

FEASIBILITY AND OUTCOMES OF AN ENDOVASCULAR AORTIC PROGRAM IN A PROVINCIAL HOSPITAL: A 5-YEAR SINGLE-CENTER EXPERIENCE

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ABSTRACT

Background: Endovascular aortic repair has become the standard treatment for many aortic diseases; however, its implementation remains limited in provincial hospitals in developing countries. This study aimed to evaluate the feasibility, safety, and clinical outcomes of an endovascular aortic program in a provincial hospital setting.

Methods: This was a single-center retrospective cohort study including 52 consecutive patients undergoing endovascular aortic interventions between April 2021 and April 2026 at Dong Nai General Hospital, Vietnam. Procedures included EVAR, TEVAR, and hybrid interventions with debranching techniques. Primary endpoints were technical success and early outcomes (≤ 30 days). Secondary endpoints included midterm survival and freedom from reintervention, analyzed using Kaplan–Meier methods.

Results: The mean age was 68.7 ± 9.4 years, with 75% male patients. EVAR accounted for 59.6% and TEVAR for 40.4% of procedures, with 26.9% requiring hybrid approaches. Technical success was achieved in all cases (100%). Early mortality was 3.8%, and major morbidity occurred in 5.8%. During follow-up up to 5 years, two late deaths were recorded, both unrelated to aortic causes. No reinterventions were required, with 100% freedom from reintervention and no significant endoleaks or aneurysm progression observed.

Conclusions: An endovascular aortic program can be safely and effectively implemented in a provincial hospital with appropriate patient selection, structured training, and multidisciplinary collaboration. Decentralization of aortic care may improve access to treatment while maintaining favorable clinical outcomes.

Keywords: Endovascular aortic repair, provincial hospital, aortic disease

1. INTRODUCTION

Aortic diseases, encompassing aneurysms and dissections, constitute a significant contributor to cardiovascular morbidity and mortality globally. In recent years, endovascular techniques, such as endovascular aneurysm repair (EVAR) and thoracic endovascular aortic repair (TEVAR), have emerged as the cornerstone of treatment for numerous aortic pathologies due to their minimally invasive nature and favorable perioperative outcomes. Contemporary international guidelines increasingly advocate for endovascular approaches as first-line therapy in anatomically suitable patients, particularly for descending thoracic aortic disease and infrarenal abdominal aortic aneurysms [1,2].

The European Society of Cardiology 2024 guidelines on peripheral arterial and aortic diseases emphasize that TEVAR is indicated in complicated type B aortic dissection and is preferred over open surgery in many scenarios due to lower early morbidity and mortality[1]. Similarly, the European Society for Vascular Surgery 2024 clinical practice guidelines highlight EVAR as the standard treatment for most patients with suitable abdominal aortic aneurysm anatomy, while also underscoring the importance of institutional experience and procedural volume in optimizing outcomes[2].

Despite these advancements, the dissemination of endovascular aortic interventions remains heterogeneous, particularly in developing countries. In Vietnam, these procedures are predominantly performed in high-volume tertiary centers, whereas provincial hospitals encounter challenges including limited case numbers, resource constraints, and the need for specialized training and multidisciplinary collaboration. These barriers raise concerns regarding the feasibility and safety of implementing such programs outside major referral institutions.

Dong Nai General Hospital, a grade I provincial hospital serving a large population in

southern Vietnam, has progressively developed a comprehensive aortic program integrating both open surgical and endovascular techniques. Since 2021, a structured endovascular program has been established with proctorship support and hybrid procedural capabilities. Given the limited evidence from provincial-level institutions, this study aims to evaluate the feasibility, safety, and early-to-midterm outcomes of an endovascular aortic program in a real-world, resource-constrained setting.

2. METHODS

2.1. Study design and setting

This study was structured as a single-center, retrospective observational cohort study conducted at Dong Nai General Hospital, a grade I provincial hospital located in southern Vietnam. The objective of the study was to assess the feasibility, safety, and clinical outcomes of an endovascular aortic program implemented in a real-world, non-tertiary setting. Institutional approval was secured prior to data collection

2.2. Study population

All consecutive patients who underwent endovascular aortic interventions between April 2021 and April 2026 were included in this study. The inclusion criteria encompassed patients diagnosed with thoracic aortic disease, including type B aortic dissection and thoracic aortic aneurysm, thoracoabdominal aortic pathology, or infrarenal abdominal aortic aneurysm deemed suitable for endovascular repair. Patients undergoing hybrid procedures, such as debranching combined with stent graft implantation, were also

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included. Exclusion criteria comprised patients treated with open surgery alone or those with incomplete clinical or imaging data.

Baseline demographic characteristics, comorbidities, and anatomical features were collected from electronic medical records and preoperative computed tomography angiography (CTA). Procedural details included the type of intervention (EVAR, TEVAR, or hybrid), use of adjunctive techniques (e.g., debranching), and perioperative management strategies.

2.3. Endpoints and definitions

Clinical endpoints were defined according to contemporary reporting standards for endovascular aortic interventions. Technical success was classified as successful delivery and deployment of the endograft at the intended anatomical location, with adequate proximal and distal sealing, without type I or III endoleak, conversion to open surgery, or intraoperative death. Early outcomes were defined as events occurring within 30 days post-procedure or during the index hospitalization.

Primary safety endpoints included all-cause mortality and major adverse events. Major complications comprised stroke, spinal cord ischemia, acute kidney injury (defined according to KDIGO criteria), prolonged mechanical ventilation (>48 hours), and access-related complications requiring intervention. Endoleaks were categorized based on standard classification (types I–V), with clinically significant endoleaks defined as type I or III.

Midterm outcomes included survival, freedom from reintervention, and aortic-related complications during follow-up. Reintervention was defined as any secondary endovascular or open surgical procedure related to the treated aortic segment. Imaging follow-up with computed tomography angiography was used to assess aneurysm exclusion, sac behavior, and device integrity over time.

2.4. Statistical analysis

Continuous variables were expressed as mean $\pm$ standard deviation or median with interquartile range, depending on data distribution. Categorical variables were presented as frequencies and percentages. Normality was assessed using the Shapiro–Wilk test.

Comparisons between groups (if applicable) were performed using the Student's t-test or Mann–Whitney U test for continuous variables and the chi-square or Fisher's exact test for categorical variables. Survival and freedom from reintervention were estimated using the Kaplan–Meier method. Statistical significance was defined as a two-sided p-value <0.05.

All statistical analyses were performed using standard statistical software (SPSS version 31).

3. RESULTS

3.1. Patient characteristics and preoperative assessment

A total of 52 consecutive patients were included in the study cohort. The population was predominantly elderly, with a mean age of 68.7 ± 9.4 years, reflecting the typical epidemiology of aortic diseases. There was a marked male predominance (75.0%), consistent with the known higher incidence of aortic aneurysm and dissection in men.

Most patients presented with multiple cardiovascular risk factors. Hypertension was the most prevalent comorbidity, observed in nearly four-fifths of the cohort, followed by a history of smoking in more than half of the patients. Other comorbid conditions included diabetes mellitus, coronary artery disease, and chronic kidney disease, although these were less frequent. Overall, the baseline clinical profile suggested a moderately high-risk population; however, extreme frailty or prohibitive surgical risk was uncommon, reflecting

a degree of preselection for endovascular suitability.

Table 1. Baseline patient characteristics (detailed)

Variable	Value
Number of patients	52
Age (mean $\pm$ SD), years	68.7 $\pm$ 9.4
Age $\geq$ 70 years, n (%)	24 (46.2%)
Male sex, n (%)	39 (75.0%)
Hypertension, n (%)	41 (78.8%)
Diabetes mellitus, n (%)	12 (23.1%)
Coronary artery disease, n (%)	9 (17.3%)
Chronic kidney disease, n (%)	6 (11.5%)
Smoking history, n (%)	28 (53.8%)

3.2. Aortic disease characteristics before intervention

Regarding anatomical distribution, infrarenal abdominal aortic aneurysm was the most common pathology, accounting for 59.6% of cases, followed by thoracic aortic disease (38.5%). Only one patient presented with thoracoabdominal involvement, requiring a more complex treatment strategy. Among thoracic aortic cases, type B aortic dissection represented the majority, while a smaller proportion consisted of degenerative aneurysms and ruptured lesions.

Table 2. Aortic pathology before intervention

Variable	Value
Infrarenal abdominal aorta, n (%)	31 (59.6%)
Thoracic aorta, n (%)	20 (38.5%)
Thoracoabdominal aorta, n (%)	1 (1.9%)

Following the overall distribution of aortic involvement, a more detailed analysis was performed for thoracic aortic diseases, given their distinct pathophysiology and procedural considerations. Within this subgroup, acute and subacute type B aortic dissection represented the predominant etiology, while degenerative aneurysms and rupture cases accounted for the remaining proportion.

Table 3. Etiology of thoracic aortic disease (n=20)

Diagnosis	Number (%)
Type B aortic dissection	11 (55.0%)
Intact thoracic aneurysm	6 (30.0%)
Ruptured thoracic aneurysm	3 (15.0%)

3.3. Procedural characteristics and technical aspects of intervention

Endovascular interventions were tailored according to aortic pathology, anatomical suitability, and the need to achieve adequate proximal and distal sealing zones. The procedures included standard endovascular techniques—endovascular aneurysm repair (EVAR) for infrarenal abdominal aortic aneurysms and thoracic endovascular aortic repair (TEVAR) for thoracic aortic diseases—as well as hybrid approaches in selected complex cases.

3.4. Overall procedural profile

Among the 52 patients, EVAR was the most frequently performed procedure, accounting for the majority of infrarenal aneurysm cases. TEVAR was primarily indicated for thoracic aortic pathologies, including type B aortic dissection and descending thoracic aneurysms. Hybrid procedures were performed in patients with inadequate landing zones or involvement of major aortic branches.

Table 4. Types of endovascular interventions

Procedure type	Number of patients (%)
EVAR	31 (59.6%)
TEVAR	21 (40.4%)
Hybrid procedures	14 (26.9%)

3.5. Debranching techniques

Debranching procedures were selectively employed to extend the proximal or distal landing zones in complex aortic anatomy. Overall, 14 patients (26.9%) required some form of debranching, reflecting the center's capability to manage advanced aortic pathology using hybrid strategies.

Table 5. Debranching characteristics

Variable	Number of patients
Any debranching	14
No debranching	38
Total arch debranching	2
Partial arch debranching	10
Visceral debranching	1
Iliac (IIA) debranching	1

Partial arch debranching was the most commonly performed technique, mainly to facilitate proximal extension of TEVAR into zone 1 or 2. Total arch debranching was reserved for highly selected cases requiring zone 0 TEVAR. Visceral debranching and iliac branch revascularization were performed in isolated cases with complex thoracoabdominal or aortoiliac involvement.

3.6. Early outcomes and perioperative complications

Overall, early clinical outcomes were favorable, with a high technical success rate and low incidence of major complications. Technical success was achieved in all cases (100%), defined as successful deployment of the endograft at the intended location without type I or III endoleak, intraoperative conversion, or procedural mortality.

Table 6. Early outcomes (≤30 days)

Outcome	Value
Technical success, n (%)	52 (100%)
Early mortality, n (%)	2 (3.8%)
Major morbidity, n (%)	3 (5.8%)
Type I/III endoleak	0

3.7. Mortality analysis

There were two cases of early mortality (3.8%), both occurring in elderly patients undergoing complex interventions.

The first case involved an 81-year-old male patient who underwent total arch debranching followed by zone 0 TEVAR. The procedure was technically successful; however, the patient developed a major postoperative stroke and subsequently died. This case highlights the inherent neurological risk associated with extensive arch manipulation and supra-aortic vessel revascularization.

The second mortality occurred in an 88-year-old female patient undergoing fenestrated EVAR involving the left renal artery. Although the procedure achieved technical success with accurate stent graft deployment and preservation of branch perfusion, the operative time was prolonged (approximately 4.5 hours). Postoperatively, the patient developed multiple organ failure and did not survive. This case underscores the impact of procedural complexity and duration on perioperative outcomes, particularly in elderly patients with limited physiological reserve.

3.8. Major complications

Major morbidity was observed in three patients (5.8%). These included one case of stroke, one case of acute renal failure, and one case of prolonged mechanical ventilation.

- **Stroke:** One patient developed postoperative stroke following a complex arch intervention (as described above), representing the most severe neurological complication in the cohort.

- **Renal failure:** One patient experienced acute kidney injury postoperatively, likely related to contrast exposure and perioperative hemodynamic factors; renal function fully recovered with conservative management.

- **Prolonged ventilation:** One patient required extended ventilatory support (3 days) due to postoperative pneumonia, with subsequent full recovery.

No cases of spinal cord ischemia were recorded. Importantly, there were no instances of type I or III endoleak detected in the early postoperative period, and no patients required emergency conversion to open surgery.

3.9. Midterm outcomes

During a median follow-up period of up to 5 years, midterm outcomes were favorable, demonstrating good durability of endovascular and hybrid aortic interventions in this cohort. Clinical follow-up was completed through scheduled visits and imaging surveillance with computed tomography angiography.

Two late deaths were recorded during the follow-up period. One patient died due to cerebrovascular accident (stroke), and another patient died from lung cancer. Importantly, neither death was considered directly related to the aortic procedure or device. No cases of aortic rupture, device migration, or aortic-related mortality were observed.

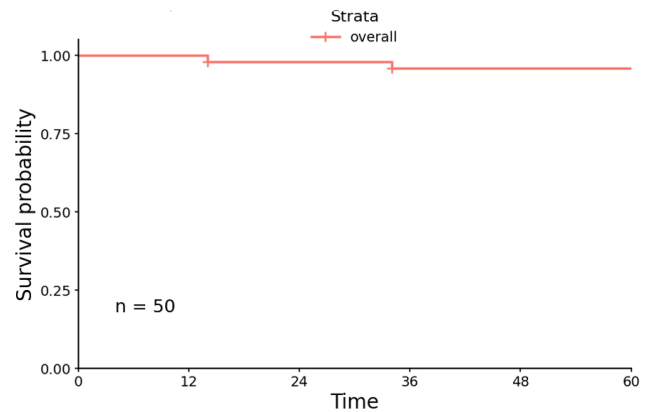


Figure 1. Kaplan–Meier overall survival curve

Notably, there were no reinterventions during the follow-up period. All patients maintained stable aortic repair with no clinically significant endoleak (type I or III), no aneurysm sac enlargement, and no need for secondary procedures. These findings suggest excellent procedural durability and appropriate patient selection.

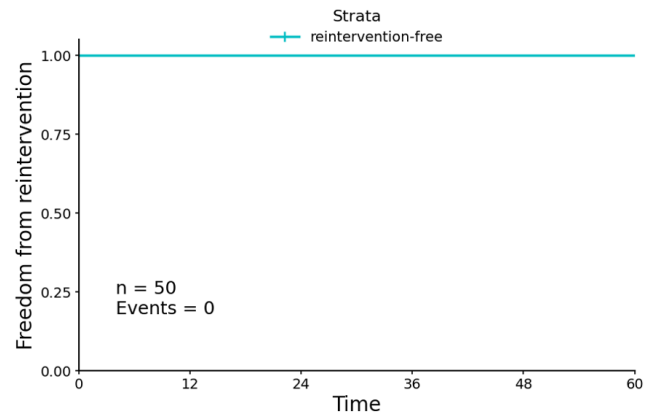


Figure 2. Kaplan–Meier freedom from reintervention

4. DISCUSSION

The present study demonstrates that an endovascular aortic program can be safely and effectively implemented in a provincial hospital setting, with favorable early and midterm outcomes. These findings contribute to an important and still debated question: whether complex aortic interventions should remain

centralized or can be safely decentralized to lower-volume centers.

4.1. Feasibility of endovascular aortic programs in non-tertiary centers

Traditionally, endovascular aortic interventions have been concentrated in high-volume centers due to their technical complexity and the requirement for multidisciplinary expertise. Several contemporary analyses suggest that higher institutional volume is associated with improved perioperative outcomes, particularly for complex procedures such as fenestrated and branched EVAR [5]. However, more recent data indicate that mortality outcomes may not differ significantly across centers when appropriate protocols and expertise are in place, although complication rates may still vary[5].

Our results are consistent with these findings, demonstrating a low early mortality rate (3.8%) despite a relatively modest annual case volume. This supports the concept that procedural safety can be achieved in provincial hospitals with structured training and careful implementation strategies.

4.2. Importance of patient selection and procedural strategy

A key determinant of success in this study is the rigorous patient selection process. During the early phase of program development, interventions were primarily performed in elective cases with favorable anatomical characteristics. This approach aligns with contemporary evidence emphasizing that outcomes of EVAR and TEVAR are highly dependent on anatomical suitability and operator experience[6].

In addition, the use of hybrid techniques, including debranching procedures, allowed treatment of more complex cases while maintaining procedural safety. Hybrid approaches have become an important strategy in modern aortic practice, enabling extension of endovascular repair to

anatomically challenging segments[4]. In our cohort, the ability to perform arch and visceral debranching was essential in expanding indications beyond standard EVAR and TEVAR.

4.3. Midterm durability and clinical outcomes

Midterm results in this study were particularly favorable, with no reinterventions and no aortic-related mortality during follow-up. These findings are consistent with recent studies demonstrating improved durability of endovascular aortic repair due to advances in device technology and imaging guidance[4,7].

Although earlier trials reported higher rates of secondary interventions after EVAR, contemporary real-world data suggest that reintervention rates have decreased significantly in modern practice, especially in carefully selected patients [6,7]. The absence of reintervention in our cohort further supports the effectiveness of a conservative and stepwise implementation strategy.

4.4. Implications for provincial healthcare systems

The establishment of endovascular aortic programs at provincial hospitals holds significant implications for healthcare delivery, particularly in resource-constrained environments. Firstly, decentralization enhances timely access to care, which is crucial for managing acute aortic syndromes. Delays associated with inter-hospital transfers may adversely affect outcomes, especially in instances of rupture or complicated dissection. Secondly, it alleviates the burden on tertiary referral centers, which frequently experience overwhelming patient volumes. By expanding capabilities at provincial hospitals, healthcare resources can be allocated more efficiently. Thirdly, local treatment improves continuity of care, facilitating long-term follow-up and imaging surveillance—essential components of successful endovascular therapy. Finally, the establishment

of such programs contributes to capacity building and professional development, fostering multidisciplinary collaboration and enhancing the overall quality of care.

4.5. Challenges and considerations

Despite these advantages, several challenges warrant consideration. The relatively low case volume may constrain the learning curve and procedural experience. Additionally, complex procedures such as total arch repair or fenestrated EVAR continue to be associated with elevated risks, as evidenced by the mortality cases in this study. Furthermore, the sustainability of such programs is contingent upon ongoing investment in infrastructure, training, and device availability. In the absence of these elements, outcomes may not be consistently replicable across different provincial settings.

5. CONCLUSION

This study illustrates that the implementation of an endovascular aortic program in a provincial hospital setting can be achieved safely and effectively, yielding high technical success and favorable early and midterm outcomes. Key factors contributing to this success include meticulous patient selection, structured training, and a multidisciplinary approach. The decentralization of aortic care may enhance timely access to treatment while maintaining acceptable clinical outcomes in appropriately selected patients.

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