Assessment of Safety and Procedural Learning Curve for Pulmonary Embolism Patients Undergoing Percutaneous Mechanical Thrombectomy

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Abstract

This multicenter retrospective study evaluated the learning curve and procedural efficiency of percutaneous mechanical thrombectomy (PMT) for 411 intermediate-risk stratified pulmonary embolism (PE) patients treated by 15 vascular surgeons (Figure 1). The primary efficiency metrics fluoroscopy time, procedure time, and contrast volume demonstrated significant reductions over the course of the study, with proficiency plateaus reached at approximately 3–9 cases per surgeon. The mortality rate was 4.49% and complication rates declined across the study period. These findings support PMT as a safe, rapidly adoptable treatment option and highlight the feasibility of its widespread implementation by vascular surgeons.

Introduction

PE is a major cause of morbidity and mortality, particularly in intermediate-high risk patients. Recent advancements in PMT offer a promising alternative to systemic thrombolysis, with improved safety profiles. However, data on adoption and procedural learning curves remain limited. This study investigated trends in procedural efficiency and safety outcomes of PMT across a large, diverse patient cohort (Table 1).

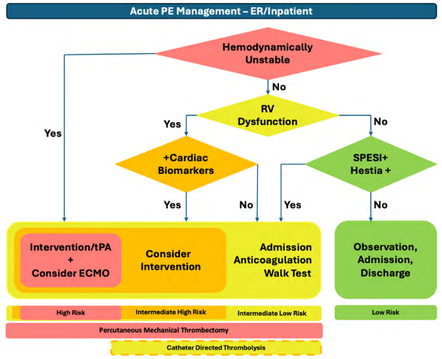

Figure 1: MedStar Health Pulmonary Embolism Treatment Algorithm

Cohort Breakdown	
Total Patients (n)	411
Age at Date of Surgery (Mean ± SD)	60.52 ± 15.42
Female (n, %)	218, 53.1
Male (n, %)	193, 46.9
Race	
African American (n, %)	244, 59.4
White (n, %)	130, 31.7
Other (n, %)	37, 8.9

Table 1: Demographics of patient cohort

Methods

This multicenter retrospective cohort study was conducted from January 2020 to July 2024. The study included 411 intermediate risk stratified PE patients undergoing PMT. The primary metrics analyzed by the study were fluoroscopy time, procedure time, and contrast volume. The secondary metrics were ICU/hospital length of stay, complication rate, mortality, etc. Linear regression analyses assessed the primary metrics for temporal trends while segmented regression and cumulative sum analysis determined efficiency plateaus and assessed procedural efficiency, respectively. T-tests compared the first 50 cases to the last 50 cases to compare secondary metrics meanwhile multivariable regression analysis adjusted for demographics and comorbidities.

Results

A total of 411 intermediate-risk PE patients underwent PMT by 15 vascular surgeons across three MedStar hospitals, with 98.5% of cases utilizing the Inari FlowTriever system. Linear regression demonstrated statistically significant reductions in fluoroscopy time, procedure time, and contrast volume over time (Table 2).

Metric	R^2	p-value
Fluoroscopy Time (minutes)	0.103	<0.001
Contrast Volume (mL)	0.071	<0.001
Procedure Time (minutes)	0.068	<0.001

Table 2: Linear Regression Analysis of Fluoroscopy Time, Contrast Volume, and Procedure Time

Segmented regression identified proficiency plateaus at 55 cases for fluoroscopy time and 138 cases for procedure time. When distributed evenly, individual surgeons achieved imaging proficiency after approximately 3.4 cases and procedural proficiency after 8.6 cases (Figure 2a, 2b).

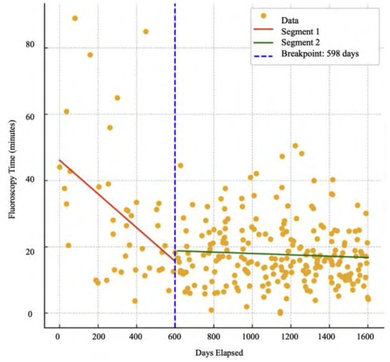

Figure 2a: Segmented Regression Analysis of Fluoroscopy Time (minutes)

Results

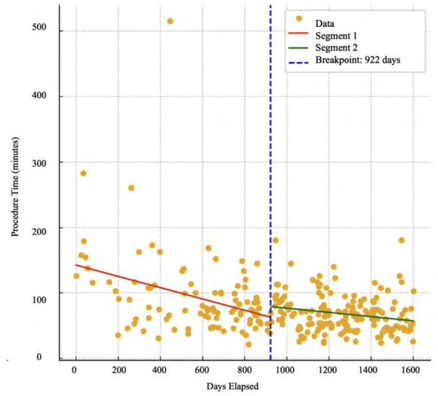

Figure 2b: Segmented Regression Analysis of Procedure Time (minutes)

Cumulative sum analysis confirmed sustained improvements across all three metrics (Figure 3). Active smoking was the only patient factor significantly associated with increased fluoroscopy time (coefficient: 9.24, p = 0.029). No statistically significant associations were found between age, sex, comorbidities, or BMI and procedural efficiency.

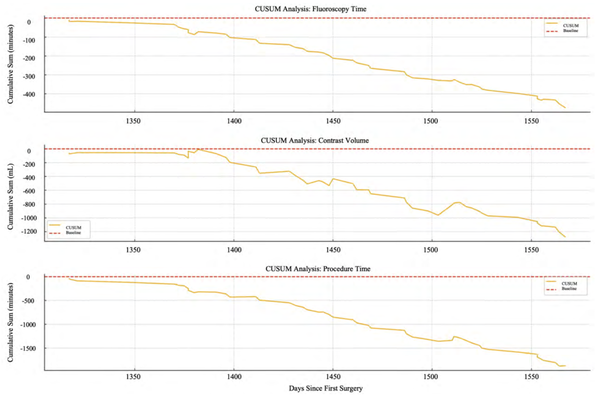

Figure 3: Cumulative Sum Analysis of Fluoroscopy Time, Contrast Volume, and Procedure Time of First 50 Cases Compared to Last 50 Cases

Comparison between the first and last 50 cases revealed non-significant trends toward reduced hospital length of stay, ICU stay, and complication rates (Table 3). The overall mortality rate for the cohort was 4.49%.

Results

Metric	First 50 Cases	Last 50 Cases	p-value
Hospital Length of Stay (Days)	6.23	5.00	0.406
ICU Length of Stay (Days)	2.31	1.23	0.256
Complication Rate	0.14	0.00	0.134

Table 3: Comparison of Mean Hospital Length of Stay in Days, ICU Length of Stay in Days, Complication Rate in the First 50 Cases Vs. Last 50 Cases

Discussion

This study demonstrates that vascular surgeons can rapidly achieve proficiency in percutaneous mechanical thrombectomy for pulmonary embolism, with significant improvements in fluoroscopy time, procedure time, and contrast volume over time. The early plateau in fluoroscopy time reflects quick adaptation to imaging techniques, while the later plateau in overall procedure time highlights the complexity of team coordination and workflow efficiency. A key strength of this study is its large, diverse cohort drawn from multiple urban hospitals, along with detailed patient-level data and consistent procedural documentation. However, limitations include its retrospective design, potential variability in operator technique, and restriction to a single healthcare system, which may limit generalizability. Despite these constraints, the findings support broader adoption of PMT and emphasize the importance of structured training and PE response teams to optimize outcomes.

Conclusion/Next Steps

PMT shows a favorable leaning curve and safety profile. Procedural adoption and proficiency are achievable with training.

These findings must be validated in a large, multicenter, prospective study. Further studies should include high-risk PE populations

References

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(Full list available upon request)

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