Outcomes of Endovascular Intervention for Infrarenal Abdominal Aortic Aneurysm with Hostile Necks

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ABSTRACT

Overview: Endovascular intervention for abdominal aortic aneurysm is currently the standard treatment method. The morphology of the aneurysm neck affects 60% of the technical success rate of procedure. Various advanced techniques to treat hostile necks have become popular; however, endovascular intervention for AAAs with hostile necks remains challenging.

Objectives: This study aims to describe the characteristics of patients with infrarenal abdominal aortic with hostile necks and evaluate the perioperative and mid-term outcomes of endovascular intervention for these cases.

Methods: Patients diagnosed with infrarenal abdominal aortic aneurysm at the Vascular Surgery Department of Cho Ray Hospital and treated with endovascular intervention from January 2020 to August 2023 were included.

Results: The technical success rate was 95.12%. The early mortality rate was 2.44%, with no aneurysm-related deaths. The early endoleak rate was 4.88%, while the late type I endoleak rate was 7.5%. The mid-term mortality rate was 9.76%, with significantly higher rates in patients with aneurysm neck lengths ≤ 15mm. There was no significant difference in late type I endoleak rates between short necks and angulated necks.

Conclusion: Endovascular intervention to treat infrarenal abdominal aortic aneurysms with hostile necks is a safe and effective treatment method.

Keywords: *endovascular intervention, abdominal aortic aneurysm, hostile neck.*

OVERVIEW

Abdominal aortic aneurysm (AAA) is characterized by the localized dilatation of a segment of the abdominal aorta, with a diameter greater than 1.5 times the normal segment. This condition is common in older people with cardiovascular risk factors, such as: Smoking, atherosclerosis, hypertension, diabetes, and dyslipidemia. The prevalence of AAA is about 5% among the population over 60 years old in the United State, 4-8% of men, and 1-3% of women over 60 years old in Europe. In Vietnam, a study by Van Tan reported a prevalence of 0.85% among individuals over 50 in Ho Chi Minh City. (1).

The aneurysm sac tends to enlarge over time, risking rupture and high mortality if not promptly diagnosed and treated. Management includes medical treatment with control of

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cardiovascular risk factors for small asymptomatic aneurysms, and surgery or endovascular intervention for large symptomatic aneurysms, or complications. Despite advances in diagnosis, treatment, anesthesia and resuscitation, mortality and complications post-AAA surgery remain challenges, particularly in high-risk surgical patients due to advanced age and comorbidities.

Currently, endovascular intervention is considered the standard treatment method. However, the unfavorable anatomical morphology of the aneurysm has limited its applicability method and is considered an "Achilles heel". Manufacturers rely on preclinical studies to guide their products, with up to 19.3 - 37% of patients with AAA not treated with endovascular intervention, mainly due to hostile necks. Literature suggests that aneurysm neck morphology can influence 60% of intervention success or failure. Advanced intervention techniques such as the chimney technique, fenestration, and endo-anchor have improved outcomes, but treating AAA with hostile necks remains challenging.

In Vietnam, endovascular interventions for AAA have been performed at several hospitals such as: Viet Duc, Bach Mai, Hue Central, Ho Chi Minh City University of Medicine and Pharmacy, Binh Dan. In Vietnam, studies evaluating these intervention's outcomes in hostile necks are scarce. At Cho Ray Hospital, we have performed endovascular intervention for AAA since May 2012, treating many hostile neck cases with positive initial results.

This study aims to describe the clinical characteristics of patients with infrarenal AAA with hostile necks and evaluate the perioperative and mid-term results of endovascular intervention for these cases.

METHODS

This is a retrospective description of case series. Patients diagnosed with infrarenal AAA at the Department of Vascular Surgery - Cho Ray Hospital, and treated with endovascular intervention, from January 2020 to August 2023, and met the including criteria. The study was conducted at the Department of Vascular Surgery at Cho Ray Hospital with the consent of the department and hospital.

Inclusion criteria:

- Patients diagnosed with infrarenal AAA meeting interventional indications.

- Patients were treated with endovascular intervention.

- Patients whose aneurysm anatomy is measured in accordance with hostile neck criteria (one of the following criteria: Neck length ≤ 15mm, neck diameter ≥ 28mm, neck angulation > 60 degrees, calcification, thrombosis ≥ 50%, conical neck, reversed conical neck, barrel neck, double-barrel neck).

- Have complete medical information for the research.

Exclusion criteria:

- Pseudoaneurysm.

- Mycotic aneurysm.

- Patients were treated by open surgery, or hybrid technique.

- Patients with a history of previous AAA surgery or endovascular intervention.

We evaluated the perioperative outcomes, including technical success, early mortality, early type I endoleak, and early re-intervention rates. Mid-term results included overall mortality, aneurysm-related mortality, late type I endoleak, late re-intervention rates.

Table 1. Risk factors, co-morbidities (N = 41)

	N	Rates (%)
Risk factors		
Smoking	21	51.2
Diabetes	9	21.9
Hypertension	30	73.2
Dyslipidemia	19	46.3
Chronic kidney disease	11	26.8
Co-morbidities		
Coronary artery disease	17	41.4
Cerebrovascular disease	4	9.7
Chronic obstructive pulmonary disease	6	14.6

Table 2. Abominal aortic aneurysm anatomy (N = 41)

Neck morphology	**Number of patients (n)**	**Rates (%)**
Short neck	11	26,82
Angulated neck	36	87,8
Conical neck	6	14,6
Reversed conical neck	5	12,2
Barrel neck	1	2,4
Short and angulated neck	10	24,4
Neck diameter ≥ 28mm	3	7,32
Common iliac artery morphology	**Right (mm)**	**Left (mm)**
Maximal length	90	99
Minimal length	12	19
Medium length	52,2 ± 17,7	53,8 ± 16,5
Maximal diameter	56	62
Minimal diameter	19	10
Medium diameter	17,93 ±8,4	18,6 ±10,1
Common femoral artery diameter	**Right (mm)**	**Left (mm)**
Maximal diameter	16	17
Minimal diameter	7	7,2
Medium diameter	8,6 ± 1,4	8,7 ± 1,5

Table 3. Early complications (N = 41)

Complications	Number of patients (n)	Rates (%)
Myocardiac infarction	0	0
Pneumonia	0	0
Acute kidney injury	3	17,07
Renal artery occlusion	0	0
Multi-organ failure	1	2,43
Access site bleeding	1	2,43
Acute limb ischemia	0	0
Stent graft migration	0	0
Death	1	2,43

Table 4. Compare early results according aneurysm anatomical factors

Early results	Neck length <15mm (%)	Neck length >15mm (%)	p
Technical success	100	92,9	p > 0.05*
Death	7,7	0	
Type I endoleak	0	3,6	
Early re-intervention	0	7,1	
Early results	**Neck angle < 75 degrees**	**Neck angle < 75 degrees**	**p**
Technical success	100	90	p > 0.05*
Death	4,8	0	
Type I endoleak	0	5	
Early re-intervention	0	10,5	

Table 6. Compare aneurysm neck morphology

Neck morphology	Torsello(2)	Setacci(3)	Matsagkas(4)	NV.Quang(5)	Our results
Neck length (mm)	13,1	10,56	6,1	27,7	26,4
Neck angle (degree)	60,3	37,67	26,6	65,1	72,8
Neck diameter (mm)	25	24,19	10	21,3	20,5
Conical neck	-	20,83%	-	-	14,6%
Reversed conical neck	-	10,8%	-	-	12,2%
Barrel neck	-	9,72%	-	-	2,4%
Double barrel neck	-	6,94%	-	-	0%
Thrombosis > 30%	-	20,83%	16%	-	0%
Calcification > 30%	-	19,44%-	11%	-	0%

Table 7. Compare technical success and early complications.

	Stather(6)	Torsello(2)	Batenburg(7)	Our results
Technical success (%)	98	96,4	93,3	95,12
Type IA endoleak (%)	9,5	-	8,7	2,44
Type IB endoleak (%)	-	-	0,7	0
Type II endoleak (%)	10,6	-	8,7	17,07
Type III endoleak (%)	1,5	0	0	2,44
Type IV endoleak (%)	0	0	0	0
Ruptured (%)	3,5	0	0	0
Re-intervention (%)	14,6	0	3,3	4,88

RESULTS

Baseline characteristics and risk factors:

A total of 41 patients met the inclusion criteria. The average age is 73.9 ± 6.9 years old, with the youngest being 51 and the oldest being 89. The male-to-female ratio was 3.5/1. Most patients (70.7%) presented with abdominal pain, with two cases diagnosed as ruptured AAA. Baseline characteristics, risk factors, and aneurysm anatomical characteristics are described in Tables 1 and 2.

Endovascular intervention technique:

The average intervention time was 183.9 ± 98.75 minutes (range: 70-435 minutes). The average blood loss was 130.5 ± 75.72 ml (range: 50-500ml). The average contrast volume used was 100.5 ± 45.1 ml (range: 70-250ml). The average hospital stay post-intervention was 4.8 ± 1.8 days (range: 2-9 days).

Bifucation stent-graft placement accounted for 95.12% of cases. Aorto-Uni-Iliac placement with femoral-femoral bypass, and straight endo-graft placement had similar rates of 2.43%. Additional internal iliac artery occlusion was used in 12 cases due to common iliac artery aneurysm.

For short neck cases, the chimney technique into the renal artery was performed in 12.19% of cases. There were two cases of stenting both renal arteries (4.87% of total cases). Three cases involved stenting the left renal artery (7.32% of total cases).

Early results:

Early results were defined as the period from immediately post-intervention to 30 days later. Technical success was achieved in 95.12% of cases, defined as correct stent-graft positioning without blocking the renal artery and no type I or III endoleak. There was one case of type IA endoleak (neck angulation 85 degrees) and one case of type III endoleak. Seven cases of type II endoleak occurred immediately post-intervention, one from the inferior mesenteric artery, and six from the lumbar vertebral artery. Other complications are shown in Table 3.

There were three cases of acute kidney injury (17.07%), including two patients with renal

artery chimney technique and one with previous stage 3 chronic kidney disease. One patient received hemodialysis and two received medical treatment, with only one patient recovering renal function before discharge. There was one early death due to multi-organ failure post-intervention. This patient underwent bifucation stent-graft placement and bilateral renal artery chimney technique. During intervention, the patient was stable, the blood loss was 400ml, the amount of urine was 700ml, the total amount of contrast used was 250ml, the interventional time was 420 minutes. Angiography after intervention found no endoleak. During the postoperative period, the patient had more severe acute kidney injury, progressive multi-organ failure and death during hospitalization (one day post-intervention).

Regarding to the neck's anatomical factor, there was no statistically significant difference in technical success between groups with neck length ≤ 15 mm and > 15 mm, or neck angulation (Table 4).

Mid-term results:

The average follow-up time was 18.51 ± 8.34 months (range: 4-40 months). Survival rate was analyzed using the Kaplan – Meier method (Figure 1).

The mortality rate in the group with neck length ≤ 15mm was statistically difference than the group with aneurysm neck length > 15mm, (30.8% and 0%, respectively). The type I endoleak rate was higher in the short neck group, though not statistically significant. There were many patients who refuse re-intervention for many different reasons. Therefore, we used the theoretical re-intervention variable. The theoretical re-intervention rates in the groups with neck length ≤ 15mm and > 15mm were 8.3% and 10.7%, respectively, with no significant difference. The theoretical re-intervention rates in the neck angulation < 75 and ≥ 75 degrees were 13.6% and 5.6%, respectively. Mortality rates in the neck angulation < 75 degrees and ≥ 75 degrees were 14.3% and 5%, respectively. Type I endoleak rates in the neck angulation ≥ 75 degrees and < 75 degrees were 15% and 0%, respectively. These rates are generally not significantly different between the groups (Table 5).

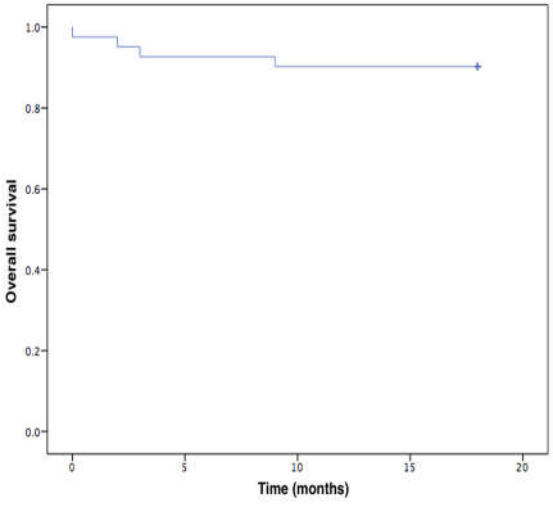

Figure 1. Mid-term survival rate

DISCUSSION

Aneurysm neck anatomical characteristics and intervention methods:

The morphology of the aneurysm's neck is crucial for endovascular intervention, as it serves as the landing zone for the stent-graft. Hostile necks are responsible for more than 60% of AAA patients not receiving endovascular intervention (2). The neck's length, angulation, shape and diameter are critical characteristics when planning for endovascular intervention (3). Previously, AAAs that did not meet the manufacturer's criteria were often considered contraindicated for endovascular intervention. However, due to the superior benefits of endovascular intervention compared to traditional open surgery, it is increasingly being applied to hostile neck cases. Criteria for hostile aneurysm necks include neck length ≤ 15mm, neck angulation > 60 degrees, neck diameter ≥ 28mm, conical neck, reverted conical neck, barrel neck, and double barrel neck (4-6).

Comparing the differences between authors, we find that the results are quite similar with domestic author N.V. Quang but difference from those of foreign authors. Our recorded average neck length is 26.4 mm. According to Torsello (2), a report in Germany recorded an average neck length of 13.1 mm; Setacci (3) in Italy recorded 10.56 mm and Matsagkas and colleagues in Greece reported 6.1 mm. The reason for the difference in the average neck length is that our center has only applied the renal artery chimney technique, not performing fenestration or branch endo-graft. Therefore, our selection of patients with short neck length was very cautious.

The average neck angulation in our study is 72.8 degrees, similar to Torsello (2) in Germany (60.3 degrees) and N.V. Quang (5) (65.1 degrees); Howerver, it differs from Setacci(3) in Italy (37.67 degrees) and Matsagkas(4) in Greece (26.6 degrees). Our patients often present with symptoms of abdominal pain, and the aneurysm size is typically large, causing more dilation and tortuosity of the aorta.

Currently, our center does not perform advanced techniques, such as fenestration or branch endo-graft or endo-anchor techniques. Given cost and equipment limitations, we used the renal artery chimney technique for very short neck cases. The chimney technique was approved in the European Society of Vascular Surgery Treatment Guidelines in 2019 for the treatment of short neck AAA. This technique will simultaneously deploys the aortic stent-graft and the cover-stent into the target artery. The advantage of this technique is that the instruments are readily available and the cost is lower than fenestration or branch endograft or endo-anchor techniques. According to K.J.Bruen (6), the chimney technique reduces blood loss, shortens hospital stays and lower postoperative risks compared to open surgery. Our patients often present with symptoms of abdominal pain, and the aneurysm size is typically large, causing more dilation and tortuosity of the aorta.

Early results:

Comparing our results (Table 7), we see that endovascular intervention has a very high technical success rate, consistent with other studies worldwide. In Stather's study (6), which compared 353 patients with favorable necks and 199 with hostile necks, the early endoleak rate was not

statistically significant difference between the two groups. A meta-analysis by G.A. Antoniou and colleagues (8) noted that the type I endoleak rate in the hostile necks group was 2%, not significantly different from the favorable necks group. However, these studies did not classify and compare each characteristic of the hostile necks. The EAGLE study by author M.B. Batenburg and colleagues (7), divided the aneurysm neck length into 3 groups: short neck, medium neck and long neck, recording an overall early type IA endoleak rate of 6.7% and each neck group was 3.6%, 12.5% and 7.6%, respectively. Author AbuRahma and colleagues (8) studied 238 patients undergoing AAA endovascular intervention, dividing neck angulation into 3 groups: < 45 degrees, 45-60 degrees, and > 60 degrees. They found a statistically significant difference in early type I endoleak for neck angulation >60 degrees. In our study, the type IA endoleak rate was 2.44%, with no significant difference between neck length groups or neck angulation groups.

Many studies have evaluated the safety of endovascular intervention for AAA compared to open surgery in the early postoperative period. The 30-day mortality rate for endovascular intervention patients is lower than for open surgery patients.. According to a meta-analysis by Antoniou and colleagues (8), the 30-day mortality rate was 2% for the hostile neck group, with no significant difference between favorable and hostile neck groups. Stather and colleagues (6) also compared favorable and hostile necks; recording 30-day mortality rates of 1.1% and 0.5%, respectively; with no significant difference. According to these studies, other early complications such as myocardial infarction, stroke or acute kidney injury was not different between the favorable and hostile neck groups. Our study recorded an early mortality rate of 2.43%, involving a case with a very short neck using the chimney technique into both renal arteries. This patient developed multi-organ failure and died postoperatively. The chimney technique in our study had a 100% technical success rate. Of the five chimney technique cases, one patient with double renal artery stenting developed multi-organ failure and died early; another patient with double renal artery stenting developed acute kidney injury but recovered with medical treatment. J.T. Lee and colleagues (9) studied changes in kidney function after chimney technique on 43 patients, with 31 deploying stents into both renal arteries and 12 into one renal artery. They found that 14 patients (32.6%) developed acute kidney injury, highlighting the importance of monitoring this complication in chimney technique cases.

Mid-term results:

Our study had a mean follow-up period of 18.51 months, with an overall mortality rate of 9.76% and no aneurysm-related deaths. The mortality rate in the group with neck length ≤ 15 mm was higher than the other group, but not significantly different. In 2018, S. Zermes reported an overall mortality rate of 24% and an aneurysm-related mortality rate of 11% after 31 months of follow-up in the unfavorable anatomical group, with no difference for the favorable anatomical group. The EAGLE study (7), recorded a 9.3% mortality rate and a 2.7% aneurysm-related mortality rate after one year, with no difference between short, medium, and long neck groups.

The most concerned issue of hostile necks is the rate of late type I endoleak, especially type IA,

which increases the re-intervention rate. Meta-analysis by G.A. Antoniou (8) showed that the type I endoleak rate after 1 year was 10%, significantly different from the favorable neck group; However, the re-intervention rate did not differ between of favorable and hostile necks groups. Our study recorded a mid-term type I endoleak rate of 7.5%, with type IA at 5% and IB at 2.5%. According to S. Zerwes and colleagues (9), the average time for endoleak or stent-graft migration complications is 29.3 months, with more than 56% occurring after two years, indicading an increasing type I endoleak rate during follow-up. Our theoretical re-intervention rate was 10% for two cases of type IA and type IB endoleak, but the actual rate was 2.5% due to patient refusal for re-intervention.

Regarding to the chimney technique, other authors are concerned about the type I endoleak due to the gap between the aortic stent-graft and branch cover-stent. The aortic stent-graft is not designed for this technique, so careful planning is essential. In our study, we did not observe any mid-term type I endoleak in chimney technique cases. According to the PERICLE study(10), type I endoleak after the chimney technique is rare, with 94.9% and 91.8% free from type I endoleak at six months and one year, respectively. Although our study had a relatively small number of chimney technique cases, the results were positive. Except for one postoperative death due to multi-organ failure, the remaining cases did not report type I endoleak.

Our study had some important limitations. First, this was a retrospective, single-center study, with a relative small sample size; therefore, it may not accurately reflect other populations. Second, and most importantly, our study could not separate each characteristic of hostile necks. Third, the patients did not use the same type of stent-graft. In upcoming studies on this topic, we will have a clear research design and more detailed analysis.

CONCLUSION

Patients with infra-renal AAA with hostile necks are often hospitalized with abdominal pain. The average age is 73.9 ± 6.9 years old, hypertension and smoking being the most common risk factors. Endovascular intervention for infrarenal AAA with hostile necks is an effective method with a technical success rate of 95.12%. The most common perioperative complication is acute kidney injury (17.07%), especially in cases using the renal arterial chimney technique. Mid-term results are relatively positive, with an overall mortality rate of 9.67% and a late type I endoleak rate of 7.5%. Treating AAA with hostile necks using endovascular intervention is a safe method with a high success rate.

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