

Treatment outcomes and factors associated with prognosis of ruptured aneurysmal subarachnoid hemorrhage managed by endovascular coiling at Thanh Hoa Provincial General Hospital

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ABSTRACT

Objective: To evaluate clinical characteristics, neuroimaging features, prognostic scales, and outcomes based on the modified Rankin Scale at discharge, 30 days, 90 days post-onset and factors associated with prognosis .

Subjects and Methods: A prospective descriptive study was conducted on 118 patients with subarachnoid hemorrhage due to ruptured cerebral aneurysms who underwent endovascular coil embolization over a 2-year period, from January 2024 to December 2025 at Thanh Hoa provincial general hospital.

Results: The mean age was 63.8 ± 12.6 years (median age 63 years), females accounted for 59.3%, hypertension was 51.7%, diabetes mellitus was 14.4%, smoking (21.2%), history of stroke(4.2%), headache(100%), nuchal rigidity (78.0%), cranial nerve palsy(25.4%), hemiparesis/hemiplegia(17.8%), seizures (10.2%), and altered consciousness or coma(16.9%). The proportions of Grade II on the PAASH(Prognosis on Admission of Aneurysmal Subarachnoid Hemorrhage), Hunt-Hess, WFNS, and modified Fisher scales were 44.1%, 46.6%, 34.7%, and 38.2%, respectively. The most common location of ruptured aneurysms was the anterior communicating artery (34.7%), saccular aneurysms with a daughter sac accounted for 48.3%, and aneurysm size between 7-10 mm represented the highest proportion at 41.5%. The most frequent complication was pneumonia (17.8%), intervention within 24 hours from onset was 27.1%, and the mean hospital stay was 15.9 ± 7.82 days. Favorable clinical outcomes according to the modified Rankin Scale(mRS 0-2) at discharge, 30 days, and 90 days were 50.8%, 60.2%, and 75.4%, respectively. Mortality at 90 days accounted for 6.8%. Both modified Fisher score ≤ 2 and Hunt-Hess grade ≤ 2 had prognostic value of favorable recovery in this study (OR = 6.59, 95% CI: 2.61-16.68, $p < 0.001$); (OR = 2.99, 95% CI: 1.23-7.29, $p = 0.017$).

Conclusion: Endovascular coiling for ruptured intracranial aneurysms is feasible in a provincial hospital setting. Early intervention within 24 hours from ictus is associated with more favorable clinical outcomes. The modified Fisher and Hunt-Hess scales associated with prognostic value for functional recovery.

Keywords: Subarachnoid hemorrhage, intracranial aneurysm, endovascular coiling, modified Rankin Scale, prognostic factors.

I. INTRODUCTION

Aneurysmal subarachnoid hemorrhage (aSAH) is a significant global public health threat. The overall worldwide incidence of aSAH is ≈ 6.1 per 100 000 person-years, with a global prevalence of 8.09 million cases. However, the incidence of aSAH is highly variable by region, with the highest incidence in Japan and Finland at 28 and 16.6 per 100 000 person-years, respectively, and the highest age-standardized prevalence in Japan and Andean Latin America. In addition, there seems to be wide regional heterogeneity among incidence trends over time, with an overall downward trend in the incidence of aSAH between 1955 and 2014 by 1.7% annually worldwide and by 0.7% annually in North America. In contrast, between 2007 and 2017, the incidence in the United States increased to 11.4 per 100 000 person-years¹.

aSAH is a severely morbid and often deadly condition. Prehospital mortality rates from aSAH have been reported to be 22% to 26%. Although hospital inpatient mortality rates from aSAH have shown no improvement (13.7% in 2006 to 13.1% in 2018 [United States] and 19%-20% in 2021 [global]), population-based studies report a decline in overall case-fatality rates (-1.5%/y between 1980 and 2020) with substantial between-country variation¹.

While surgical clipping was historically the standard of care, endovascular coil embolization has become an established first-line modality due to its minimally invasive approach, lower perioperative complication rates, shorter length of hospital stay, and superior functional outcomes. Current clinical guidelines from the American Heart Association/American Stroke Association (AHA/ASA) strongly recommend endovascular intervention for anatomically amenable aneurysms and emphasize the necessity of ultra-early aneurysm securement—ideally within the first 24 hours of ictus—to eliminate rebleeding risk¹.

Clinical trials like ISAT and BRAT emphasize that evaluating patients with aSAH requires multidisciplinary expertise—involving specialists skilled in both endovascular and surgical techniques. Therefore, collaborative assessment by both endovascular and surgical experts is essential to properly weigh the risks and benefits of each treatment modality¹.

Before 2020, most patients with aSAH at Thanh Hoa General Hospital were transferred to high-level specialized hospitals, resulting in treatment delays and higher financial burdens for patients. To reduce the burden on patients, our hospital—a tertiary care facility serving a population of over 4 million—has been implementing endovascular coiling for acute aSAH.

However, real-world data detailing clinical profiles, logistical timelines, complication rates, and functional outcomes at the provincial hospital level remain limited. Specifically, this study aims to: evaluate the clinical characteristics, neuroimaging features, and treatment outcomes of endovascular coiling; determine the safety profile and complication rates; and identify prognostic associated factors with clinical recovery in this patient population.

II. SUBJECTS AND METHODS

2.1. Study population

A total of 118 patients diagnosed with aneurysmal subarachnoid hemorrhage (aSAH) due to ruptured cerebral aneurysms who underwent endovascular coil embolization were consecutively enrolled.

• **Inclusion criteria:**

1. Confirmed diagnosis of subarachnoid hemorrhage by computed tomography (CT) or magnetic resonance imaging (MRI).
2. Ruptured intracranial aneurysm confirmed by digital subtraction angiography (DSA) or CT angiography (CTA).
3. Patients treated with endovascular coil embolization.
4. Complete medical records and available follow-up data.

• **Exclusion criteria:**

1. Non-aneurysmal subarachnoid hemorrhage (e.g., perimesencephalic hemorrhage, vascular malformations, trauma).
2. Aneurysms treated primarily by surgical clipping or managed conservatively.
3. Severe concomitant systemic illnesses with a life expectancy of less than 90 days.

2.2. Data Collection and Variables

Data were collected and recorded using a standardized pro forma, including:

• **Clinical characteristics:** Age, gender, comorbidities (hypertension, diabetes mellitus, smoking, prior stroke), presenting symptoms (headache, nuchal rigidity, cranial nerve palsy, hemiparesis/hemiplegia, seizures, and altered consciousness or coma...).

• **Preintervention grading scales:** Hunt-Hess scale, World Federation of Neurosurgical Societies (WFNS) scale, modified Fisher scale, PAASH (Prognosis on Admission of Aneurysmal Subarachnoid Hemorrhage) scale.

• **Aneurysm and procedural characteristics:** Aneurysm location (e.g., anterior communicating artery), morphology (saccular with daughter sac), size, time from symptom onset to endovascular intervention, and procedural complications (such as pneumonia).

• **Clinical outcomes:** Functional outcomes were evaluated using the modified Rankin Scale (mRS) at discharge, 30 days, and 90 days post-ictus. A favorable outcome was defined as an mRS score of 0-2, while an unfavorable outcome or death was defined as an mRS score of 3-6. All-cause mortality at 90 days was also recorded.

2.3. Statistical Analysis

Data were analyzed using appropriate statistical software. Continuous variables were expressed as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), depending on data distribution. Categorical variables were presented as frequencies and percentages. Univariate and multivariate analyses were performed to identify prognostic factors associated with clinical outcomes (mRS 0-2 vs. 3-6), with statistical significance set at $p < 0.05$.

2.4 Ethical Considerations

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The study protocol and data collection procedures were approved by the Institutional Ethics Review Board of Thanh Hoa Provincial General Hospital. Given the observational nature of the study, written informed consent was obtained from all participating patients or their legally authorized representatives prior to enrollment. All patient data were anonymized and handled with strict confidentiality to protect patient privacy.

III. RESULTS

3.1. Baseline Clinical and Demographic Characteristics

Table 1. Characteristics of the patients at baseline (N = 118)

Characteristics	n(%)	Characteristics	n(%)
Mean age(yr)	63.8 ± 12.6	Thunderclap headache	105(89.0%)
Median age(yr)	63	Warning headache	31(26.3%)
Male sex	48(40.7%)	Nausea/vomiting	78(66.1%)
Female sex	70(59.3%)	Nuchal rigidity	92(78.0%)
Hypertension	61(51.7%)	Cranial nerve palsy	30(25.4%)
Diabetes mellitus	17(14.4%)	Disarthria	6(5.1%)
Dyslipidemia	61(51.7%)	Aphasia	9(7.6%)
History of stroke	5(4.2%)	Hemiplegia	21(17.8%)
Current smoker	25(21.2%)	Seizures	12(10.2%)
Sudden onset	115(97.5%)	Transient unconsciousness	45(38.1%)
Headache	118(100%)	Impaired consciousness/coma	20(16.9%)

The mean age of 63.8 ± 12.6 years (median: 63 years) and a female majority (59.3%). Hypertension and dyslipidemia were the most prevalent comorbidities (51.7% each). All patients presented with acute headache (100%), with 89.0% describing a classic thunderclap headache. Nuchal rigidity was documented in 78.0% of cases, while altered mental status or coma was present in 16.9% at presentation.

3.2. Time from symptom onset to hospital admission and coiling intervention

Table 2. Interval from symptom onset to hospital admission and endovascular coiling

Time window	Hospital admission (n, %)	Endovascular intervention (n, %)
Within 24h	46(39.0%)	32(27.1%)
> 24h - 48h	61(51.7%)	60(50.8%)
> 48h	11(9.3%)	26(22.0%)
Total	118(100%)	118(100%)

A total of 46 patients(39.0%) presented within 24 hours of symptom onset, of which 32 patients (27.1%) underwent early intervention within 24 hours of onset.

3.3. Severity grading by scales

Table 3. Severity scores on admission (N = 118)

Scales	PAASH	Hunt - Hess	WFNS	Modified Fisher
Grade	n(%)	n(%)	n(%)	n(%)
I	33(28.0%)	31(26.3%)	21(17.8%)	43(36.4%)
II	52(44.1%)	55(46.6%)	41(34.7%)	45(38.2%)
III	28(23.7%)	28(23.7%)	35(29.7%)	19(16.1%)
IV	5(4.2%)	4(3.4%)	19(16.1%)	11(9.3%)
V	0(0.0%)	0(0.0%)	2(1.7%)	
Total	118	118	118	118

Patients predominantly presented with mild-to-moderate severity. Grade II was the most common presentation across all scales: PAASH (44.1%), Hunt-Hess (46.6%), WFNS (34.7%) and modified Fisher (38.2%).

3.4. Characteristics of ruptured cerebral aneurysms

Table 4. Anatomical and morphological characteristics of ruptured intracranial aneurysms

Locations		No. of pts(n)	Rate (%)
Anterior circulation	Anterior cerebral artery (ACA)	16	13.6
	Anterior communicating artery (AcoA)	41	34.7
	Middle cerebral artery (MCA)	21	17.8
	Posterior communicating artery (PCoA)	8	6.8
	Internal carotid artery (ICA)	21	17.8
Posterior circulation	Basilar artery (BA)	6	5.1
	Posterior cerebral artery (PCA)	4	3.4
	Vertebral artery (VA)	1	0.85
Morphology			
Saccular aneurysms		118	100.0
Saccular aneurysms with a daughter sac		57	48.3
Wide-necked aneurysms		10	8.5
Multiple aneurysms		24	20.3
Size			
< 7mm		44	37.3
7mm - 10mm		49	41.5
> 10mm		25	21.2
Total		N=118	100.0

Ruptured aneurysms were located within the anterior communicating artery (AComA) being the single most frequent site (34.7%). Medium-sized aneurysms (7-10 mm) constituted 41.5% of lesions, and 48.3% exhibited daughter sac configurations.

3.5. In-Hospital stay and secondary Complications

Table 5. Inpatient complications

Complications	No. of patients(n)	Rate(%)
Cerebral vasospasm	11	9.3
Ischemic stroke	9	7.6
Hydrocephalus on CT scan	14	11.9
Electrolyte disorder	12	10.2
Recurrent aneurysm rupture	3	2.55
Seizures	8	6.8
Clinical intracranial hypertension	11	9.3
Pneumonia	21	17.8
Pressure ulcer	11	9.3
Deep vein thrombosis (DVT)	1	0.9
Urinary tract infection (UTI)	15	12.7
Aneurysm perforation	3	2.5
No documented complications	61	51.7
Length of hospital stay	15.9 ± 7.82 days	

Over half of the cohort (51.7%) experienced an uneventful hospitalization. The most common systemic complication was hospital-acquired pneumonia (17.8%), followed by urinary tract infections (12.7%). Neurological complications included secondary hydrocephalus (11.9%), cerebral vasospasm (9.3%), and ischemic stroke (7.6%). Procedural aneurysm perforation occurred in 2.5%. The mean length of hospital stay was 15.9 ± 7.8 days.

3.6. Functional outcome and mortality trajectory across follow-up intervals

Table 6. Clinical outcome at time points (N = 118)

Follow-up time point	Favorable Outcome (mRS 0-2)	Unfavorable Outcome (mRS 3-6)	Mortality (mRS 6)
At discharge	60 (50.8%)	58 (49.2%)	4 (3.4%)
At 30 Days	71 (60.2%)	47 (39.8%)	6 (5.1%)
At 90 Days	89 (75.4%)	29 (24.6%)	8 (6.8%)

Functional recovery showed progressive improvement across follow-up intervals. Favorable recovery rates (mRS 0-2) increased from 50.8% at discharge to 60.2% at 30 days and 75.4% at 90 days. All-cause mortality was 3.4% at discharge, 5.1% at 30 days, and 6.8% at 90 days.

3.7. Prognostic factors at 90th day

Table 7. Univariate analysis of the association between characteristics/severity scores and clinical outcomes at 90th day

Characteristics/severity scores		Modified Rankin		OR Confidence Interval	p Fisher exact test
		≤ 2, n (%)	> 2, n (%)		
Genders	Male	37(77.1%)	11(22.9%)	1.16 (0.49 - 2.75)	0.829
	Female	52(74.3%)	18(25.7%)		
Onset to groin window	≤ 24h	29(90.6%)	3(9.4%)	4.19 1.17 - 14.99	0.029
	> 24h	60(69.8%)	26(30.2%)		
Modified Fisher score	≤ 2	75(85.2%)	13(14.8%)	6.59 2.61 - 16.68	< 0.001
	> 2	14(46.7%)	16(53.3%)		
Hunt - Hess score	≤ 2	70(81.4%)	16(18.6%)	2.99 1.23 - 7.29	0.017
	> 2	19(59.4%)	13(40.6%)		
WFNS score	≤ 2	51(82.3%)	11(17.7%)	2.20 0.93-5.19	0.088
	> 2	38(67.9%)	18(32.1%)		
PAASH score	≤ 2	64(75.3%)	21(24.7%)	0.98 0.38 - 2.49	1.000
	> 2	25(75.8%)	8(24.2%)		

Univariate logistic regression identified three related prognostic factors of 90-day good functional recovery:

- Intervention timing: Patients treated within 24 hours achieved higher rates of favorable outcome compared to those treated after 24 hours (90.6% vs. 69.8%; OR = 4.19, 95% CI: 1.17-14.99, p = 0.029).

- Radiographic severity: A modified Fisher score ≤ 2 was associated with favorable outcome

in this study (85.2% vs. 46.7%; OR = 6.59, 95% CI: 2.61-16.68, p < 0.001).

- Clinical severity: A Hunt-Hess grade ≤ 2 upon presentation significantly correlated with favorable recovery in this study (81.4% vs. 59.4%; OR = 2.99, 95% CI: 1.23-7.29, p = 0.017).

Sex, WFNS grade, and PAASH grade did not show statistically significant difference in this cohort (p > 0.05).

IV. DISCUSSION

4.1. Clinical outcomes and mortality rate

In this single-center cohort of 118 patients with aSAH treated via endovascular coiling, functional independence (mRS 0-2) increased progressively over time: 50.8% at discharge, 60.2% at 30 days, and 75.4% at 90 days. The mortality rates at discharge, 30 days, and 90 days post-ictus were 3.4%, 5.1%, and 6.8%, respectively. These mortality figures compare favorably with findings from a multicenter study by Luong et al. (2021) in top-tier central hospitals in Hanoi, which reported corresponding 90-day mortality of 10.1% in endovascular coiling group², as well as broader international registry data citing average in-hospital mortality rates of approximately 20%¹. This favorable difference may be attributed to patient selection criteria, baseline clinical grading, and improvements in provincial endovascular management.

The favorable functional recovery profiles observed in our cohort should be interpreted with caution. First, selection bias inherent to our single-center provincial registry may have influenced these outcomes, as severely compromised patients—such as those with extremely high clinical grades or complex giant aneurysms—were frequently transferred directly to national neurosurgical centers. Consequently, our cohort predominantly comprised patients with low-to-moderate clinical grades (Hunt-Hess grades I-III accounted for 96.6%, PAASH grades I-III for 95.8%, and WFNS grades I-III for 82.2% of presentations). While these results demonstrate the safety and feasibility of endovascular coiling in a provincial setting, this potential referral bias and the absence of a surgical control group represent limitations of our study.

4.2. Impact of early endovascular timing

Intervention within 24 hours of onset was a

strong predictor of 90-day favorable functional recovery (90.6% vs. 69.8%, OR = 4.19, $p = 0.029$). Early aneurysm occlusion eliminates the risk of catastrophic rerupture, which carries a case-fatality rate exceeding 50-70%, and permits early hemodynamic management (e.g., induced hypertension) for cerebral vasospasm^{3,4}.

Despite these clear clinical benefits, only 27.1% of patients in our series received treatment within the 24-hour therapeutic window. This remains lower than rates reported by Bangyue Wang⁵ and Guangbiao Li⁶, where early intervention rates exceeded 50%. This delay was predominantly driven by pre-hospital transport delays: over 60% of patients arrived at our facility more than 24 hours post-onset. Delayed presentation often reflects broad geographic distances and under-recognition of warning headaches by primary care facilities. Improving community awareness of acute thunderclap headaches and optimizing inter-facility transfer protocols are critical next steps for provincial stroke networks.

4.3. Prognostic stratification and inpatient care

Univariate analysis confirmed the modified Fisher score and Hunt-Hess grade as significant determinants of functional recovery at 90 days. A modified Fisher grade > 2 conferred a 6.59-fold increase of unfavorable outcomes ($p < 0.001$), reflecting the well-documented association between thick cisternal blood burden, toxic hemoglobin degradation, delayed vasospasm, and secondary cerebral infarction⁷. Similarly, high clinical severity on presentation (Hunt-Hess > 2) was associated with poor functional outcomes (OR = 2.99, $p = 0.017$). These observations are consistent with multivariable models reported by Luong et al.². However, our study only performed univariate analysis; therefore, this comparison is for reference purposes only. Nevertheless, overall, our findings

do not contradict previously published data.

Limitation: Several limitations of this study should be acknowledged. First, its single-center, prospective observational design and relatively small sample size (118 patients) limit generalizability. Second, potential referral and selection bias occurred as severely ill patients were frequently transferred to central institutes. Finally, the reliance on univariate analysis without a surgical control group precludes definitive causal conclusions, highlighting the need for larger, multicenter, multivariate studies.

V CONCLUSION

Endovascular coiling for ruptured aneurysmal subarachnoid hemorrhage is feasible in a provincial hospital setting. Early intervention within 24 hours post-onset is associated with more favorable clinical outcomes. The modified Fisher and Hunt-Hess scales associated with prognostic value for functional recovery.

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