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Outcomes after Endovascular Arch Repair in Patients with a Mechanical Aortic Valve: Results from a Multicentre Study

Nikolaos Konstantinou [a,*], **Tomasz Jakimowicz** [b], **Stephan Haulon** [c], **Maximilian Pichlmaier** [d], **Said Abisi** [e], **Luis Mendes Pedro** [f], **Adib Khanafer** [g], **Nikolaos Tsilimparis** [a]

[a] Department of Vascular Surgery, University Hospital, LMU Munich, Munich, Germany
[b] Department of General, Vascular and Transplant Surgery, Medical University of Warsaw, Warsaw, Poland
[c] Aortic Centre, Hôpital Marie Lannelongue, GHPSJ, Université Paris Saclay, Paris, France
[d] Department of Cardiac Surgery, University Hospital, LMU Munich, Munich, Germany
[e] Department of Vascular Surgery, Guy's and St Thomas' NHS Foundation Trust, London, UK
[f] Department of Vascular Surgery, Centro Hospitalar Universitário Lisboa Norte; Faculdade de Medicina da Universidade de Lisboa; Centro Cardiovascular da Universidade de Lisboa, Lisbon, Portugal
[g] Vascular, Endovascular, and Renal Transplant Unit, Christchurch Hospital, Canterbury District Health Board, New Zealand

WHAT THIS PAPER ADDS

Patients with a mechanical aortic valve have traditionally been excluded from endovascular arch repair since it was considered a major contraindication. The outcomes of this international multicentre study, however, show that endovascular arch treatment is technically feasible and reasonably safe in experienced hands when the technique for valve cannulation is correctly used, potentially rendering historical concerns less prohibitive.

Objective: The aim of this study was to investigate outcomes after endovascular aortic arch repair in patients with a mechanical aortic valve where the valve needs to be crossed.

Methods: An international, multicentre, retrospective observational study was undertaken including all consecutive patients who underwent endovascular arch repair with mechanical aortic valve crossing.

Results: From March 2020 to August 2023, 12 patients were included in the study (median age 55 years, interquartile range 45, 67 years; 58% male). Five patients (42%) had a genetically confirmed connective tissue disorder (CTD) and three more had a high clinical suspicion of CTD. Most patients had a bileaflet valve (11/12; 92%) and one patient had a monoleaflet one. All patients had previously undergone surgical ascending aortic repair. Technical success was 100% with successful completion of the procedure with no valve damage. Two deaths (17%) were observed in the first 30 days post-operatively with no signs of valve malfunction: one patient died of major stroke due to excessive wire and sheath manipulation in the arch; and another due to cardiac arrest of unknown cause, with no valve damage being detected in the autopsy. No intra-operative technical difficulties regarding valve cannulation were observed. During a median follow up of eight months, one patient died fifteen months after the procedure owing to non-aortic related causes, and four endoleaks were present on the latest computed tomography angiography, none type I or III.

Conclusion: Endovascular aortic arch repair in a selected group of patients with a mechanical aortic valve, treated in experienced high volume aortic centres, seems technically feasible and reasonably safe. These preliminary results underline the complexity of the procedure and should be validated by larger cohort studies. With careful patient selection and adequate physician experience, the presence of a mechanical aortic valve could potentially no longer pose a major contraindication to endovascular arch repair in the future.

Keywords: Aortic repair, Complex endovascular aortic treatment, Mechanical aortic valve, Open surgical aortic repair
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INTRODUCTION

Endovascular arch repair has emerged in the last decade as an attractive alternative to open surgery with comparable results with regard to death and neurological complications, even though patients treated with endovascular means in the early period of this technique were older than open

* Corresponding author. Department of Vascular Surgery, University Hospital, LMU Munich, Marchioninistraße 15, 81377 Munich, Germany.
E-mail address: ni.konstantinou@outlook.com (Nikolaos Konstantinou).

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surgical patients.[1] Moreover, the need for prolonged ventilation post-operatively is reduced with endovascular means,[2] especially in patients with previous open thoracic aortic repair.[3] However, one of the biggest limitations of endovascular arch repair up until recently has been the presence of a mechanical aortic valve, which was traditionally considered a major contraindication.[4]

To overcome this limitation, modifications to the stent graft system design have been proposed, for example with a short bullet tip introducer without crossing the valve.[5] Since a previous report a few years ago detailing the technique for crossing a mechanical aortic valve to facilitate very proximal stent graft delivery and presenting the first successfully treated case,[6] an increasing number of physicians have been performing endovascular arch treatments, but the literature remains limited to two single case reports.[6,7]

Here is presented a multicentre experience with endovascular repair of arch pathologies in patients with a mechanical aortic valve to shed more light on these challenging procedures and their results, to identify risk factors for adverse outcomes, and to present technical considerations and solutions.

METHODS

This was an international, multicentre, retrospective study on the outcomes of endovascular repair of aortic arch pathologies in patients with a mechanical aortic valve. Six high volume, tertiary aortic centres participated in the study (five European and one from New Zealand), with each centre contributing one to four cases. All procedures included were performed in consecutive patients, and there were no planned procedures that had to be aborted. All patient data, including demographics, intra- and post-operative values, and outcome data, were collected by the individual institutes separately using a standardised datasheet with clearly pre-defined variables. The datasheet was created by the Munich centre and was then distributed to participating centres followed by a thorough review by all authors. A formal closed invitation was sent out to high volume aortic centres with experience in the technique.

Patient selection and data collection

Patients with a mechanical aortic valve undergoing endovascular aortic arch repair were included in the study. Crossing of the mechanical valve either with the tip of the introducer or with the endograft dilator was a prerequisite for inclusion; patients undergoing procedures with proximal landing close to the prosthetic valve but without valve crossing were excluded. Hybrid procedures with extra-thoracic cervical debranching for antegrade flow in supra-aortic vessels (i.e., carotid—subclavian bypass, carotid—carotid bypass, etc.) were included in the study; hybrid procedures requiring sternotomy or thoracotomy were excluded.

All procedures were performed by experienced endovascular surgeons in high volume aortic centres in collaboration with cardiac surgeons. All surgical indications were discussed in multidisciplinary aortic meetings including vascular and cardiac surgeons, and multiple treatment modalities were evaluated. Ultimately, choice of treatment was based on physician expertise and aimed to avoid a redo sternotomy. Another significant factor influencing the choice of treatment was that all of the included patients had undergone ascending aortic or hemi-arch replacement in the past, minimising the risk of retrograde type A dissection or other major complications in the proximal landing zone, especially in patients with connective tissue disorders (CTDs). Electronic patient database records were scrutinised at each centre locally by an experienced physician for demographic patient characteristics (age, sex), comorbidities, clinical and anatomical characteristics including details about the previous aortic surgery and prosthetic valve implantation, peri-operative details, as well as post-operative outcomes in the first 30 days and during follow up. Follow up aortic outcomes were confirmed through computed tomography angiography (CTA), and death was determined through in office or phone call visits. Alternatively, for patients who failed to attend follow up visits, electronic patient records were scrutinised and their general practitioners were contacted. Special attention was given to technical procedure details and considerations, including type, diameter, and age of the prosthetic valve, as well as intra-operative parameters associated with valve crossing (method of valve crossing, aortic regurgitation during graft deployment, systolic and diastolic pressure changes, intra-operative echocardiogram, etc.).

Technique description

The technique of crossing a mechanical aortic valve to facilitate endovascular arch repair has previously been described in detail elsewhere.[6] To cross a bileaflet prosthetic valve without damaging the valve itself or causing significant regurgitation, it is essential that valve penetration occurs laterally on the side of one leaflet, allowing the second leaflet to continue functioning properly. Canulation of the valve is achieved with a hydrophilic tip wire, and the wire position is verified with fluoroscopy in multiple projections (Fig. 1). Since adequate fluoroscopic valve leaflet visualisation is critical for success, all procedures took place in hybrid theatres with ceiling suspended or floor mounted C arms. In most cases a fluoroscopic frame rate of 7.5 images/second was enough, and in cases where the valve leaflets were not easily discernible a frame rate of up to 10 images/second was used. In case of doubt, trans-oesophageal echocardiogram (TOE) can help with wire visualisation. The hydrophilic tip wire was then exchanged for a stiff metallic wire, in this series for a Lunderquist wire (Cook Medical, Bloomington, IN, USA), and again the correct wire positioning was verified fluoroscopically. The endograft introducer was then advanced until the tip of the dilator crossed the valve while monitoring patient vitals for significant aortic regurgitation. To ensure that the dilator fitted through the lateral valve orifice, it is important to know the diameters of the implanted valve and the introducer dilator.

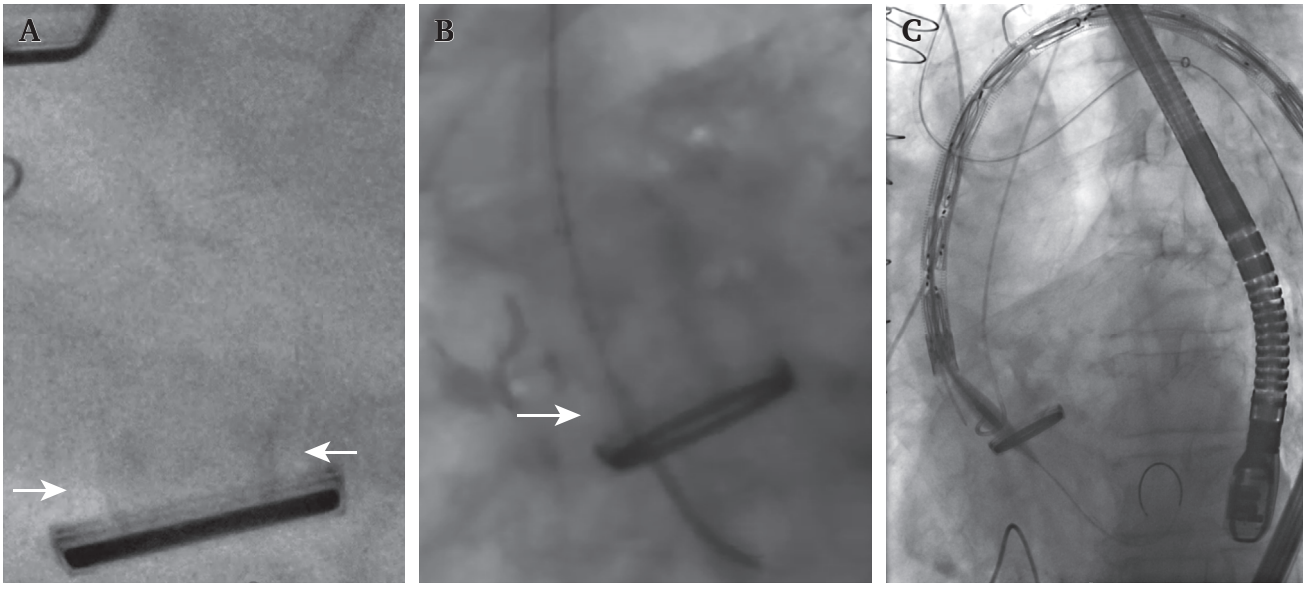

Figure 1. (A) The two leaflets of a bileaflet mechanical aortic valve (arrows) visualised on fluoroscopy and (B) canulated on the lateral side (arrow), which (C) allows the advance of the modified short tip introducer through the valve.

Both the size of the lateral orifice and the length of insertion needed are calculated on the pre-operative CT scan (Fig. 2). The dilator is tapered and its maximum diameter usually ranges from 20 — 24 French (6.7 — 8 mm). During planning of the procedure, a maximum penetration distance up to half of the dilator length and diameter (4 mm) is calculated, which required ordering a short, 35 mm long introducer tip without notch on the custom made device in order to keep the insertion distance to a minimum and to reduce the risk of wedging in the valve. The graft is then deployed under controlled cardiac output reduction using standard techniques (Munich Valsalva implantation technique [MuVIT],[8] inferior vena cava balloon occlusion, rapid pacing, etc.) and the introducer is then withdrawn as soon as possible. After pulling the sheath back, the valve is examined for potential malfunction or paravalvular leaks by angiography combined with TOE. A similar technique was used for cannulation of the monoleaflet valve in one case. This procedure posed an additional technical challenge in visualising the leaflet, but with high frame rate and high quality fluoroscopy the valve could be adequately visualised in the open and closed state, which allowed for successful wire cannulation (Supplementary Fig. S1).

Transfemoral access for the introduction of the aortic stent graft was used in every patient. Access routes for cannulation of the aortic stent graft branches and introduction of bridging stent grafts was at the discretion of each physician and included transbrachial, transcarotid, or transaxillary access, depending on personal preference, hybrid theatre limitations, and previous debranching procedures.

Due to the retrospective nature of the study, there was no standardised operating procedure across participating centres. The procedural outline described above was

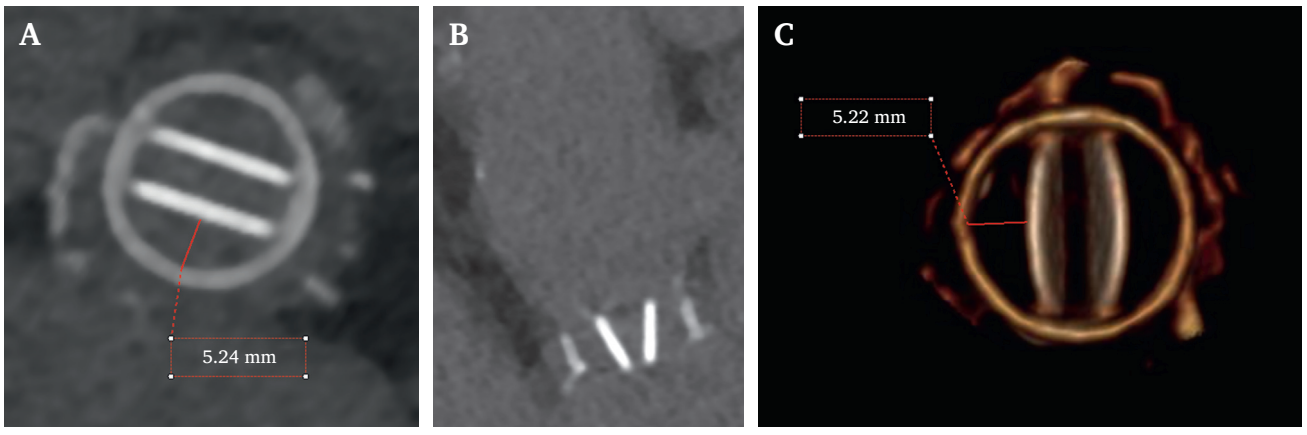

Figure 2. A bileaflet prosthetic aortic valve as shown (A) on the pre-operative computed tomography scan after double oblique image reformatting, (B) in sagittal oblique view, and (C) in a 3D reconstruction.

generally followed by all centres, however differences in specific materials used or deviations in parts of the procedure are to be expected.

Definition of endpoints

Technical success and death during the early post-operative period as well as during follow up were the primary study endpoints.

Technical success was defined as successful completion of the planned procedure with patent target vessels, no type I or III endoleaks on the completion angiogram, and without damaging the prosthetic aortic valve. Early death was defined as death during the first 30 days post-operatively or during the initial hospital stay. Haemodynamically significant aortic regurgitation was defined as a reduction of more than 20 mmHg in systolic blood pressure during valve cannulation.

Post-operative morbidity (including major and minor stroke, transient ischaemic attack, vascular and surgical complications) and re-intervention rates during the early post-operative period (30 days) as well as during follow up were the secondary endpoints. Major stroke was defined as disabling or fatal stroke, either haemorrhagic or ischaemic. Minor stroke was defined as an ischaemic stroke with a National Institutes of Health Stroke Scale (NIHSS) score of ≤ 5. Transient ischaemic attack was defined as focal neurologic symptoms lasting less than 24 hours. For focal neurological deficit or delayed emergence from anaesthesia, a native head CT scan with CTA of the thoracic, neck, and brain vessels was performed, and a neurological consultation was requested. Acute post-operative heart failure was defined as rapid onset of symptoms and signs secondary to abnormal cardiac function, and the primary diagnosis was through haemodynamic monitoring.

Statistical analysis

Continuous data were reported as the median and interquartile range (IQR). Categorical data were expressed as absolute numbers and percent prevalence (%) in the study cohort. Categorical variables were compared by use of the χ^2 test or Fisher's exact test for discrete values. The Wilcoxon rank sum test was used for continuous and ordinal variables. Follow up duration was calculated using the reverse Kaplan–Meier method to account for early deaths. All tests were two sided. A p value of $< .050$ was considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics for Windows Version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS

From March 2020 to August 2023, 12 patients (median age 55 years, IQR 45, 67 years; 58% male) with a mechanical aortic valve underwent endovascular aortic arch repair with crossing of the mechanical valve in the participating centres. One patient (8%) suffered from coronary artery disease, and none had diabetes, chronic renal failure requiring dialysis, or cerebrovascular disease. Five patients (42%) had a genetically confirmed CTD, most commonly Marfan syndrome (4/12; 33%), and three additional patients (25%) had a suspected CTD based on clinical and morphological signs. The comorbidities and cardiovascular risk factors of the study cohort are given in Table 1.

Table 1. Comorbidities and cardiovascular risk factors of the study group (n = 12).

Comorbidities and risk factors	Patients (n = 12)
Coronary artery disease	1 (8)
Previous coronary artery bypass	1 (8)
Congestive heart failure	1 (8)
Dysrhythmia	3 (25)
Hypertension	9 (75)
Hyperlipidaemia	8 (67)
Active smoker	4 (33)
Ex-smoker	4 (33)
COPD	3 (2)
Diabetes mellitus	0 (0)
Chronic renal failure without dialysis	2 (17)
Dialysis	0 (0)
Cerebrovascular disease	0 (0)
Confirmed connective tissue disorder	5 (42)
Marfan syndrome	4 (33)
Loeys–Dietz syndrome	1 (8)
Suspected connective tissue disorder	3 (25)

Data are presented as n (%). COPD = chronic obstructive pulmonary disease.

The most common type of prosthetic valve found in this cohort was a bileaflet valve (11/12 patients; 92%); one patient had a monoleaflet valve and none had a caged ball type of valve. The most common indications for surgery were degenerative aortic arch aneurysm, anastomotic aneurysm or pseudoaneurysm after previous open aortic repair, and post-dissection aneurysm with 25% (3/12 patients) each. Other indications included aortic dissection with true lumen collapse and type Ia endoleak after previous thoracic endovascular aortic repair (TEVAR). Ten patients (83%) underwent elective repair based on aortic diameter and morphology and two (17%) presented with symptomatic pathology: one with symptomatic compression of the true lumen after dissection and one with a rapidly expanding aneurysm due to type Ia endoleak after previous TEVAR. None was ruptured. Endovascular repair was performed with a triple branched endograft in most cases (7/12; 58%) and controlled cardiac output reduction was used in 10 cases (83%), most commonly with the MuVIT/Valsalva technique (5/12; 42%). Temporary haemodynamically significant aortic regurgitation during valve cannulation was observed in four patients (33%), with return to normal blood pressure after dilator retraction. Two patients required no additional cardiac output reduction measures due to temporary aortic regurgitation.

Correct wire placement through the mechanical aortic valve was verified through fluoroscopy alone in most cases (8/12; 67%), followed by TOE in three cases (25%) and angiography with a vessel dilator inserted in one case (8%). No instances of valve damage or paravalvular leak after

Table 2. Surgical history, indications, and operative data of patients (n = 12) in the study group.

Detail	Patients (n = 12)
Type of mechanical aortic valve	
Bileaflet	11 (92)
Monoleaflet	1 (8)
Previous aortic surgical history	
Bentall surgery	6 (50)
Ascending aortic or hemi-arch replacement	6 (50)
Indication for surgery	
Degenerative aneurysm	3 (25)
Pseudoaneurysm or anastomotic aneurysm	3 (25)
Post-dissection aneurysm	3 (25)
Dissection with true lumen collapse	2 (17)
Type Ia endoleak after TEVAR	1 (8)
Urgent repair, without rupture	2 (17)
Cervical debranching	4 (33)
Proximal landing zone	
Ishimaru zone 0	11 (92)
Ishimaru zone 1	1 (8)
Branches or graft openings – n	
1	1 (8)
2	4 (33)
3	7 (58)
Controlled hypotension during deployment	10 (83)
MuVIT/Valsalva	5 (42)
Right atrial inflow occlusion	3 (25)
Rapid pacing	2 (17)
Intra-operative TOE	7 (58)
Aortic regurgitation during valve canulation*	4 (33)
Confirmation of correct wire placement	
Fluoroscopy only	8 (67)
TOE	3 (25)
Angiography with vessel dilator	1 (8)
Valve malfunction or paravalvular leak after graft deployment	0 (0)
Guidewire or endograft tip stuck on valve	0 (0)

Data are presented as n (%). TEVAR = thoracic endovascular aortic repair; MuVIT = Munich Valsalva implantation technique; TOE = transoesophageal echocardiography.
* Defined as a reduction of more than 20 mmHg in systolic blood pressure during valve cannulation compared with baseline.

withdrawal of the endograft dilator was observed. The median operating time was 249 minutes (IQR 151, 304 minutes) and median fluoroscopy time 53 minutes (IQR 34, 78 minutes). The median radiation dose recorded was 2 093 cGy/cm^2 (IQR 1 499, 4 014 cGy/cm^2) and median volume of contrast agent used was 280 mL (IQR 195, 305 mL). Additional details about surgical indications, clinical characteristics, and procedural data can be found in Table 2. Additional technical details regarding the endovascular repairs are given in Table 3.

Peri-operative adverse events with regards to valve or wire destruction were not reported. No catheter or wire fractures occurred. One patient experienced ventricular fibrillation during graft deployment that was reverted to sinus rhythm after the first defibrillator shock without sequelae. In one case the physician reported that the tip of the graft was temporarily wedged in one of the bileaflet valves after deployment, which required some additional force to retract, without further sequelae regarding valve integrity.

Early outcomes

Technical success was achieved in all cases (12/12; 100%) with successful completion of the procedure with no valve damage. Two deaths (17%) were observed in the first 30 days post-operatively. One patient died four hours after procedure completion owing to acute heart failure and subsequent cardiac arrest of unknown reason. This patient had a genetically verified Loeys—Dietz syndrome and pre-operative echocardiogram had shown normal heart function; the autopsy was inconclusive regarding cause of death, and the prosthetic aortic valve was examined by the surgical team and revealed no defects. Another patient died on post-operative Day 11 due to a major ischaemic stroke in both the anterior and posterior circulation and sepsis secondary to pneumonia. Excessive wire and sheath manipulation in the carotid arteries due to difficulties in cannulating the branches as a result of slight graft malrotation was identified as the probable cause of the massive stroke. The patient with the monoleaflet valve had, apart from small haematomas in the access areas without the need for re-intervention, an uneventful post-operative course and was discharged home on post-operative Day 4. No statistically significant mortality risk factors could be identified in the univariable analysis.

Access vessel complications occurred in two cases (17%), with one of them requiring surgical drainage of a diffuse cervical haematoma. This was also the only case of re-intervention for any cause observed in the early post-operative period. No cases of acute kidney failure, spinal cord ischaemia, or wound infection were observed. Endoleaks were observed on the completion angiogram in two cases (17%): one type II endoleak and one type IV/diffuse. A detailed description of early post-operative outcomes can be found in Table 4.

Late outcomes

Median follow up was eight months (IQR 0, 14, range 0 – 42 months). One patient died fifteen months after the procedure due to non-aortic related causes. No re-interventions were reported during the follow up period. An endoleak on the latest CTA was present in four cases (33%); one endoleak from persistent false lumen perfusion in a dissection patient that was already planned for distal endovascular extension, one type II endoleak from an intercostal artery, and two undetermined endoleaks without signs of bridging or landing zone leaks and without aneurysm sac enlargement.

DISCUSSION

For decades open surgical aortic arch repair has been the gold standard and nowadays outcomes have improved through the use of sophisticated operating techniques. However, open arch repair in patients with a previous sternotomy has significantly higher short and long term

Table 3. Technical details regarding the endovascular repair and endografts used for each of the 12 patients.

Patient	Previous aortic surgery	Indication for surgery	Cervical debranching	Timing of debranching	Proximal aortic endograft size – mm	Distal aortic endograft size – mm	Aortic endograft length – mm	Graft branches or fenestrations	Modified short tip endograft introducer	Proximal landing zone – Ishimaru class	Distance from prosthetic valve to start of endograft – mm	
											Outer curvature	Inner curvature
1	Bentall	Pseudoaneurysm/ anastomotic aneurysm	Carotid –subclavian bypass both sides	Before index procedure	36	36	231	Two inner branches	Yes	Zone 0	17	26
2	Bentall	Pseudoaneurysm/ anastomotic aneurysm	–	–	38	34	256	Three inner branches	Yes	Zone 0	22	14
3	Bentall	Degenerative aneurysm	Carotid– subclavian bypass both sides	Before index procedure	36	44	256	Two inner branches	Yes	Zone 0	54	34
4	Ascending aortic replacement	Degenerative aneurysm	Left carotid to right carotid + right carotid to right subclavian (with proximal subclavian artery ligation) + right vertebral re-implantation in the right common carotid	Before index procedure	44	44	251	Two inner branches	Yes	Zone 0	29	21
5	Bentall procedure with innominate artery bypass	Pseudoaneurysm/ anastomotic aneurysm	–	–	34	26	211	One *in situ* fenestration for LSA (occluded LCCA)	No	Zone 1	82	52
6	Bentall	Type Ia endoleak after TEVAR	Carotid –subclavian bypass left side	Simultaneous to index procedure	38	38	211	Two inner branches	Yes	Zone 0	45	25
7	Bentall	Post-dissection aneurysm	–	–	38	34	231	Three inner branches	No	Zone 0	74	55
8	Ascending aortic replacement	Dissection	–	–	40	32	221	Three inner branches	No	Zone 0	Unknown (no post-operative CT scan)	Unknown (no post-operative CT scan)
9	Ascending aortic replacement	Dissection	–	–	36	32	221	Three inner branches	Yes	Zone 0	34	30
10	Ascending aortic replacement	Post-dissection aneurysm	–	–	34	42	255	Three inner branches	Yes	Zone 0	51	40
11	Partial ascending aortic replacement and CABG to patent but stenosed right coronary artery	Degenerative aneurysm	–	–	36	36	256	Three inner branches	Yes	Zone 0	32	24
12	Ascending aortic replacement	Dissection	–	–	40	28	243	Three inner branches	Yes	Zone 0	15	18

LSA = left subclavian artery; LCCA = left common carotid artery; TEVAR = thoracic endovascular aortic repair; CT = computed tomography; CABG = coronary artery bypass graft.

mortality rates, reaching up to 14%, as well as increased rates of pulmonary complications such as prolonged intubation, tracheostomy, and pneumonia.[9,10] Endovascular aortic arch repair in these patients provides the benefit of avoiding a redo sternotomy and cardiopulmonary bypass altogether while maintaining antegrade brain perfusion during the procedure. In order to achieve adequate proximal sealing, however, the tip of the graft introducer needs to be passed through the aortic valve and the presence of a mechanical aortic valve has been widely considered a major

Table 4. Early outcomes at 30 days post-operatively.

Outcome	Patients (n = 12)
Technical success	12 (100)
Death	2 (17)
Major stroke	1 (8)
Minor stroke	0 (0)
Transient ischaemic attack	0 (0)
Acute heart failure	1 (8)
Acute kidney failure	0 (0)
Spinal cord ischaemia	0 (0)
Access vessel complications	2 (17)
Bleeding	2 (17)
Stenosis or occlusion	0 (0)
Access site infection	0 (0)
Endoleak at final angiography	2 (17)
Type II	1 (8)
Type IV/diffuse	1 (8)

Data are presented as n (%).

contraindication until recently owing to the risk of damaging the valve with the dilator tip and causing severe regurgitation.

Mechanical aortic valves have been widely used for decades in younger patients undergoing aortic root replacement owing to their good long term outcomes compared with biological aortic valves,[11] which is also reflected in the joint recommendations of the latest guidelines on valvular disease treatment of the European Society of Cardiology and European Association for Cardio-Thoracic Surgery.[12] There are three major types of mechanical aortic valves, with the oldest being caged ball valves that were the first artificial heart valves and use a metal cage to house a silicone elastomer ball. Caged ball valves are no longer implanted owing to increased risk of blood clot formation. The second type are monoleaflet or tilting disc valves consisting of a single metal disc swinging on a rigid metal frame creating two distinct openings. Finally, bileaflet valves consist of two semicircular discs attached to a rigid valve ring and are the most widely used mechanical valves owing to their low thrombogenic risk.[13] Indeed, most patients (11/12) in the current cohort had a bileaflet valve, whereas one presented with a monoleaflet one. To the best of the authors' knowledge, this constitutes the first reported case of endovascular aortic arch repair in a patient with a monoleaflet aortic valve and demonstrates the technical feasibility of the procedure. Since monoleaflet aortic valves have only been used rarely in the last decades owing to less favourable outcomes compared with bileaflet valves, only this single case was encountered in the participating centres in consideration for endovascular repair. Although this single case could demonstrate the technical feasibility of the procedure, it is certainly not enough to draw any conclusions about procedure safety owing to the limited experience with the technique, and extreme caution when considering endovascular repair in these patients is advised. The case was included in the cohort for the sake of continuity, but for the reasons mentioned above this report has focused on endovascular repair in patients with bileaflet aortic valves.

The study's reported 100% technical success is encouraging, affirming the feasibility of endovascular arch repair in patients with mechanical aortic valves and rendering historical concerns less prohibitive from a technical standpoint. Crossing the valve through the lateral aperture and confirmation of wire placement is crucial in avoiding potentially catastrophic consequences such as permanent valve damage and aortic regurgitation. In the current series, adequate wire and valve visualisation were achieved with fluoroscopy alone in most cases. To achieve this, a high fluoroscopic image acquisition rate of 10 images per second was advised, which allowed for the valve to be visualised. TOE was used as an adjunct in cases where wire placement could not be verified from fluoroscopy alone; although image quality is not always excellent on TOE, verification of wire positioning can be achieved with a high degree of certainty when used together with fluoroscopy. It is important to note that these results were achieved in the hands of experienced endovascular surgeons and might not reflect the results achieved by less experienced physicians.

Despite the high technical success rate achieved in this series, two deaths occurred in the early post-operative period. In one case death occurred after bilateral ischaemic stroke, which it is postulated was the result of excessive wire and sheath manipulation in the carotid arteries owing to difficulties in cannulating the stent graft branches and was not associated with the valve cannulation since this was completed uneventfully. In the second case an early cardiac arrest of unknown cause led to death hours after procedure completion in a patient with Loeys—Dietz syndrome with normal systolic heart function and ejection fraction pre-operatively. In this case valve cannulation was also uneventful and no significant regurgitation was noted during graft deployment; the autopsy report was inconclusive regarding cause of death. Although none of the deaths could be associated with valve damage, they highlight the complexity of the repair.

Although endovascular arch repair had been until recently reserved for elderly patients unfit for open repair, the median age in the current cohort was 55 years. This is because almost half of the patients included in the study had a verified CTD and in three more a high degree of clinical suspicion of a CTD was present. These patients typically present with dilatation of the aortic root leading to aortic dissection from a very young age[14,15] and need to undergo several aortic procedures over their lifetime. These patients are often treated by mechanical aortic valve replacement owing to the favourable long term outcomes. The current results after endovascular arch repair in these patients were acceptable and helped avoid a redo sternotomy. Moreover, these patients have often already undergone open surgical proximal or hemi-arch replacement, which eliminates the risk of a retrograde type A dissection when deploying a stent graft in these fragile vessels.

Limitations

The retrospective nature of the study and highly selected patient population may have introduced a selection bias, which should be considered when interpreting the results. Moreover, the small number of patients did not allow for analyses with adequate statistical power. The recruitment of patients from high volume aortic centres may limit the generalisability of results in everyday practice. Additionally, there were no *a priori* defined practices for functional heart diagnostics pre- and post-operatively; echocardiogram, troponin and N-terminal pro B-type natriuretic peptide (NT-proBNP) tests were not routinely performed, which could have an impact in the detection of post-operative heart failure. These patients were nonetheless monitored post-operatively in specialised intensive care units with highly experienced personnel in the treatment of aortic pathologies.

Conclusion

Endovascular aortic arch repair in a selected group of patients with a mechanical aortic valve treated in experienced, high volume aortic centres seems technically feasible and reasonably safe. These preliminary results underline the complexity of the procedure and should be validated by larger cohort studies. With careful patient selection and adequate physician experience, the presence of a mechanical aortic valve may potentially no longer pose a major contraindication to endovascular arch repair in the future.

CONFLICTS OF INTEREST

Nikolaos Tsilimparis: honoraria and consulting fees from Cook Medical and Bentley InnoMed. Nikolaos Konstantinou: speaker fees from Cook Medical and Astra Zeneca.

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejvs.2024.09.029.

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