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Original research

OUTCOMES OF AORTIC ARCH DEBRANCHING COMBINED WITH ENDOVASCULAR INTERVENTION FOR THORACIC AORTIC DISEASES

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ABSTRACT

Objectives: *To evaluate the outcomes of hybrid surgery-aortic arch debranching combined with thoracic endovascular aortic repair-in the treatment of complex aortic arch and descending thoracic aortic diseases.*

Methods: *A retrospective study was conducted on 45 patients treated with hybrid surgery (aortic arch debranching combined with TEVAR) at University Medical Center, Ho Chi Minh City (2017-2022).*

Results: *Mean age was 64.6 years; males accounted for 75.6%. Chest pain was the most common symptom (71.1%). The average intervention time was 82.3 minutes. No intraoperative deaths were recorded. Complications included renal failure (11.1%), stroke (8.9%), endoleak (4.4%), and retrograde type A dissection (2.2%). In-hospital mortality was 6.7%. The clinical success rate was 88.9%. With a mean follow-up of 29.4 months, cumulative survival rates at 3, 12, and 24 months were 98%, 93%, and 93%, respectively.*

Conclusions: *Hybrid aortic arch debranching combined with TEVAR expands indications for minimally invasive treatment and yields favorable short- and mid-term results.*

Keywords: *Hybrid surgery, thoracic aortic diseases, endovascular intervention, TEVAR.*

I. INTRODUCTION

Thoracic aortic diseases, particularly thoracic aortic aneurysms and dissections, are life-threatening conditions associated with high mortality rates. The 5-year survival rate ranges from only 15-55%, and is significantly lower when the aortic arch is involved [1]. Thoracic Endovascular Aortic Repair (TEVAR), using stentgraft implantation, has emerged as a minimally invasive technique that offers faster recovery and comparable outcomes to open surgery [2]. However, when the lesion involves branches of the aortic arch, TEVAR is limited by the lack of an adequate proximal landing zone for safe stent deployment. To overcome this limitation, a combined approach involving aortic arch debranching and TEVAR-referred to as a "hybrid technique"-has been implemented. This strategy expands treatment indications, improves safety, and avoids the risks of open surgery, especially in high-risk patients [3]. This study aims to evaluate the outcomes of hybrid repair in treating lesions involving the aortic arch and descending thoracic aorta at our department.

II. METHODS AND MATERIALS

2.1. Study design

This was a retrospective, cross-sectional descriptive study with follow-up, conducted at University Medical Center, Ho Chi Minh City, from 2017 to 2022. The study enrolled patients who underwent aortic arch debranching combined with TEVAR.

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Inclusion criteria: Patients diagnosed with thoracic aortic disease [4], including: lesions involving the origin of the left subclavian artery or left common carotid artery, with a remaining proximal landing zone > 20 mm (corresponding to zones 1-3); aortic arch lesions with inadequate proximal landing zone but an intact ascending aorta suitable for stentgraft anchoring.

All patients underwent aortic arch debranching combined with TEVAR

Exclusion criteria:

Ascending aortic lesions requiring open repair (Stanford type A dissection or ascending aortic aneurysm).

Inability to perform partial clamping of the ascending aorta due to calcification or anatomical abnormalities.

Patients who underwent open-heart surgery in combination with arch debranching and TEVAR.

Aortic debranching procedure:

Zone 0 lesions: Median sternotomy was performed. A Y-shaped graft (16-8 mm) was used to revascularize the brachiocephalic artery, left common carotid artery, and left subclavian artery from the ascending aorta.

Zone I-III lesions: The left subclavian, left common carotid, and right common carotid arteries were revascularized using a ringed synthetic graft (6-7 mm) via two small cervical incisions. Temporary vascular clamping was performed, and end-to-side anastomoses were constructed using 5-0 sutures. The origin of the left common carotid artery was either ligated or transected.

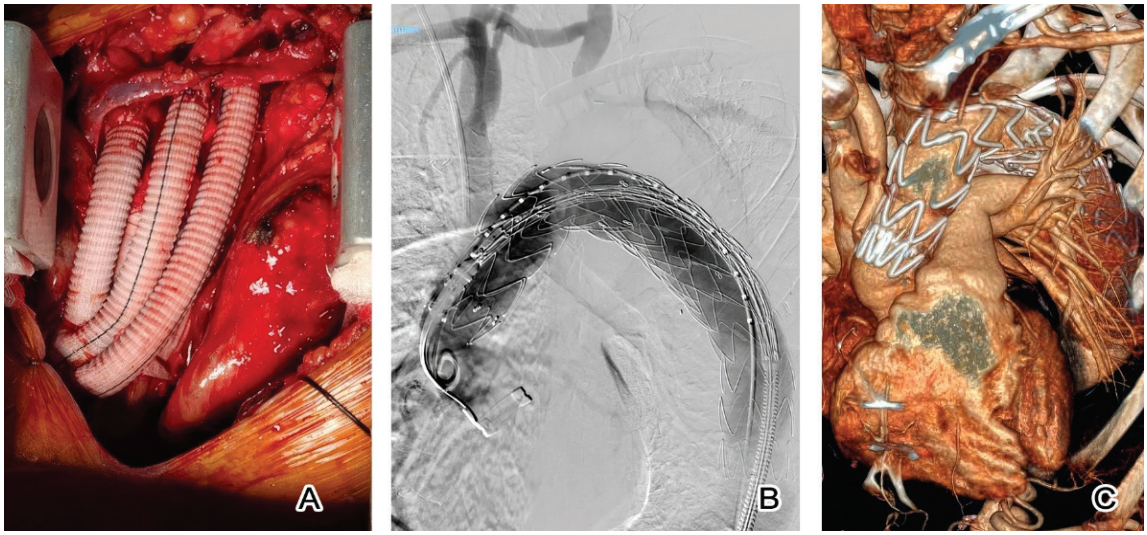

Image 1: A hybrid repair case of type B aortic dissection at our center requiring stentgraft deployment in zone 0

A. Intraoperative photo showing debranching of the brachiocephalic artery, left common carotid artery, and left subclavian artery from the ascending aorta.

B-C. Intra-procedural DSA and 3D CT reconstruction after stentgraft placement.

Outcome Assessments

Research parameters were defined according to the Society for Vascular Surgery guidelines [5]: type of thoracic aortic pathology (dissection, intramural hematoma, aneurysm) identified by CT scan; zone of lesion involvement (zones I, II, III); mean diameters of the thoracic aortic segments; postoperative complications: mortality, endoleak, retrograde type A dissection, multiorgan failure, infection, etc.

Clinical success was defined per Fillinger and Conway [2],[6]: No perioperative mortality; No type I or III endoleak on follow-up CT; No aortic rupture; No conversion to open surgery due to debranching or endovascular failure; Complete thrombosis of the aneurysmal sac with < 5 mm growth (in aneurysm cases);

Full coverage of the primary entry tear, partial thrombosis of the false lumen, and no new dissection (in type B dissection cases).

2.2. Data collection and analysis

Data were collected using Microsoft Excel and analyzed with Stata version 14.2. Categorical variables were expressed as frequencies and percentages. Continuous variables were expressed as means ± standard deviation. Cumulative survival was analyzed using Kaplan–Meier survival curves.

2.3. Ethical considerations

This study was approved by the Institutional Review Board of the University of Medicine and Pharmacy at Ho Chi Minh City (Approval No. 330/HĐĐĐ-ĐHYD, dated March 14, 2023).

III. RESULTS

A total of 45 patients underwent surgery. The mean age was 64.6 years, with the majority aged ≥ 60. Males predominated, with a male-to-female ratio of 3.1:1. Table 1 summarizes the baseline preoperative characteristics:

Table 1: Preoperative characteristics

Characteristics		**Value (N = 45)**
Clinical presentation		
Symptoms	Chest pain	32 (71.1%)
	Dyspnea	6 (13.4%)
	Hemoptysis	1 (2.2%)
	Hoarseness	2 (4.4%)
	Abdominal pain	3 (6.7%)
	Asymptomatic	1 (2.2%)
CT scan findings		
Type of aortic lesion	Aortic dissection	13 (28.9%)
	Intramural hematoma	7 (15.6%)
	Aneurysm	25 (55.6%)
Zone of involvement	Zone I	13 (28.9%)
	Zone II	22 (48.9%)
	Zone III	10 (22.2%)
Mean aortic diameter (mm)	Ascending aorta	35.7 ± 3.6
	Aortic arch	34.9 ± 5.9
	Descending aorta	30.0 ± 4.6

Chest pain was the most common presenting symptom (71.1%). CT imaging revealed that thoracic aortic aneurysm was the most frequent lesion (55.6%), with zone II involvement being the most common (48.9%). Procedural characteristics are presented in Table 2:

Table 2: Procedural characteristics

Characteristics		Value (N = 45)
Zone of intervention	Zone 0	12 (26.7%)
	Zone I	23 (51.1%)
	Zone II	9 (20%)
	Zone III	1 (2.2%)
Debranching pattern	Right subclavian - right common carotid	1 (2.2%)
	Right & left subclavian - right & left common carotid	1 (2.2%)
	Left subclavian - left common carotid	8 (17.8%)
	Left subclavian - left & right common carotid	23 (51.1%)
	Brachiocephalic trunk - left common carotid - left subclavian - ascending aorta	12 (26.7%)
Number of Stentgrafts used	1 stent	30 (66.7%)
	2 stent	12 (26.7%)
	3 stent	3 (6.6%)
Intraoperative mortality		0 (0.0%)
Procedural times	Intervention duration (min)	82.3 ± 41.6
	Intubation time (min)	26.9 ± 40.5
	ICU stay (days)	4.3 ± 4.4
	Postoperative hospitalization (days)	11.7 ± 10.1

Zone I was the most frequent site of intervention (51.1%). The most common debranching pattern was left subclavian-left and right common carotid (51.1%). Most patients received one stentgraft (66.7%). There were no intraoperative deaths. Postoperative outcomes are detailed in Table 3:

Table 3: Postoperative outcomes

Postoperative outcome	Value (N = 45)
Endoleak	2 (4.4%)
Retrograde type A dissection	1 (2.2%)
Renal failure	5 (11.1%)
Stroke	4 (8.9%)
Infection	3 (6.7%)
In-hospital mortality	3(6.7%)
Clinical success	40(88.9%)

Two patients (4.4%) developed post-intervention endoleaks (1 type I and 1 type III). One patient had retrograde type A dissection requiring open thoracotomy. Three patients (6.7%) died during the postoperative period. The clinical success rate was 88.9%.

Among 42 patients followed up, the mean follow-up duration was 29.4 ± 21.6 months (up to 73 months). Two patients died during follow-up (4.8%), and the midterm clinical success rate was 90.5%. Figure 2 illustrates the cumulative survival rates:

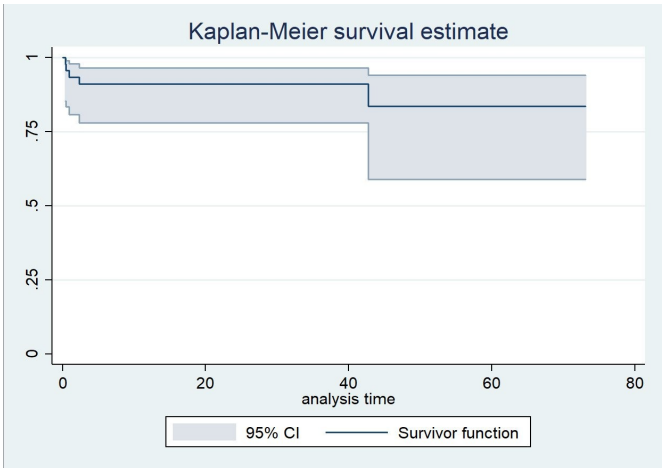

Figure 2: Kaplan-Meier survival curve

Cumulative survival rates at 3, 12, and 24 months were 98%, 93%, and 93%, respectively.

IV. DISCUSSION

4.1. Procedural characteristics

In this study, 66.7% of patients received one stentgraft, and 33.3% received two or more. These results are comparable to the multicenter analysis by Koulias et al., reporting an average of 1.3 stentgrafts per patient [7]. The number of stentgrafts used depends on factors such as lesion length, aneurysm versus dissection, and presence of type I or III endoleaks.

Two main reasons necessitate the use of two stentgrafts:

First, when the aneurysm length exceeds 160 mm, two stentgrafts are required to isolate the lesion and maintain a minimum landing zone of 20 mm to avoid type I endoleaks.

Second, when the proximal and distal diameters differ by more than 6 mm but less than 8 mm, two stentgrafts are used to accommodate the gradual tapering and prevent complications like migration, endoleak, or thrombosis.

Additionally, when the distal end of the first stentgraft is larger than the proximal diameter of the next stentgraft, the conventional technique is not applicable. In such cases, the bottom-up approach is employed-placing a smaller stentgraft in the descending aorta first, followed by a larger one from the proximal side telescoped into the initial stent. This technique allows successful TEVAR in patients with significant proximal-distal diameter mismatch [8].

4.2. Postoperative outcomes

We observed one case (2.2%) of retrograde type A dissection requiring reoperation. Surgical exploration of the ascending aorta showed no coronary ostial damage but revealed aortic valve leaflet tear. The valve was repaired using pericardial patch, and the ascending aorta was wrapped with a prosthetic graft. According to Eggebrecht et al., retrograde type A dissection after TEVAR occurs in 1.3% of cases and is more common in patients with type B dissection, younger age, Marfan syndrome, or stent-induced new entry (SINE). Emergency surgery remains the only life-saving option, while delayed diagnosis may lead to mortality rates of 42-50% [9].

No cases of spinal cord ischemia were recorded. All 9 patients undergoing zone II intervention with subclavian revascularization had left subclavian artery preserved to minimize spinal ischemia risk. High-risk factors included coverage length > 200 mm, young age, dominant vertebrobasilar circulation, and presence of dialysis fistula in the left arm. Prophylactic cerebrospinal fluid drainage was

performed before or after surgery in selected cases and proved effective. Preservation of collateral networks, especially the left subclavian artery and the artery of Adamkiewicz, is crucial. The Society for Vascular Surgery strongly recommends left subclavian revascularization (Class I), albeit with Level C evidence [5].

We reported a stroke rate of 8.9% (4 patients), which is higher than the global average of 4.1% [10]. Dillavou et al. noted similar neurological complication rates (4%) in both hybrid and conventional surgery groups [11].

There were no intraoperative deaths. Compared to Ferrero et al. [12], who reported 11.1% mortality (3/27 patients) during arch debranching and TEVAR, our result is favorable. However, three early postoperative deaths (6.7%) occurred in our study:

Case 1: A male with diabetes, ischemic cardiomyopathy, chronic kidney disease, and prior stroke underwent total arch debranching and TEVAR. The patient developed ventricular fibrillation during the procedure, was resuscitated successfully, but later died from sepsis on day 5.

Case 2: A 69-year-old male with heart failure, chronic kidney disease, triple-vessel coronary disease (previous PCI), and gastrointestinal bleeding history. After TEVAR and iliac stenting, he developed septic shock, GI bleeding, and multiple cerebral infarctions, dying on postoperative day 10.

Case 3: A 60-year-old male with significant cardiovascular disease, untreated syphilis, and renal insufficiency. He developed intraoperative ventricular arrhythmia with cardiac arrest, recovered, but subsequently experienced seizures, multiple cerebral infarctions, renal failure, pneumonia, and died on postoperative day 20.

Our postoperative clinical success rate was 88.9%, which is comparable to that reported by Conway et al. (90.4%) [6].

4.3. Follow-up outcomes

The average follow-up duration was 29.4 ± 21.6 months (maximum: 73 months). The midterm mortality rate was 4.76%, and the clinical success rate at the average follow-up point was 86.7%, higher than that of Conway et al. (81.4%) [6].

Joo et al. studied 125 patients with descending aortic disease involving the distal arch. Open surgery had a higher short-term mortality (OR = 4.396; p = 0.086) and significantly more pulmonary complications than hybrid repair (OR = 4.372; p = 0.025). However, midterm outcomes were comparable between groups. After 10 years, the hybrid group had a significantly lower reintervention rate (46.3% vs. 85.2%, p < 0.01) [13].

Similarly, Lee et al. reported 36-month mortality related to aortic disease in TEVAR and open surgery groups at 11.5% and 13.9%, respectively (p = 0.45). The reintervention rate in the TEVAR group was significantly lower (65.3% vs. 100%; p = 0.03) [14].

In our study, cumulative survival at 24 months reached 93%, which is higher than that reported by Rango et al. in a cohort of 104 patients undergoing arch debranching combined with TEVAR (12- and 24-month survival: 89% and 86.5%, respectively) [8]. These findings suggest our midterm results are comparable or even more favorable than previous international studies.

However, this study has several limitations. First, it was a single-center retrospective analysis with a relatively small sample size, which may limit the generalizability of the findings. Second, long-term outcomes beyond 3 years were not available for all patients, and further multicenter prospective studies are needed to validate these results.

V. CONCLUSION

Aortic arch debranching combined with TEVAR is an effective and minimally invasive treatment for complex thoracic aortic diseases. This technique improves survival outcomes and reduces major complications, especially in patients without adequate proximal landing zones for conventional stentgraft deployment.

Conflict of Interest

The authors declare no conflict of interest related to the study, authorship, or publication of this article.

REFERENCES

1. Bergeron P, Mangialardi N, Costa P, Coulon P, Douillez V, Serreo E, et al. Great vessel management for endovascular exclusion of aortic arch aneurysms and dissections. Eur J Vasc Endovasc Surg. 2006; 32(1): 38-45.
2. Fillinger MF, Greenberg RK, McKinsey JF, Chaikof EL, Society for Vascular Surgery Ad Hoc Committee on TRS.

Reporting standards for thoracic endovascular aortic repair (TEVAR). J Vasc Surg. 2010; 52(4): 1022-33, 1033 e15.
3. Czerny M, Schmidli J, Carrel T, Grimm M. Hybrid aortic arch repair. Ann Cardiothorac Surg. 2013; 2(3): 372-7.
4. Gelpi G, Romagnoni C, Epifani F, Contino M, Antona C. Hybrid Surgery to Manage Aortic Arch Pathology. Medicina (Kaunas). 2021; 57(9).
5. Olin JW, Allie DE, Belkin M, Bonow RO, Casey DE, Jr., Creager MA, et al. A report of the American College of Cardiology Foundation/American Heart Association Task Force on Performance Measures, the American College of Radiology, the Society for Cardiac Angiography and Interventions, the Society for Interventional Radiology, the Society for Vascular Medicine, the Society for Vascular Nursing, and the Society for Vascular Surgery J Vasc Surg. 2010; 52(6): 1616-52.
6. Conway AM, Qato K, Mondry LR, Stoffels GJ, Giangola G, Carroccio A. Outcomes of thoracic endovascular aortic repair for chronic aortic dissections. J Vasc Surg. 2018; 67(5): 1345-1352.
7. Koullias GJ, Wheatley GH, 3rd. State-of-the-art of hybrid procedures for the aortic arch: a meta-analysis. Ann Thorac Surg. 2010; 90(2): 689-97.
8. De Rango P, Cao P, Ferrer C, Simonte G, Coscarella C, Cieri E, et al. Aortic arch debranching and thoracic endovascular repair. J Vasc Surg. 2014; 59(1): 107-14.
9. Eggebrecht H, Thompson M, Rousseau H, Czerny M, Lonn L, Mehta RH, et al. Retrograde ascending aortic dissection during or after thoracic aortic stent graft placement: insight from the European registry on endovascular aortic repair complications. Circulation. 2009; 120(11 Suppl): S276-81.
10. Kotani S, Inoue Y, Oki N, Yashiro H, Hachiya T. Actual incidence of cerebral infarction after thoracic endovascular aortic repair: a magnetic resonance imaging study. Interact Cardiovasc Thorac Surg. 2022; 34(2): 267-273.
11. Dillavou ED, Makaroun MS. Predictors of morbidity and mortality with endovascular and open thoracic aneurysm repair. J Vasc Surg. 2008; 48(5): 1114-9; discussion 1119-20.
12. Ferrero E, Ferri M, Viazzo A, Robaldo A, Zingarelli E, Sansone F, et al. Is total debranching a safe procedure for extensive aortic-arch disease? A single experience of 27 cases. Eur J Cardiothorac Surg. 2012; 41(1): 177-82.
13. Joo HC, Youn YN, Ko YG, Choi D, Won JY, Lee DY, et al. Comparison of open surgical versus hybrid endovascular repair for descending thoracic aortic aneurysms with distal arch involvement. J Thorac Dis. 2018; 10(6): 3548-3557.
14. Lee HC, Joo HC, Lee SH, Lee S, Chang BC, Yoo KJ, et al. Endovascular Repair versus Open Repair for Isolated Descending Thoracic Aortic Aneurysm. Yonsei Med J. 2015; 56(4): 904-12.