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IMPACT OF TIME-TO-TREATMENT AND THROMBECTOMY TECHNIQUE ON OUTCOMES IN ACUTE ISCHEMIC STROKE: A SINGLE-CENTER COHORT ANALYSIS

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Abstract

Introduction: Mechanical thrombectomy (MT) is the standard of care for acute ischemic stroke (AIS) secondary to large vessel occlusion (LVO). Time-to-reperfusion is the most critical determinant of patient outcome. This study aimed to conduct a comprehensive analysis of key time metrics and the efficacy of MT at our institution, evaluating their impact on both angiographic and clinical results to identify areas for process optimization.

Methods: We conducted a retrospective analysis of a cohort of 17 consecutive patients treated with MT for LVO stroke. We analyzed demographics, baseline clinical status (mRS), occlusion location, detailed time-to-treatment intervals, procedural techniques, and outcomes. The primary angiographic endpoint was successful reperfusion, defined as an extended Thrombolysis in Cerebral Infarction (eTICI) score of $\geq 2b$. Clinical endpoints included functional outcome at 3 months, measured by the mRS, and the rate of symptomatic intracranial hemorrhage (sICH).

Results: The mean patient age was 60.9 years, with a significant male predominance (70.6%). All patients presented with severe stroke (initial mRS 4-5), indicating a high-acuity cohort. The mean time from symptom onset to final reperfusion was prolonged at 505 minutes (8 hours 25 minutes). Despite this, a high rate of successful reperfusion (eTICI $\geq 2b$) was achieved in 85.7% of patients, with complete reperfusion (eTICI $\geq 2c/3$) in 57.1%. However, this technical success did not fully translate to clinical recovery, as a good functional outcome (mRS 0-2) at 3 months was achieved in only 30.8% of patients. The rate of sICH was 15.4%.

Conclusion: Our center achieves high rates of technical success in reperfusion (85.7% eTICI $\geq 2b$), comparable to international benchmarks. However, prolonged treatment delays are significantly attenuating clinical outcomes, with only 30.8% of patients achieving functional independence. This analysis underscores that procedural excellence alone is insufficient; optimizing system-wide time-to-treatment protocols is the critical next step to improve patient recovery.

Keywords: stroke, ischemic; thrombectomy; endovascular procedures; time-to-treatment; reperfusion; treatment outcome.

Introduction

Acute ischemic stroke caused by a large vessel occlusion (LVO) is a devastating condition associated with high rates of long-term disability and mortality if left untreated. The landscape of stroke care was fundamentally transformed in 2015 with the publication of five pivotal randomized controlled trials, which collectively demonstrated the overwhelming benefit of mechanical thrombectomy (MT) for patients with LVO in the anterior circulation [1].

The principle of "time is brain" is paramount in stroke treatment, as every minute of delay to reperfusion results in the irreversible loss of millions of neurons, underscoring the urgency of intervention [2]. Consequently, international bodies such as the American Heart Association/American Stroke Association (AHA/ASA) and the European Stroke

Organisation (ESO) have established stringent guidelines with target time metrics for every step in the stroke care pathway, including in-hospital benchmarks like door-to-puncture times [3,4].

Continuous quality assessment is essential for any center performing MT. The primary objectives of this study are therefore to: (1) critically analyze our center's performance against these key time-to-treatment benchmarks, (2) evaluate the technical efficacy of our MT procedures based on angiographic outcomes, and (3) determine the impact of these factors on the final clinical outcomes for our patients, with the ultimate goal of identifying specific opportunities for process improvement.

Materials and Methods

Study Design and Population

A retrospective analysis was conducted on a cohort of 17 consecutive patients who underwent MT for AIS at our center. The study period and patient selection criteria were defined to capture a representative sample of our current practice.

All patients included had an LVO confirmed by angiography and were treated according to our institutional protocol.

Data Collection

Data were extracted from our prospectively maintained electronic patient database. The following variables were collected:

- **Baseline Data:** Age, gender, initial modified Rankin Scale (mRS) score, and angiographic location of the primary vessel occlusion.
- **Time Metrics:** Time of symptom onset, hospital arrival (door), and key procedural milestones (puncture, end of procedure). From these, the following intervals were calculated in minutes: Onset-to-Door, Door-to-Puncture, and Onset-to-End.
- **Procedural Data:** First-pass technique employed (e.g., aspiration, stent retriever, combination) and the total number of passes required.
- **Outcome Data:** Angiographic outcome was assessed using the extended Thrombolysis in Cerebral Infarction (eTICI) scale, recorded after the first pass and at the conclusion of the procedure. Clinical outcomes included the mRS score at 3 months post-procedure and the incidence of symptomatic intracranial hemorrhage (sICH) within 24 hours.

Endpoints and Definitions

The primary angiographic endpoint was successful reperfusion, defined as achieving a final eTICI score of $\geq 2b$. Complete reperfusion was defined as eTICI $\geq 2c$.

The primary clinical endpoint was functional independence, defined as a modified Rankin Scale (mRS) score of 0-2 at 90 days. Symptomatic intracranial hemorrhage (sICH) was defined according to the Heidelberg Bleeding Classification.

Statistical Analysis

Data were analyzed using descriptive statistics. Continuous variables are presented as means with standard deviations (SD), while categorical variables are presented as frequencies and percentages.

Results

Baseline Characteristics

The cohort comprised 17 patients with a mean age of 60.9 (± 10.7) years. The majority were male (70.6%). All patients presented with severe strokes, with 94.1% having an initial mRS of 5. The most common occlusion locations were the M1 segment of the middle cerebral artery and tandem occlusions involving the internal carotid artery. Detailed characteristics are presented in Table 1.

Time-to-Treatment Metrics

Significant treatment delays were noted across the cohort (Table 2). The mean time from symptom onset to final reperfusion was 505 minutes (8 hours and 25 minutes), indicating that many patients were treated in the late window. The mean in-hospital door-to-puncture time was 115 minutes (1 hour and 55 minutes). A summary of time metrics is provided in Table 2.

Procedural and Angiographic Outcomes

A combined technique (stent retriever plus aspiration) was the most common first-pass approach (75%). A high rate of technical success was achieved, with successful reperfusion (eTICI $\geq 2b$) in 85.7% of patients. Furthermore, complete reperfusion (eTICI $\geq 2c/3$) was achieved in 57.1% of cases.

Clinical Outcomes

At 3-month follow-up, 30.8% of patients achieved functional independence (mRS 0-2). The rate of sICH was 15.4%, and the all-cause mortality rate at 3 months was 38.5%. A full summary of outcomes is available in Table 3.

Table 1. Patient Demographics and Base line Characteristics.

Characteristic	Value
Number of Patients	17
Mean Age(SD)	60.9(± 10.7)years
Gender Distribution	70.6%Male/29.4%Female
Initial mRs	94.1% mRs5/5.9% mRs4
Most Common Occlusion Location	M1 and Tandem Lesions(ICA+M1)

Table 2. Key Treatment Time Metrics (Mean Values).

Time Interval	Mean Time (minutes)
Onset to Door	235min(3h 55m)
Door to Puncture	115min(1h 55m)
Puncture to End	90min(1h30m)
Total: On set to End	505min(8h25m)

Table 3: Summary of Reperfusion and Clinical Outcomes.

Outcome Measure	Result
Successful Reperfusion(FinaleTICI \geq 2b)	85.7%
Complete Reperfusion(Finale TICI \geq 2c/3)	57.1%
Good Functional Outcome(3-month mRS0-2)	30.8%
sICHRateat24hours	15.4%
Mortality at 3months	38.5%

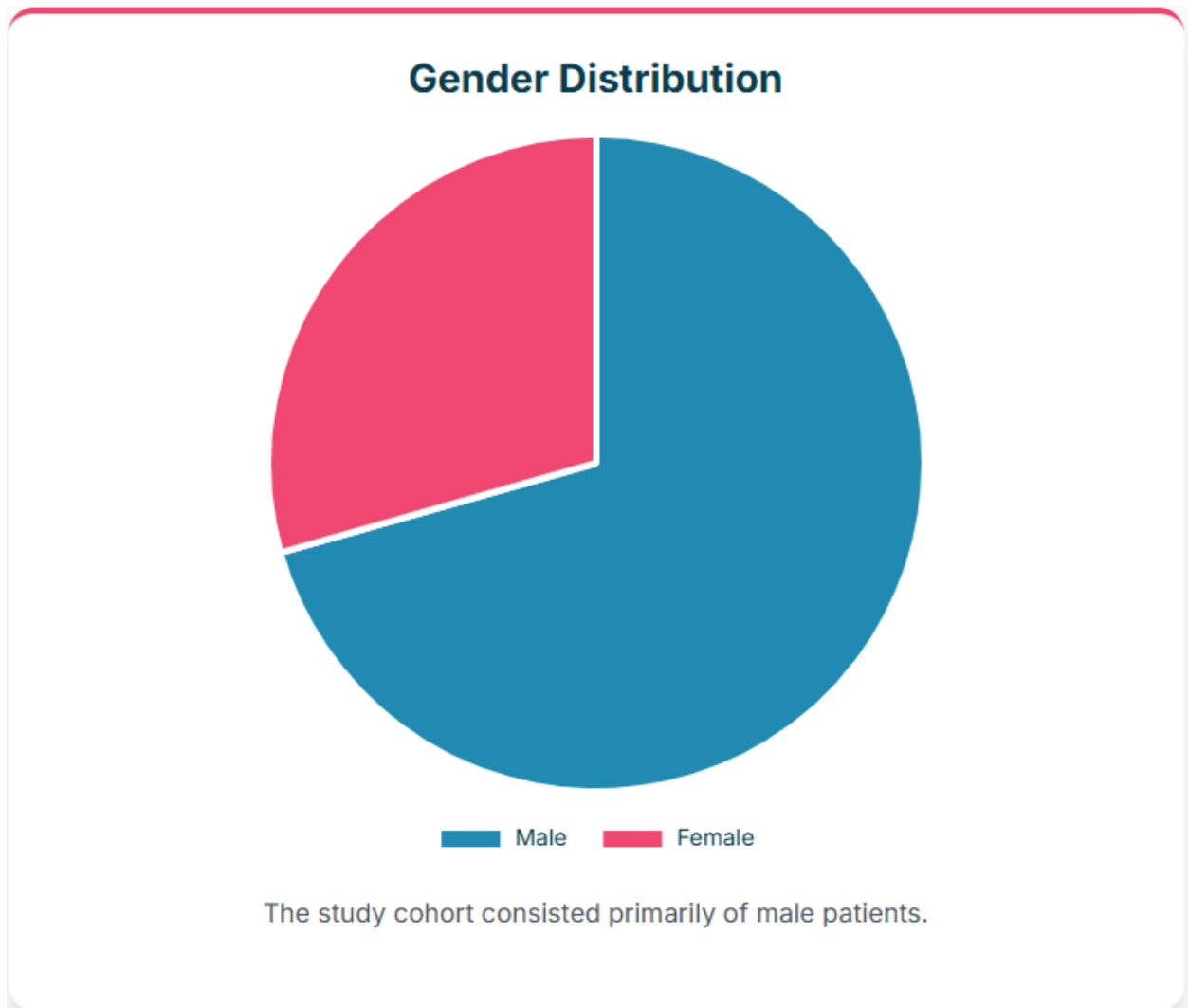


Figure 2: Final reperfusion success rate (eTICI score).

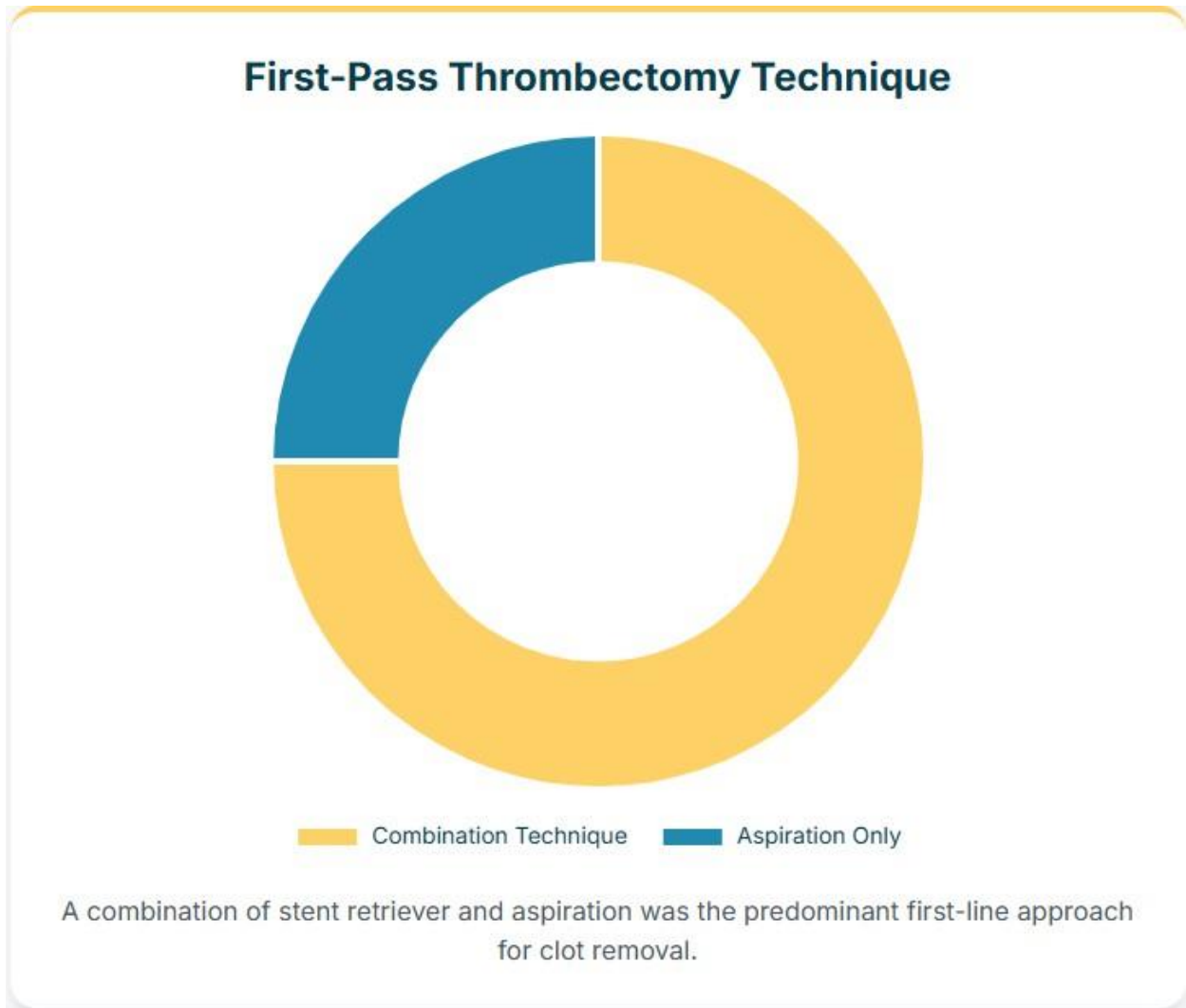
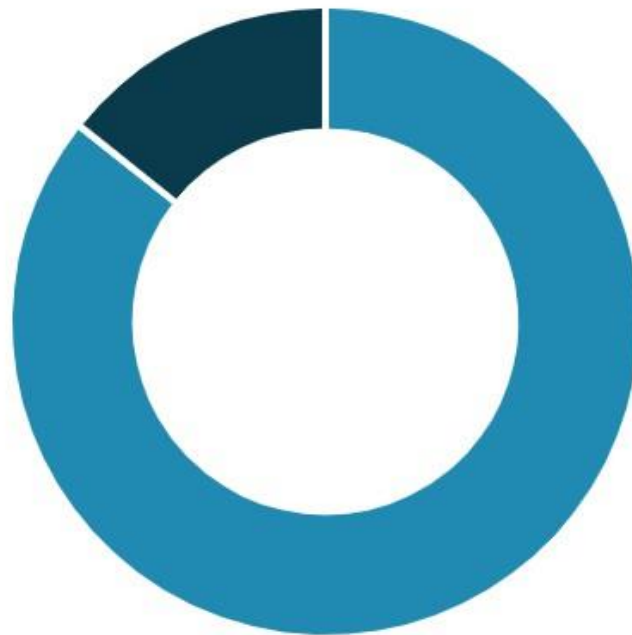


Figure 3: Functional outcome of patients at 3 months (mRS).

Final Reperfusion Success (eTICI)

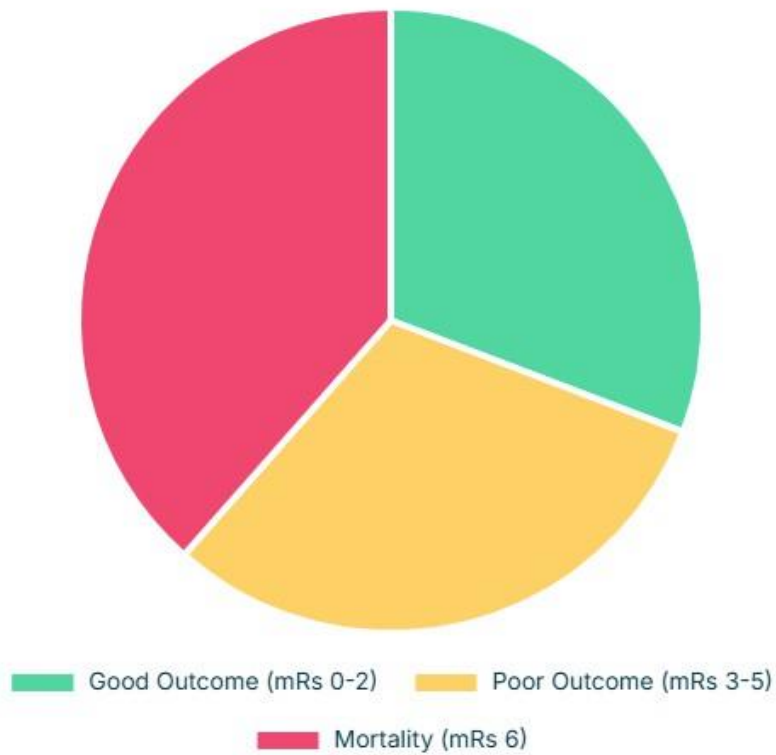


Successful Reperfusion (eTICI \geq 2b)

Unsuccessful Reperfusion

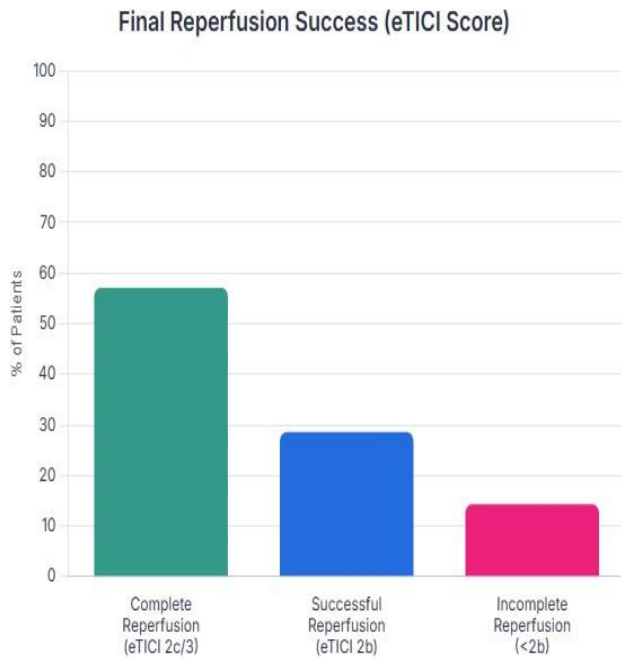
A high rate of technical success was achieved, with the vast majority of patients having their vessel successfully reopened.

Functional Outcome at 3 Months

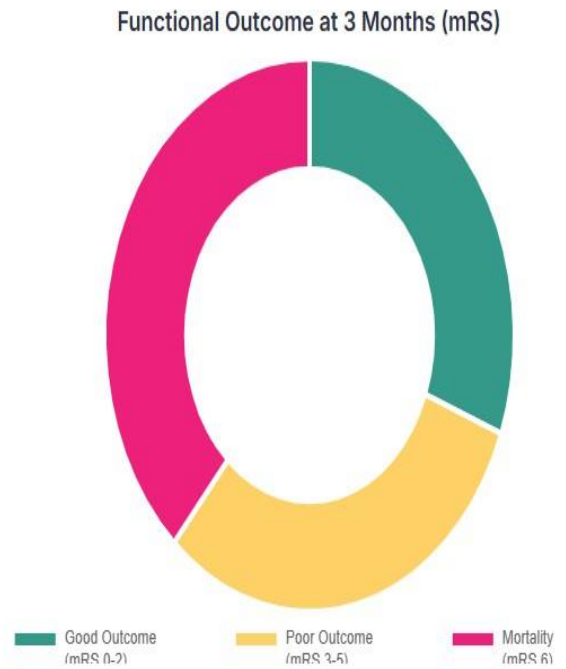


The outcomes show a challenging recovery path, with less than a third of patients achieving functional independence.

Angiographic vs. Clinical Outcomes: A Tale of Two Results



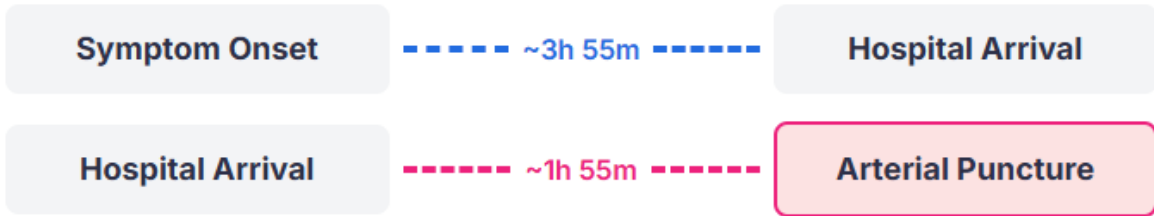
A high percentage of patients achieved successful or complete reopening of the blocked vessel, indicating strong technical performance.



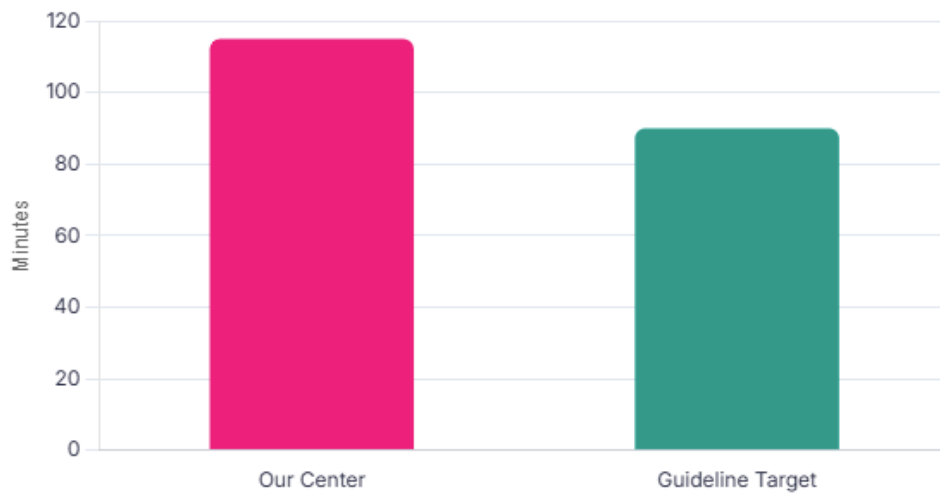
Despite successful reperfusion, the rate of functional independence was low, with high rates of severe disability and mortality.

The Critical Delay: Time-to-Treatment

Analysis of the treatment timeline reveals significant delays, particularly in the in-hospital phase.



Door-to-Puncture Time vs. Guideline Target



Discussion

The results of our study demonstrate a high rate of technical success for mechanical thrombectomy. The rate of successful reperfusion (eTICI $\geq 2b$) of 85.7% is fully consistent with the results from large randomized trials, such as the HERMES meta-analysis, where this rate was approximately 86% [1].

More importantly, the rate of complete reperfusion (eTICI $\geq 2c/3$) of 57.1% is a strong indicator of procedural efficacy, as a growing body of evidence suggests that this measure, and not just eTICI $\geq 2b$, is associated with the best clinical outcomes [5,6].

This suggests that our interventional team is proficient in achieving the primary technical goal of the procedure.

However, a critical divergence emerges when comparing angiographic success to clinical outcome. The rate of good functional outcome (30.8%) is substantially lower than the ~46% benchmark from the HERMES meta-analysis [1].

This gap strongly suggests that while the technical procedure is effective, significant irreversible ischemic injury has already occurred by the time of reperfusion. The prolonged mean onset-to-reperfusion time of over 8 hours is the most likely explanation for this discrepancy.

Our mean door-to-puncture time of 115 minutes, while within some guideline limits, is well above the target of <90 minutes for high-performing centers [3,4] and represents a key area for internal quality improvement. This in-hospital delay could be attributed to several factors, including time for initial imaging, patient transport logistics, or delays in angiography suite activation, all of which warrant a detailed internal process review.

The sICH rate in our cohort was 15.4%. Although this is a serious complication, this figure falls within the upper range reported in various studies and registries, which can vary from 2% to 16% depending on the definition and patient population [7,8].

This may be partially attributable to the long treatment times, as delayed reperfusion is a known risk factor for hemorrhagic transformation [9].

Reperfusion of tissue that has already sustained significant ischemic damage increases the fragility of the blood-brain barrier, elevating the risk of hemorrhage post-procedure.

Limitations: This study is limited by its small sample size and retrospective design. A significant limitation is the lack of data on the Alberta Stroke Program Early CT Score (ASPECTS), which is a crucial tool for patient selection and an independent predictor of functional outcome and hemorrhagic risk after successful reperfusion [10].

A low ASPECTS score at baseline would inherently predispose patients to poorer outcomes, regardless of reperfusion success, and its absence in our analysis is a key confounding factor.

Conclusion

Our center demonstrates high technical proficiency in mechanical thrombectomy.

The primary barrier to improving patient outcomes is not procedural but systemic: prolonged time-to-treatment.

Future efforts must be twofold:

1. Public-facing campaigns to reduce symptom-to-door time, and
2. A rigorous, internal quality improvement initiative focused on reducing door-to-puncture times to under 90 minutes.

Achieving these goals will be essential to translate our technical success into superior functional independence for our patients.

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