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ORIGINAL ARTICLE

Outcomes in High-Risk Pulmonary Embolism Patients Undergoing FlowTriever Mechanical Thrombectomy or Other Contemporary Therapies: Results From the FLAME Study

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BACKGROUND: Hemodynamically unstable high-risk, or massive, pulmonary embolism (PE) has a reported in-hospital mortality of over 25%. Systemic thrombolysis is the guideline-recommended treatment despite limited evidence. The FLAME study (FlowTriever for Acute Massive PE) was designed to generate evidence for interventional treatments in high-risk PE.

METHODS: The FLAME study was a prospective, multicenter, nonrandomized, parallel group, observational study of high-risk PE. Eligible patients were treated with FlowTriever mechanical thrombectomy (FlowTriever Arm) or with other contemporary therapies (Context Arm). The primary end point was an in-hospital composite of all-cause mortality, bailout to an alternate thrombus removal strategy, clinical deterioration, and major bleeding. This was compared in the FlowTriever Arm to a prespecified performance goal derived from a contemporary systematic review and meta-analysis.

RESULTS: A total of 53 patients were enrolled in the FlowTriever Arm and 61 in the Context Arm. Context Arm patients were primarily treated with systemic thrombolysis (68.9%) or anticoagulation alone (23.0%). The primary end point was reached in 9/53 (17.0%) FlowTriever Arm patients, significantly lower than the 32.0% performance goal ($P<0.01$). The primary end point was reached in 39/61 (63.9%) Context Arm patients. In-hospital mortality occurred in 1/53 (1.9%) patients in the FlowTriever Arm and in 18/61 (29.5%) patients in the Context Arm.

CONCLUSIONS: Among patients selected for mechanical thrombectomy with the FlowTriever System, a significantly lower associated rate of in-hospital adverse clinical outcomes was observed compared with a prespecified performance goal, primarily driven by low all-cause mortality of 1.9%.

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Key Words: anticoagulant ■ pulmonary embolism ■ thrombosis

See Editorial by Vedantham

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WHAT IS KNOWN

- Patients with hemodynamically unstable high-risk pulmonary embolism (PE) have reported in-hospital mortality rates over 25%.
- Societal guidelines recommend systemic thrombolysis as front-line treatment in high-risk PE despite limited efficacy data and high bleeding risks.

WHAT THE STUDY ADDS

- The FLAME study (FlowTriever for Acute Massive PE) is the largest prospective interventional study in high-risk PE, a hemodynamically unstable population that presents enrollment challenges in traditional prospective randomized clinical trials.
- In patients selected for mechanical thrombectomy with the FlowTriever System, a lower associated rate of in-hospital adverse outcomes was observed compared with historical literature.
- The FLAME study provides evidence to incorporate large-bore mechanical thrombectomy into standardized care pathways for high-risk PE.

Nonstandard Abbreviations and Acronyms

FLAME	FlowTriever for Acute Massive PE
LBMT	large-bore mechanical thrombectomy
PE	pulmonary embolism

High-risk, or massive, pulmonary embolism (PE) is characterized by hemodynamic instability and right ventricular (RV) strain leading to acute right heart failure, hemodynamic collapse, and death, with reported in-hospital mortality over 25%.[1–4] Current treatment guidelines recommend prompt initiation of anticoagulation followed by reperfusion treatment with systemic thrombolytic therapy.[5,6] These guidelines are based on limited data.[7] Additionally, randomized trials of systemic thrombolysis in largely intermediate-risk patients have demonstrated major bleeding and intracranial hemorrhage rates of 9.2% and 1.5%, respectively.[8] These bleeding risks are greater in high-risk PE populations.[4]

Data in high-risk PE patients are generally lacking, as these patients have been largely excluded from randomized trials and single-arm studies of PE treatments.[9–12] A retrospective multicenter study of large-bore mechanical thrombectomy (LBMT) in a patient population including high-risk PE and severely ill intermediate-risk PE showed excellent outcomes with 97% of patients surviving through follow-up.[13] But with limited high-quality clinical evidence available for interventional treatments in high-risk PE, guidelines recommend catheter-directed treatment only in patients with contraindications to thrombolysis or who fail systemic thrombolytic treatment.[5,6]

Interventional studies in high-risk PE have inherent randomization challenges related to the low incidence, the emergent presentation, and likely high rates of crossover or combined treatment approaches.[14] Given these challenges, nonrandomized studies with prespecified performance goals were suggested by a Scientific Statement from the American Heart Association as an important initial step to generate evidence in this population.[14] The FLAME study (FlowTriever for Acute Massive PE) was designed based on this Scientific Statement to evaluate outcomes in consecutive high-risk PE patients treated with LBMT using a prespecified performance goal developed from a contemporary systematic review and meta-analysis of the literature.[4]

METHODS

The data that support the findings of this study may be made available from the corresponding author upon reasonable request.

Study Design

The FLAME study is a prospective, multicenter, nonrandomized, parallel group, observational study of high-risk PE. Institutional review board approval was obtained at all sites. To capture all presenting patients, a waiver of consent for participation in the study was included to enable unbiased enrollment of patients regardless of mortality outcome. A chart review was performed as an additional measure to ensure the inclusion of all patients and reduce selection bias. Treating physicians obtained procedure-related informed consent per institutional policies.

Adult patients were eligible if the treatment team determined that the PE was the cause of their shock and they met at least 1 of the following criteria: systolic blood pressure (BP) <90 mm Hg or systolic BP decrease of ≥40 mm Hg for >15 minutes, need for vasopressor support, or resuscitation after cardiac arrest with <30 minutes of cardiopulmonary resuscitation and Glasgow Coma scale score >8. Key exclusion criteria were out-of-hospital cardiac arrest with Glasgow Coma Scale score ≤8, witnessed cardiac arrest with ongoing cardiopulmonary resuscitation ≥30 minutes, and history or current evidence of medical conditions or participation in other clinical studies that would preclude enrollment. Full eligibility criteria are specified in Table S1. Investigators were required to have performed a minimum of 10 cases with the FlowTriever System.

Treatment Selection and Follow-Up

The FLAME study protocol did not dictate a specific treatment for PE, so treatment selection was at the discretion of the treating physician. Treatments could include LBMT with the FlowTriever System (Inari Medical, Irvine, CA) or other devices, systemic or catheter-directed thrombolysis, anticoagulation alone, or surgical thrombectomy. Patients were concurrently enrolled in parallel registries depending on the primary treatment strategy selected: the FlowTriever Arm (treated using the FlowTriever System) or Context Arm (treated using other non-FlowTriever therapies). Patients who initially presented with low or intermediate-risk PE and received advanced therapy but

progressed to high-risk PE in the same setting were included in a separate registry (Prior Therapy Arm) because their subsequent clinical course could be influenced by the original treatment. As suggested by the American Heart Association Scientific Statement, this parallel registry structure captured relevant information from the full spectrum of clinical scenarios. Importantly, the Context and Prior Therapy Arms were not intended as comparators to the FlowTriever Arm, and no statistical comparisons were planned between these arms. Patients were followed through hospital discharge or 45 days if still hospitalized, whichever was sooner.

End Points

The primary end point was an in-hospital composite of all-cause mortality, bailout to an alternate thrombus removal strategy, clinical deterioration, and major bleeding (Table S2). All potential primary end point events were adjudicated by an independent Clinical Events Committee (CEC; Boston Clinical Research Institute) for the FlowTriever and Context Arms. In the FlowTriever Arm, the primary end point was compared with a prespecified performance goal (see Statistical Analysis).

Secondary safety end points included the primary end point components; ischemic or hemorrhagic stroke; device-related complications, including those related to primary treatment devices, bailout devices, and extracorporeal membrane oxygenation if part of the primary treatment strategy; and injury to a venous or arterial access site utilized for treatment of PE that required intervention to resolve. All secondary safety end points were adjudicated by the CEC. Other secondary end points included utility measures consisting of the length of hospital and intensive care unit stay, use of extracorporeal membrane oxygenation, time to extubation, and discharge location.

Statistical Analysis

Data are presented as numbers (%), mean±SD, or median (interquartile range). Analyses were performed separately for the FlowTriever Arm and the Context Arm. No statistical analyses were performed directly comparing patient characteristics or outcomes between the parallel registries. Analyses were performed using SAS 9.4 (SAS Institute, Cary, NC) and R v4.1.2.

The composite primary end point for the FlowTriever Arm was compared with a historical performance goal (32.0%) derived from a subset of 18 published studies (Supplemental Methods and Tables S3 and S4) from a recent systematic review and meta-analysis of high-risk PE outcomes by the FLAME investigators.[4] The FLAME study was stopped early after a prespecified interim analysis was performed at enrollment of 50 FlowTriever Arm patients and the primary end point results met established criteria for early stoppage (Supplemental Methods; Table S5).

RESULTS

Patient Characteristics and Primary Treatments

A total of 115 high-risk PE patients were enrolled between March 2021 and November 2022 from 11 sites in the United States: 53 patients in the FlowTriever Arm, 61 patients in the Context Arm, and 1 patient in the Prior Therapy Arm (Figure S1). Baseline characteristics are summarized in Table 1. Patients were most often classified as high-risk PE due to their systolic BP or the need for vasopressor support. A contraindication to thrombolytics was present in 22 (41.5%) FlowTriever Arm patients and 7 (11.7%) Context Arm patients. The FlowTriever Arm and Context Arm each had a large majority of patients in the Society for Cardiovascular Angiography and Interventions shock stage C or higher at the time of presentation, including 11 (20.8%) FlowTriever Arm and 32 (52.5%) Context Arm patients who were in stage D or E.

In the FlowTriever Arm, the median estimated blood loss was 100.0 mL (20.0–240.0 mL) overall and 50.0 mL (0.0–200.0 mL) in the 10 procedures that used the FlowSaver device for blood return. In the Context Arm, most patients were treated with systemic thrombolytic therapy as the primary treatment (42/61, 68.9%), followed by anticoagulation alone (14/61, 23.0%), catheter-directed thrombolytic therapy (4/61, 6.6%), and surgical thrombectomy (1/61, 1.6%). No mechanical thrombectomy devices were used as primary treatment in the Context Arm, though non-FlowTriever devices were permitted by the study protocol.

Treatment occurred following PE Response Team activations in 46 (86.8%) FlowTriever Arm patients and 46 (75.4%) Context Arm patients. Off-hours treatments (nights between 18:00 and 7:00 or weekends) occurred in 19 (40.4%) FlowTriever Arm patients and 38 (63.3%) Context Arm patients. The median time to treatment initiation was 6.1 (2.4–27.6) hours in the FlowTriever Arm and 4.1 (1.5–19.6) hours in the Context Arm.

End Points

The primary end point was reached in 9/53 (17.0% [95% CI, 8.1%–29.8%]) FlowTriever Arm patients, significantly lower than the performance goal of 32.0% ($P<0.01$; Table 2). The primary end point was reached in 39/61 (63.9% [95% CI, 50.6%–75.8%]) Context Arm patients (Table 3); this included 28/42 (66.7%) patients treated with systemic thrombolytics and 10/14 (71.4%) patients treated with anticoagulation alone.

In-hospital mortality occurred in 1/53 (1.9% [95% CI, 0.0%–10.1%]) FlowTriever Arm patients and 18/61 (29.5%; [95% CI, 18.5%–42.6%]) Context Arm patients. In-hospital mortality stratified by Society for Cardiovascular Angiography and Interventions shock stage is shown in Tables S6 and S7. Bailout occurred in 2/53 (3.8% [95% CI, 0.5%–13.0%]) FlowTriever Arm patients and 16/61 (26.2% [95% CI, 15.8%–39.1%]) Context Arm patients. Clinical deterioration occurred in 8/53 (15.1% [95% CI, 6.7%–27.6%]) FlowTriever Arm patients and in 13/61 (21.3% [95% CI, 11.9%–33.7%]) Context Arm patients. Major bleeding occurred in 6/53 (11.3% [95% CI, 4.3%–23.0%]) FlowTriever Arm patients and in 15/61 (24.6% [95% CI, 14.5%–37.3%]) Context Arm

Table 1. Demographics, Medical History, and Clinical Presentation

	FlowTriever arm (n=53)	Context arm (n=61)
Age, y	64.8±15.3	61.6±13.9
Female	26 (49.1%)	35 (57.4%)
BMI, kg/m^2	32.2±6.1	33.9±8.5
Race		
American Indian or Alaskan Native	0 (0.0%)	0 (0.0%)
Asian	0 (0.0%)	0 (0.0%)
Black or African American	16 (30.2%)	40 (65.6%)
Native Hawaiian or Pacific Islander	0 (0.0%)	0 (0.0%)
White	33 (62.3%)	18 (29.5%)
Other	0 (0.0%)	1 (1.6%)
Not provided	4 (7.5%)	2 (3.3%)
History		
Congestive heart failure	1/51 (2.0%)	1/59 (1.7%)
Chronic obstructive pulmonary disease	2/51 (3.9%)	3/56 (5.4%)
Systemic hypertension	37/51 (72.5%)	41 (67.2%)
Pulmonary hypertension	4/48 (8.3%)	2/59 (3.4%)
Diabetes	18/51 (35.3%)	21/58 (36.2%)
Cancer	12 (22.6%)	13/59 (22.0%)
Active cancer	7/52 (13.5%)	5/59 (8.5%)
Pulmonary embolism	7 (13.2%)	7/60 (11.7%)
Deep vein thrombosis	16/52 (30.8%)	12/60 (20.0%)
Contraindication to thrombolytics	22 (41.5%)	7/60 (11.7%)
Absolute contraindication	6 (11.3%)	3/60 (5.0%)
Relative contraindication	16 (30.2%)	4/60 (6.7%)
Prior COVID-19	3/47 (6.4%)	5/54 (9.3%)
Clinical presentation at admission or time of high-risk PE diagnosis		
SCAI shock stage*		
A	2 (3.8%)	1 (1.6%)
B	11 (20.8%)	6 (9.8%)
C	29 (54.7%)	22 (36.1%)
D	5 (9.4%)	12 (19.7%)
E	6 (11.3%)	20 (32.8%)
Systolic BP, mm Hg	97.4±21.4 n=49	93.5±33.4 n=59
Diastolic BP, mm Hg	65.5±14.7 n=49	57.8±23.5 n=59
Heart rate, bpm	99.9±22.6 n=48	103.1±29.4 n=58
Tachycardia, >100 bpm	29 (54.7%)	34 (55.7%)
Respiration rate, breaths/min	22.2±8.2 n=46	26.0±9.4 n=53
Peripheral O_2 saturation (SpO_2), %	95.2±4.7 n=46	92.4±10.0 n=55
Supplemental O_2	38 (71.7%)	47 (77.0%)
Nasal cannula	25 (47.2%)	17 (27.9%)
Face mask	5 (9.4%)	10 (16.4%)
Intubated	8 (15.1%)	20 (32.8%)
Reason for high-risk PE diagnosis†		
Systolic BP <90 mm Hg for at least 15 min or decrease of >40 mm Hg for at least 15 min	34 (64.2%)	31 (50.8%)
Need for vasopressor support	32 (60.4%)	46 (75.4%)
Resuscitation after cardiac arrest with <30 min of CPR and Glasgow Coma Scale score >8	11 (20.8%)	20 (32.8%)
Lactate ≥2 mmol/L	26/35 (74.3%)	34/38 (89.5%)
RV/LV ratio (echo or CTPA composite‡)	1.69±0.46 n=23	1.55±0.47 n=19
Location of PE§		
Central	49 (92.5%)	40/53 (75.5%)
Lobar	36 (67.9%)	36/53 (67.9%)
Segmental	27 (50.9%)	25/53 (47.2%)
Segmental only	0 (0%)	0 (0%)

Values are mean±SD or n (%). Denominators are 53 for the FlowTriever Arm and 61 for the Context Arm unless otherwise noted. BMI indicates body mass index; BP, blood pressure; CPR, cardiopulmonary resuscitation; CTPA, computed tomography pulmonary angiography; LV, left ventricle; PE, pulmonary embolism; RV, right ventricle; and SCAI, Society for Cardiovascular Angiography and Interventions.

*At the time of the high-risk PE presentation.

†Patients could have more than 1 reason.

‡Composite used either CTPA or echo measurements, with CTPA prioritized.

§Central PE is defined as saddle, left main pulmonary artery, right main pulmonary artery, or any combination of the 3; lobar PE as right or left lobar, or both; and segmental PE is defined as right or left segmental, or both. Subjects could have more than 1 PE location.

patients. There were no Bleeding Academic Research Consortium 3c (intracranial hemorrhage) major bleeding events in the FlowTriever Arm. There were 2 (3.3%) such events in the Context Arm, both occurring in patients who received systemic thrombolytics (2/42, 4.8%).

Secondary safety end points, serious adverse event incidence, and resource utilization measures are shown in Table S8 (FlowTriever Arm) and Table S9 (Context Arm). Serious adverse events related to the primary treatment device or therapy occurred in 10 (18.9%) FlowTriever Arm patients and 23 (37.7%) Context Arm patients. Device-related complications occurred in 12 (22.6% [95% CI, 12.3%–36.2%]) patients in the FlowTriever Arm, the most common of which were related to hemoglobin decrease or anemia (Table S10) and did not include reports of tricuspid valve injuries, other cardiac injuries, or pulmonary vascular injuries. Device-related complications occurred in 10 (16.4% [95% CI, 8.2%–28.1%]) patients in the Context Arm; the most common are listed in Table S11. Serious adverse event listings are provided in Tables S12 and S13.

DISCUSSION

The FLAME study is the largest prospective study of interventional treatment in high-risk PE. All patients in

Table 2. Primary End Point in the FlowTriever Arm

	FlowTriever arm (n=53)	Performance goal
Primary end point*	9 (17.0%†; 8.1%–9.8%)	32.0%
Primary end point components*		
All-cause mortality	1 (1.9%; 0.0%–10.1%)	28.5% (20.6%–37.9%)
Cardiovascular death	1	
Noncardiovascular death	0	
Bailout to alternate thrombus removal strategy‡	2 (3.8%; 0.5%–13.0%)	30.3% (15.5%–50.7%)
Systemic thrombolytic therapy	0	
Catheter-directed thrombolytic therapy	1	
Surgical thrombectomy	0	
Mechanical circulatory support	0	
Mechanical thrombectomy	1	
FlowTriever	1	
Non-FlowTriever	0	
Other	0	
Clinical deterioration after primary treatment initiation‡	8 (15.1%; 6.7%–27.6%)	15.6% (6.7%–32.5%)
New need for CPR	4	
New need for intravenous vasopressors	8	
New need for mechanical ventilation	3	
New need for noninvasive positive pressure ventilation	1	
Major bleeding‡	6 (11.3%; 4.3%–23.0%)	11.5% (6.0%–21.0%)
BARC 3b	5	
BARC 3c	0	
BARC 5a	0	
BARC 5b	1	

Values are n (%; 95% CI). All events contributing to the primary end point were adjudicated by an independent Clinical Events Committee. BARC indicates Bleeding Academic Research Consortium; and CPR, cardiopulmonary resuscitation.

*A subject could have more than 1 component of the primary end point; however, each subject could contribute only once to any component of the primary end point.

†Significantly lower than the performance goal of 32% ($P<0.01$).

‡A subject could have more than 1 event.

Table 3. Primary End Point in the Context Arm

	Context arm (n=61)
Primary end point*	39 (63.9%; 50.6%–75.8%)
Primary end point components*	
All-cause mortality	18 (29.5%; 18.5%–42.6%)
Cardiovascular death	16
Noncardiovascular death	2
Bailout to alternate thrombus removal strategy†	16 (26.2%; 15.8%–39.1%)
Systemic thrombolytic therapy	1
Catheter-directed thrombolytic therapy	3
Surgical thrombectomy	1
Mechanical circulatory support	0
Mechanical thrombectomy	13
FlowTriever	12
Non-FlowTriever	1
Other	0
Clinical deterioration after primary treatment initiation†	13 (21.3%; 11.9%–33.7%)
New need for CPR	5
New need for intravenous vasopressors	13
New need for mechanical ventilation	3
New need for noninvasive positive pressure ventilation	0
Major bleeding†	15 (24.6%; 14.5%–37.3%)
BARC 3b	16
BARC 3c	2
BARC 5a	0
BARC 5b	1

Values are n (%; 95% CI). All events contributing to the primary end point were adjudicated by an independent Clinical Events Committee. BARC indicates Bleeding Academic Research Consortium; and CPR, cardiopulmonary resuscitation.

*A subject could have more than 1 component of the primary end point; however, each subject could contribute only once to any component of the primary end point.

†A subject could have more than 1 event.

the FLAME study were critically ill, having met at least one of the European Society of Cardiology criteria for high-risk PE.[5] Given the nonrandomized study methodology, FLAME was not designed to enforce the similarity of disease severity or comorbidities across the FlowTriever and Context Arm populations, nor to statistically evaluate differences in patient characteristics or outcomes across these parallel registries. In the FlowTriever Arm, the composite primary end point of clinically relevant adverse outcomes was reached in 17.0% of patients, a significantly lower rate than the performance goal of 32.0% ($P<0.01$). Importantly, this outcome was driven by a low in-hospital mortality rate of 1.9%. In contrast, the historical mortality rate informing the performance goal was 28.5%. In the Context Arm consisting of all other treatments, the composite primary end point was reached in 63.9% of patients, with an in-hospital mortality rate of 29.5%.

Historically, high-risk PE patients have significant in-hospital mortality of over 25%. Along with their emergent presentation, the low incidence and high rate of crossover treatments make randomization inherently challenging. The difficulty in conducting randomized trials in emergent high-risk PE patients has led to a dearth of quality evidence. To generate evidence in this challenging patient population, the FLAME study was designed based on principles outlined in an American Heart Association Scientific Statement addressing

research priorities for interventional studies.[14] The FLAME study included a nonrandomized design, parallel registry structure, and an informed consent waiver to enable unbiased enrollment of all high-risk PE patients regardless of mortality outcome. Also, a robust meta-analysis of contemporary treatment strategies in high-risk PE[4] was used to establish the prespecified performance goal.

Mechanical thrombectomy with the FlowTriever System was associated with low in-hospital mortality of 1.9%, with only a single in-hospital death. A post hoc analysis stratifying mortality outcomes by disease severity using Society for Cardiovascular Angiography and Interventions shock stages showed that the single death was in a shock stage B patient. All patients treated with the FlowTriever System who were in severely decompensated stages (D/E) survived their hospitalization. The low mortality in the FlowTriever Arm may be due to the rapid effect of thrombus removal, which likely promptly reverses RV strain. Although not collected in FLAME, prior studies have shown an immediate impact on hemodynamics with LBMT. In 800 patients from the FLASH registry (FlowTriever All-Comer Registry for Patient Safety and Hemodynamics), which included 63 (7.9%) high-risk PE patients, significant improvements in hemodynamics were demonstrated immediately after mechanical thrombectomy with the FlowTriever System.[15]

Importantly, the FLAME study design mimics real-world PE management where treatment selection may be influenced by several factors including PE Response Team consultations, off-hours availability of catheterization laboratory resources, the presence of contraindications to thrombolysis, PE location, whether or not the patient can be both promptly and safely transported to the catheterization laboratory, and the availability of an experienced PE interventionalist. To this end, there were more patients in the Context Arm who were treated off-hours and who had more advanced shock.

The FLAME study results suggest there is a subset of patients with high-risk PE in whom LBMT may be a safe and effective treatment option. Although systemic thrombolytics are the current guideline-recommended treatment and may be the only option for patients too ill to transfer for other treatment, their reflexive utilization in high-risk patients should be reconsidered given known concerns with both safety and efficacy. Outcomes in high-risk PE patients may be positively impacted by the alignment of resources to include LBMT in the standardization of care. This would include immediate transportation of patients who can be stabilized to the cardiac catheterization suite where there is a team accustomed to treating critically ill patients, similar to the care pathways for ST-segment–elevation myocardial infarction and acute ischemic stroke.

Study Limitations

FLAME was not a randomized controlled trial; due to the challenges randomizing critically ill patients, FLAME was designed as a prospective, multicenter, observational study using parallel registries. Several measures were used to capture consecutive patients meeting enrollment criteria at each study site, including informed consent waivers for study participation and hospital-based chart reviews for case capture; despite these efforts, full consecutive enrollment at each site over the enrollment period cannot be guaranteed. Derivation of the meta-analytic performance goal was dependent on largely retrospective high-risk PE literature with variable data missingness and clinical adjudication; as such, we cannot ensure that the historical patient population had a similar acuity to either treatment arm. In addition, as the primary treatment selection was at the discretion of the treating physicians, selection bias was expected to create differences in patient characteristics between the parallel registries, which were not designed to facilitate treatment comparisons. Randomized trials that eliminate selection bias would provide definitive data on the potential benefit of LBMT in high-risk PE.

Conclusions

In hemodynamically unstable high-risk PE patients, patients selected for FlowTriever mechanical thrombectomy incurred a significantly lower associated rate of meaningful in-hospital adverse clinical outcomes compared with a prespecified performance goal, primarily driven by low in-hospital mortality of 1.9%.

ARTICLE INFORMATION

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Supplemental Material

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