal of a patient's suitability for surgery, optimization of multimorbidity and frailty, and facilitates shared decision making with regards to treatment options [15]. The clinical and cost effectiveness of perioperative CGA has been demonstrated [16, 17, 18]. The information generated from this CGA is fed into the aortic MDM attended by a quorum of vascular surgical consultants, anesthetic consultants and POPS consultants together with nursing and therapy representation. The MDM considers the potential

surgical options in the context of information from the holistic appraisal of patient characteristics. Once realistic choice regarding aortic surgery has been defined at the MDM, shared decision making occurs with patients and their carers. For patients where a joint decision is made for non-operative management, in addition to ensuring visible documentation and cessation of surveillance, advanced care planning is undertaken with patients, their families and community and primary care teams. The reasons for non-operative management may be medical (multimorbidity, geriatric syndromes or estimated lack of benefit), surgical (anatomically difficult or complex surgical options with prohibitive risk profiles), patient choice (when patients decline surgery knowing the risks and benefits) or a combination of these factors.

Objectives

Aim: To describe the medical and surgical characteristics of patients assessed for abdominal aortic aneurysm repair with care delivered through a multidisciplinary pathway and examine associations with 12-month mortality:

- To describe the caseload discussed at a MDM at a tertiary referral center for aneurysm repair.
- To describe medical and geriatric syndromes, and surgical factors associated with the decision to manage patients with aortic aneurysms non-operatively.
- To describe 12-month aneurysm and all-cause mortality in patients with aortic aneurysm according to operative or non-operative management.

Design and methods

An observational cohort study was conducted at a tertiary referral center for aortic surgery. All patients with aortic aneurysms at this center are referred for discussion at the aortic MDM. Those referred between 1st May 2020 and 30th November 2021 were included. Patients were excluded from data analysis if they died prior to MDM discussion, required emergency surgery due to aneurysm rupture, had infected or mycotic aneurysms as these are treated via a different pathway, moved out of area and were lost to follow up or if they were treated at a different center or a private hospital. Data were collected via a prospectively maintained clinical database and included aneurysm characteristics, patient demographics such as age and gender, medical co-morbidities, social history, geriatric syndromes such as frailty, decision for operative or non-operative management and 12 month mortality, both aneurysm-related and all-cause including cause of death.

Aneurysms were classified anatomically based on cross-sectional imaging review during the aortic MDM.

Comorbidities were transcribed into the database from the preoperative CGA clinic letter. Geriatric syndromes were described using validated scoring systems including the Edmonton Frailty Scale and Montreal Cognitive Assessment, measurement of gait speed and Timed Up And Go and transcribed into the database. As CGA is nuanced to patient's needs, missing data exist in a small number of cases. All data were anonymized under institutional governance obviating the need for ethical approval as no patient identifying data was recorded. Data were analysed using Python version 3 statistics software and presented using Tableone package [19].

Results

During the 17 month data collection period, 621 patients were referred to the aortic MDM. At MDM, 292 patients were listed for operative management, 141 patients continued on surveillance due to sub-threshold aneurysms or because they were awaiting further medical investigation or optimization, and in 138 patients a decision was made for non-operative aneurysm management (Fig. 1).

Sixty-five patients were excluded from data analysis: emergency cases (43), died before MDM discussion [7], infected/mycotic aneurysms [9], missing follow up data as patients had moved out of area and been lost to follow up or treated elsewhere [6].

Two hundred and thirty-six patients underwent major primary aneurysm repair: 61 open repair and 175 endovascular repair. Twenty-nine patients underwent major revision surgery following previous aneurysm repair with eight undergoing intermediate revision and eight undergoing minor revision (see table 1 and table 2).

Data presented in table 3 illustrates the difference in patient characteristics between those who underwent operative versus non-operative aneurysm management. Patients in whom a decision was made for non-operative management were older, more likely to have cardiac and respiratory disease and more likely to be living with frailty, cognitive impairment and functional limitation, than those whose aneurysms were managed surgically.

The data presented in Table 4 shows a significantly higher 12-month mortality rate in the non-operative aneurysm group compared to the operatively managed patients (41% vs 7%, $P < 0.001$). In the non-operative group, of the 55 patients who died, 16 died from aneurysm rupture within 12 months, with 39 patients dying from other medical causes (29% vs 71%). The predominant cause of death, other than aneurysm rupture, in the non-operative group was respiratory. Cause of death was not determined in 13 patients in the non-operative group. In the operative group, there was one death from multiorgan failure within 30 days of surgery in a patient who required emergent surgery for a symptomatic aneurysm. In the operative group, on average, the time from surgery to death was 215 days. Table 4 reports no predominant cause of death in the operative group of patients. Cause of death was not determined in six patients in the operative group.

Discussion

This is the first study to describe the baseline clinical characteristics, geriatric syndromes and associations with 12-month mortality in patients with aortic aneurysms, according to

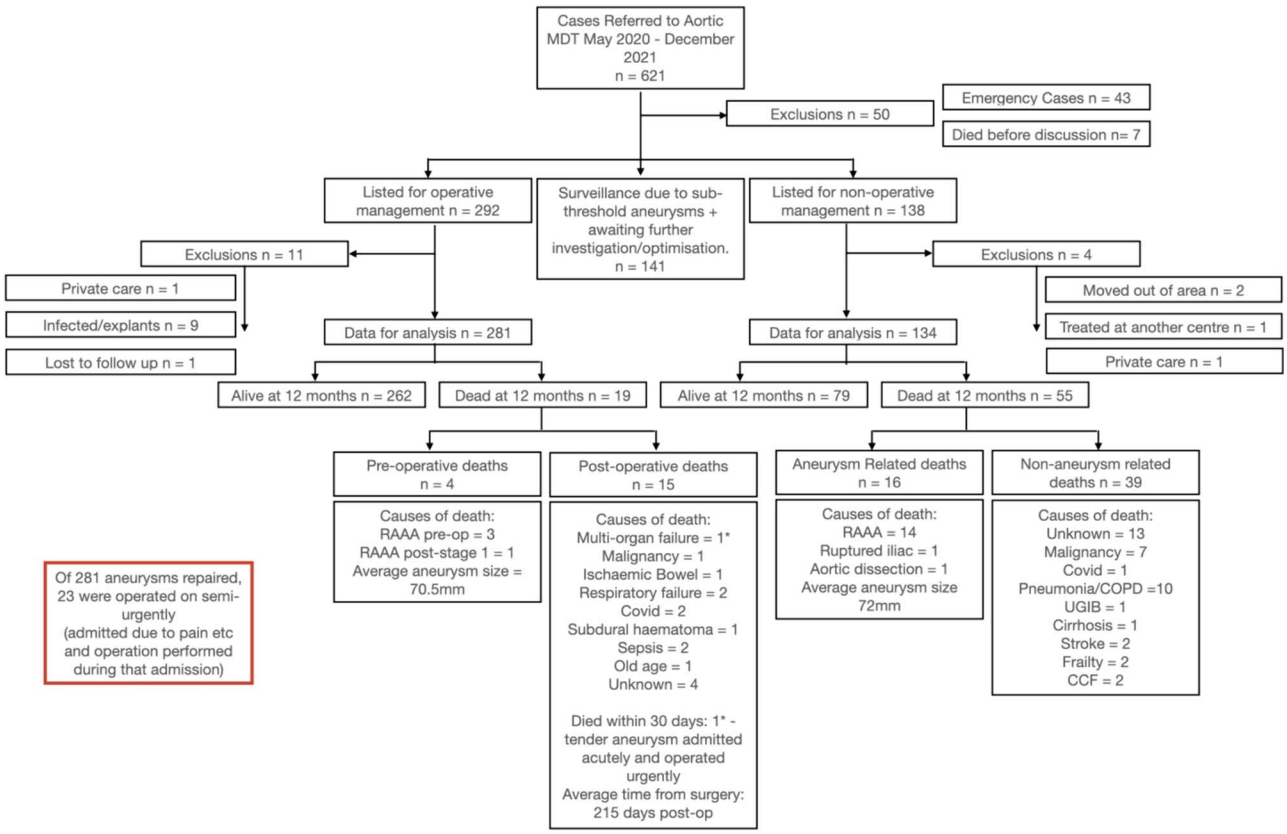

Figure 1. Flowchart describing referrals to and outcomes following aortic MDM.

Table 1. Surgical classification of aneurysm pathology according to operative or non-operative

	Operative management (n = 281)	Non-operative management (n = 134)
Infra-renal	85 (30%)	58 (43%)
Juxta-renal	76 (27%)	26 (19%)
Supra-renal	2 (0.1%)	4 (3%)
Thoracic	17 (6%)	15 (11%)
Thoraco-abdominal	31 (11%)	10 (8%)
Iliac	20 (7%)	8 (6%)
Endoleak (all types)	34 (12%)	12 (9%)
Saccular (all types)	7 (2.5%)	1 (1%)
Dissection	3 (1%)	0 (0%)
Stent Relining	5 (2%)	0 (0%)
False aneurysm	1 (0.4%)	0 (0%)

Table 2. Surgical procedure undertaken following aortic MDM discussion

	Operative management (n = 281)	Open	Endovascular
Major primary	236	61 (26%)	175 (74%)
Major revision	29		
Intermediate revision	8		
Minor revision	8		

decision made for operative or non-operative management through an MDM approach and shared decision making. Of the over six hundred patients referred to a tertiary aortic MDM during the study period, after discussion and shared decision making, just over half underwent operative aneurysm repair, almost a quarter continued with aneurysm surveillance and a quarter were not offered surgery as the risks of surgery outweighed the potential benefit. In the operative group, 30-day mortality was 0.4% and 12-month mortality 7%, in keeping with literature from other tertiary centers. The 12-month mortality rate in the non-operative group (n = 55, 41%) was higher than in the operative group (n = 19, 7%) including three preoperative deaths while awaiting surgery and one death prior to second stage surgery. In the non-operative group, the majority of deaths (39 of 55) occurred from causes other than aneurysm rupture. This is unsurprising considering the higher prevalence of cardiorespiratory, multimorbidity and geriatric syndromes in the non-operative group, contributing to the majority of deaths. These findings are in keeping with previous retrospective studies describing mortality rates in patients with aortic aneurysms managed operatively and non-operatively [20]. Interestingly, aneurysms that ruptured in the non-operative group had, on average, an aortic diameter of 72 mm, in keeping with recent data suggesting that rupture risk is low in smaller aneurysms [5–9].

Table 3. Baseline clinical characteristics according to MDM decision for operative or non-operative aneurysm management

		Missing	Overall	OPERATIVE	NON-OPERATIVE	P-Value
n			415	281	134	
Age, median [Q1, Q3]		0	77.0 [70.5,82.8]	74.0 [68.0,79.0]	83.0 [79.0,86.8]	<**0.001**
Sex, n (%)	**Male**	0	85 (20.5)	46 (16.4)	39 (29.1)	**0.004**
Size of Aneurysm, mm, median [Q1, Q3]		11	63.0 [60.0,70.0]	64.0 [60.0,70.0]	62.0 [58.0,69.8]	0.008
Comorbidity Count, median [Q1, Q3]		0	3.0 [2.0,4.0]	3.0 [2.0,4.0]	4.0 [2.0,5.0]	<**0.001**
Alcohol Units/week, median [Q1, Q3]		54	0.0 [0.0,5.0]	0.0 [0.0,7.0]	0.0 [0.0,0.0]	0.035
Edmonton Frailty Scale, Score/17, median [Q1, Q3]		117	3.0 [2.0,6.0]	2.0 [1.0,4.0]	6.0 [5.0,8.0]	<**0.001**
Body Mass Index, kg/m ^{2}, median [Q1, Q3]		111	27.0 [23.6,30.2]	27.4 [24.3,30.1]	25.4 [22.0,31.2]	0.101
Nottingham Extended Activities of Daily Living, score/66, median [Q1, Q3]		130	59.0 [48.0,66.0]	63.0 [56.0,66.0]	46.0 [33.0,51.0]	<**0.001**
Timed Up and Go, seconds, median [Q1, Q3]		133	11.0 [9.1,15.3]	10.4 [9.0,12.8]	16.0 [12.0,23.5]	<**0.001**
Gait speed, m/s, median [Q1, Q3]		128	1.0 [0.7,1.2]	1.0 [0.8,1.2]	0.7 [0.5,0.9]	<**0.001**
Montreal Cognitive Assessment, score/30, median [Q1, Q3]		197	25.0 [22.0,27.0]	26.0 [23.0,28.0]	22.0 [17.0,25.5]	<**0.001**
Anemia, n (%)		6	48 (11.7)	28 (10.0)	20 (15.6)	0.138
Atrial Fibrillation, n (%)	**1**	6	85 (20.8)	48 (17.1)	37 (28.9)	**0.009**
Cerebrovascular Accident, n (%)	**1**	6	50 (12.2)	32 (11.4)	18 (14.1)	0.547
Chronic Kidney Disease, n (%)	**1**	6	118 (28.9)	79 (28.1)	39 (30.5)	0.712
Chronic Obstructive Pulmonary Disease, n (%)	**1**	6	160 (39.1)	96 (34.2)	64 (50.0)	**0.003**
Dementia/Cognitive impairment, n (%)	**1**	6	66 (16.1)	25 (8.9)	41 (32.0)	<**0.001**
Diabetes, n (%)	**1**	6	74 (18.1)	48 (17.1)	26 (20.3)	0.517
Systolic Heart Failure, n (%)	**1**	6	35 (8.6)	15 (5.3)	20 (15.6)	**0.001**
Diastolic Heart Failure, n (%)	**1**	6	15 (3.7)	6 (2.1)	9 (7.0)	**0.022**
Hypertension, n (%)	**1**	6	227 (55.5)	167 (59.4)	60 (46.9)	**0.024**
Ischemic Heart Disease, n (%)	**1**	6	130 (31.8)	90 (32.0)	40 (31.2)	0.966
Malignancy, n (%)	**1**	6	114 (27.9)	65 (23.1)	49 (38.3)	**0.002**
Obstructive Sleep Apnea, n (%)	**TRUE**	6	14 (3.4)	11 (3.9)	3 (2.3)	0.563
Osteoarthritis, n (%)	**1**	6	89 (21.8)	61 (21.7)	28 (21.9)	1.000
Peripheral Vascular Disease, n (%)	**1**	6	28 (6.8)	17 (6.0)	11 (8.6)	0.463
Pulmonary Hypertension, n (%)	**1**	6	10 (2.4)	5 (1.8)	5 (3.9)	0.298
Valvular Heart Disease, n (%)	**1**	6	40 (9.8)	24 (8.5)	16 (12.5)	0.284
Falls, n (%)	**1**	8	44 (10.8)	17 (6.1)	27 (21.3)	<**0.001**
Smoking, n (%)	**Current Smoker**	45	99 (26.8)	68 (25.2)	31 (31.0)	0.274
	Ex-smoker		223 (60.3)	163 (60.4)	60 (60.0)	
	Never smoked		48 (13.0)	39 (14.4)	9 (9.0)	

Table 4. Twelve-month mortality and cause of death according to operative or no operative aneurysm management

	Operative management n = 281	Non-operative management n = 134	P value
All cause mortality at 12 months	19 (7%)	55 (41%)	<**0.001**
Aneurysm related/aortic dissection	4 (pre-operative)	16	
Multiorgan failure	1	0	
Bowel ischemia	1	0	
Malignancy	1	7	
Respiratory	2	10	
COVID	2	1	
Stroke	1	2	
Old age/Frailty	1	2	
Sepsis	2	0	
Other	0	4	
Unknown	4	13	

Professional bodies recommend MDMs as a mechanism to enable clinicians from different disciplines to collectively appraise realistic treatment options and inform shared decision making [21]. At the study center, the aortic MDM has become central to the delivery of a 'joined-up' approach to aortic aneurysm care. The MDM requires quorate representation from relevant specialties and disciplines, in particular surgeons, interventional radiologists, geriatricians and anesthetists. Information presented at this meeting includes surgical consideration of anatomically and surgically feasible operative options, alongside CGA-based, geriatrician led holistic appraisal of patient characteristics. The need for CGA to accurately describe patient characteristics is illustrated in an observational study showing that two thirds of patients received new diagnoses following preoperative CGA [22] and has demonstrated clinical and cost effectiveness in the vascular surgical setting [17, 18]. Presentation of this CGA information at the MDM, allows the team to achieve consensus on realistic options tailored to the individual patient. Such consensus involves interpretation of available data using clinical expertise, to overcome the paucity of literature regarding the natural history of aortic aneurysms and other conditions. These realistic treatment options are then discussed with patient and their carers facilitating meaningful shared decision making. In the majority of patients in this study, the reason for non-operative management could not be attributed to a single factor such as anatomy, clinical factors or patient choice, and instead resulted from this process of holistic, multi-specialty assessment and shared decision making. Of note, none of the patients who were not offered operative management requested reconsideration or second opinions during the study period.

Embedding such an MDM into the aortic pathway of care is in keeping with recommendations from national organizations such as Getting It Right First Time, which advocate a hub and spoke model for vascular surgery, with provision of multispecialty care including physician, anesthetic and therapy input to inform decision making and quality care delivered at a hub. Despite such recommendations, a recent UK survey reported variation and duplication of work in aortic care pathways with inconsistencies in how risk is assessed and communicated [23]. Respondents to this survey cited insufficient job planning support for MDM attendance as a significant barrier to the standardization of preoperative workup in patients with aortic aneurysm. An additional barrier to informed and consistent decision making at aortic MDMs is the missed opportunity to consider the aortic aneurysm in the context of medical comorbidities or geriatric syndromes that may confer an equal or worse prognosis. For some patients, this may necessitate a discussion about likely cause of death, acknowledging that the majority of deaths in the non-operative group in this study, died of causes unrelated to the aneurysm. In conditions such as aortic aneurysm, which remain asymptomatic until sudden death, it is important to ensure the patient understands the difference in dying from aneurysm rupture in comparison to dying from malignancy, frailty or heart failure for example. Such a discussion may assist patients in appraising their values to inform the shared decision making. Current decision aid tools for patients with aortic aneurysms do not prompt these more nuanced aspects of shared decision making [24, 25].

The limitations in this study are inherent to those in all observational research. In particular, there are acknowledged issues in obtaining accurate data on cause of death [20]. This may be due to poor recording or lack of post-mortem examination to definitively confirm or refute ruptured aneurysm as cause of death. In addition, the study population is heterogenous including both primary and secondary aortic intervention in a variety of anatomically different aneurysms. This heterogeneity however, represents a 'real life' vascular surgical patient population discussed at aortic MDMs and as such provides pragmatic clinically relevant data. Finally, while this study is limited in reporting data from a single center only, the wide eligibility criteria increase the probability that study findings are representative of patients managed at other vascular hubs.

Conclusion

This study reports that nearly a quarter of patients with unruptured aortic aneurysm, discussed at an aortic MDM following pre-operative CGA, did not undergo surgical repair following shared decision making. This non-operative group were more likely to be living with frailty, cognitive impairment and have multiple long-term conditions. Two fifths of patients managed non-operatively had died at 12 months, with the majority dying from causes other than aneurysm rupture. These findings support the need for CGA based preoperative assessment followed by multispecialty discussion to define realistic choice prior to shared decision making.

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