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ORIGINAL RESEARCH

Pulmonary

Disposition of emergency department patients with acute pulmonary embolism after ambulance arrival

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Abstract

Objective: Most outpatients with pulmonary embolism (PE) are diagnosed in the emergency department (ED). The relationship between means of arrival, site of diagnosis, and disposition in ED patients with PE is unknown. We compared discharge home between patients arriving by emergency medical services (EMS) and those arriving by other means. Within the EMS cohort, we compared those with a recent PE diagnosis in the outpatient clinic setting to those who were diagnosed with PE in the ED.

Methods: This study was a secondary analysis of a retrospective cohort that included all adult, non-pregnant ED patients treated for acute PE across 21 community EDs from January 2013 to April 2015. The primary outcome was discharge home within 24 h of ED registration; we also examined mortality. We described associations with patient arrival method and other patient characteristics.

Results: Among 2996 ED patient encounters with acute PE, 644 (21.5%) arrived by EMS. This group had a lower frequency of discharge (9.2% vs 26.4%) and higher 30-day all-cause mortality (8.7% vs 3.1%) than their counterparts ($p < 0.001$ for both). These associations remained after adjusting for confounding variables. Among the EMS cohort, 14 patients (2.2%) arrived with a PE diagnosis recently made in the outpatient setting.

Conclusion: Patients with PE who arrived at the ED by EMS were less likely to be discharged home within 24 h and more likely to die within 30 days than those who arrived by other means. Less than 3% of the EMS group had been diagnosed with PE before ED arrival.

KEYWORDS
ambulance transport, hospitalization, outpatient management, pulmonary embolism

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1 | INTRODUCTION

1.1 | Background

Pulmonary embolism (PE) is a common disease process with approximately 10 million cases globally per year and is responsible for 100,000 deaths annually in the United States.[1,2] Historically, emergency department patients with PE were routinely hospitalized.[3] Now, risk stratification tools (eg, the PE Severity Index and the Hestia clinical decision rule) can help identify patients with PE who may be safely managed in the outpatient setting.[4–7] However, the ongoing challenges of risk stratifying PE patients in the ED make it difficult for emergency clinicians to determine appropriate disposition.[8,9]

1.2 | Importance

The clinical setting in which a patient is diagnosed (ED vs clinic) can serve as a prognostic indicator. In a retrospective cohort of over 2000 ambulatory adults with acute PE, those diagnosed in an outpatient clinic and subsequently referred to the ED for definitive care were less likely to be hospitalized compared to those diagnosed with PE in the ED.[10] The cohort, however, excluded patients transported by emergency medicine services (EMS), a population not well characterized in the literature. Many PE registries do not include means of ED arrival in their analyses.[11–14] Generally, ED patients who arrive by EMS are significantly more likely to be hospitalized than those arriving by other means.[15] Whether this differential in site-of-care management by means of arrival is evident among patients with acute PE is unknown.

Some patients complete an outpatient PE diagnostic evaluation and then are transferred via EMS to the ED for definitive care. This group has not been well described. We know that patients who undergo a complete clinic-based diagnostic PE evaluation in the outpatient setting are significantly lower risk than their ED counterparts.[16] Their outpatient clinicians felt these patients were sufficiently stable to undergo what can be a prolonged diagnostic evaluation. This relatively lower risk profile is reflected in their management and outcomes.[10,16–18]

The outcomes of those with a clinic-based PE diagnosis and a subsequent EMS transport to the ED may depend on why EMS was consulted. If called because of worrisome symptoms or deteriorating vital signs since their index clinic evaluation, then their ED disposition and outcomes may be similar to those transported by EMS who underwent diagnostic imaging in the ED. However, if EMS was consulted because PE can be a potentially high-risk condition and not because of a decompensation in patient status, then outcomes might more closely approximate the lower risk ambulatory primary care population.

1.3 | Goals of this investigation

We undertook this study to investigate two hypotheses. We suspected that (1) ED patients with acute PE who were transported by EMS (regardless of the timing or setting of their diagnosis) would be a higher risk cohort compared with ED PE patients who arrived by other means and (2) among the EMS cohort, those who arrived with a PE diagnosis in hand would be more likely to be discharged within 24 h and have a lower 30-day mortality rate than those diagnosed in the ED. We tested these hypotheses by completing a secondary analysis of a retrospective cohort study.[18]

The Bottom Line

Although previous literature documented that arrival to the emergency department by emergency medical services (EMS) is associated with higher illness severity, the relationship between mode of arrival to the ED and outcome has not been previously described among patients with pulmonary embolism. This retrospective cohort study of nearly 3000 patients demonstrated that arrival by EMS was associated with lower rates of discharge within 24 h and higher 30-day mortality compared with other modes of arrival. Emergency physicians should be aware that patients arriving by EMS with suspected pulmonary embolism are at risk for worse outcomes.

2 | METHODS

2.1 | Study design and setting

This retrospective cohort study is a secondary analysis of the Management of Acute Pulmonary Embolism (MAPLE) study.[18] The MAPLE study was undertaken across 21 community hospitals across Kaiser Permanente (KP) Northern California, a large, integrated health care system that serves over 4.5 million members, with over 1.5 million annual ED visits. KP members are demographically and socioeconomically representative of the local and statewide population.[19,20]

2.2 | Selection of subjects

The MAPLE study included health plan members aged ≥18 years with 1 or more eligible ED visits from January 2013 through April 2015.[18,21] Non-gravid adults with a PE diagnosis who underwent venous thromboembolism (VTE) imaging in the ED or within 12 h before arrival were eligible if their positive imaging results were confirmed on manual chart review. Cases were excluded if the patient was known to be pregnant; had a diagnosis of VTE ≤ 30 days before their index ED encounter; the index diagnosis of PE occurred in the inpatient, not ED, setting; or the patient left the ED against medical advice, was designated in the ED to receive only comfort care, or did not have health plan membership for at least 30 days after the index visit.

2.3 | Exposures

The primary exposure was arrival to the ED by EMS. The means of ED arrival was treated in a binary fashion: ambulance or non-ambulance. The secondary exposure was setting of PE diagnosis and was treated in a binary fashion: diagnosed in the ED or diagnosed in an outpatient clinic within 12 h of ED arrival. The timing and setting of diagnostic imaging (ED or prearrival) was validated by manual chart review. We then manually reviewed the electronic health records of the EMS cases who arrived with a PE diagnosis in hand to identify the site of EMS engagement.

2.4 | Measurements

The data collection method has been described elsewhere.[18,21] Definitions of the PE Severity Index variables were based on the initial derivation and validation study.[4] We used in the PE Severity Index calculation the most abnormal vital sign value in the direction in question that was documented in the ED record, including immediate prearrival measurements. Patients whose scores were <86 points (Classes I–II) were classified as lower risk and those whose scores were ≥86 points (Classes III–V) were classified as higher risk (Table S1).[4,22] We include race and ethnicity data as they have been shown to be associated with interventions and outcomes for patients with acute PE.[23,24]

2.5 | Outcomes

The primary study outcome was discharge within 24 h of ED registration, whether discharged from the ED, observation, or inpatient setting. Others have used a similar outcome in ED PE management studies.[5,25] A secondary outcome was 30-day all-cause mortality. Deaths were identified via a health care system mortality database linked to Social Security and the California State Department of Vital Statistics to capture in- and out-of-system deaths.

2.6 | Data analysis

We described patient characteristics using median with interquartile range for continuous variables and frequency with proportion for categorical variables for each group of interest and compared patient characteristics between groups (patients arriving by EMS and by other means) using Wilcoxon rank-sum test for continuous variables and chi-square test for categorical variables. We calculated relative risks (RRs) (patients arriving by EMS vs patients arriving by other means) of discharge within 24 h of ED registration and 30-day all-cause mortality with 95% confidence intervals (CIs). We then used modified Poisson regression to examine the association between EMS and the 2 outcomes, adjusting for PE Severity Index class (I–II, III–V), Charlson Comorbidity score (0, 1+), race and ethnicity (White, non-White), syncope/presyncope (Yes, No), troponin (non-elevated or no measurement, elevated), and B-type natriuretic peptide (BNP; <100 or no measurement, ≥100), and reported adjusted RR. The PE Severity Index is an 11-variable weighted score that predicts 30-day all-cause mortality of patients with acute PE (Table S1).[4,22] Limited by the small sample size of the number of patients with a recently secured PE diagnosis (n = 14), we provided only descriptive information for patients with and without a recently secured prearrival PE diagnosis among those arriving by EMS. We set the significance level at 0.05. All analyses were conducted with SAS (version 9.4; SAS Institute, Inc., Cary, NC).

3 | RESULTS

3.1 | Patient population

Of the 2996 patient encounters identified within the parent MAPLE cohort, 644 (21.5%) arrived by EMS and 2352 (78.5%) did not (Figure 1). On average, the EMS cohort was older than their non-EMS counterparts and more likely to have medical comorbidities and abnormal vital signs, which contributed to higher risk class on the PE Severity Index (Table 1).

3.2 | Primary and secondary outcomes

Patients transported by EMS were less likely to undergo discharge within 24 h: 9.2% versus 26.4% (p < 0.001) with RR 0.34 (95% CI, 0.27–0.45). The EMS cohort also exhibited a higher 30-day all-cause mortality, 8.7% versus 3.1% (p < 0.001) with RR 2.80 (95% CI, 2.00–3.92). These associations held true when adjusting for PE Severity Index class, Charlson Comorbidity score, race/ethnicity, syncope/presyncope, troponin, and BNP with adjusted RR 0.51 (95% CI, 0.39–0.66) for discharge and adjusted RR 1.90 (95% CI, 1.34–2.67) for 30-day all-cause mortality (Table 2).

3.3 | Subanalysis of EMS arrivals: Setting of PE diagnosis

Of the 644 EMS transports, 14 (2.2%) arrived with a recent, outpatient PE diagnosis, and 630 (97.8%) underwent their initial diagnostic imaging in the ED. Outpatients who arrived by EMS with a recently diagnosed PE were similar to their other EMS counterparts, including age, PE Severity Index class, discharges, and 30-day mortality (Table 1). Among the 14 patients who arrived by EMS with a recent PE diagnosis, 8 came from an outpatient radiology suite, 2 from an outpatient clinic, and 4 from home after being called by radiology or the physician who ordered the imaging study. There was no documentation in the health records that any of these 14 patients were thought to have decompensated from their initial stable evaluation based on symptoms, clinical appearance, or vital signs. The only EMS patient who died within 30 days was an elderly patient with active cancer, a recent admission for delirium and urinary tract infection, who was hospitalized after

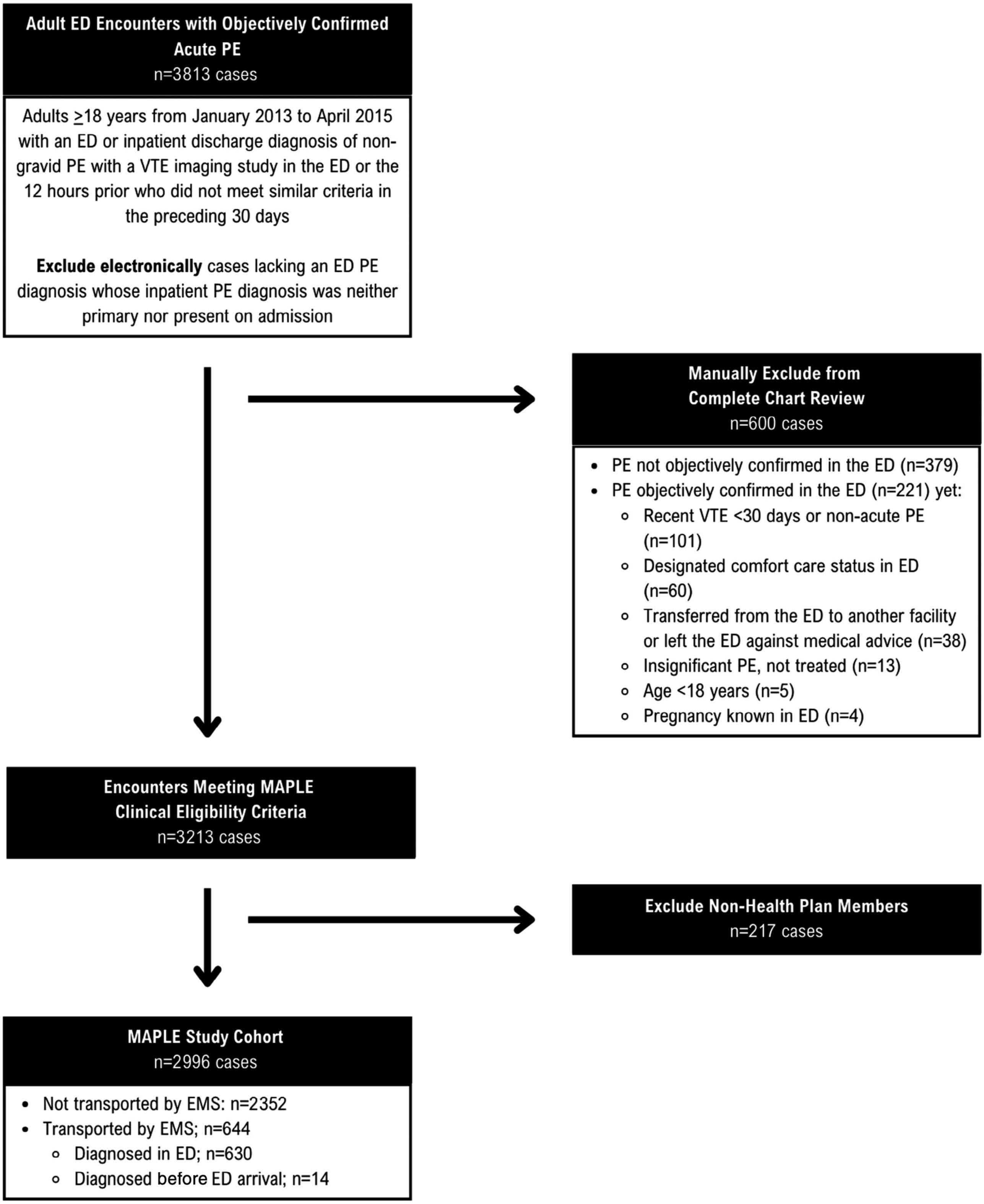

FIGURE 1 Cohort assembly of ED patients with PE who arrived via EMS. ED, emergency department; PE, pulmonary embolism; EMS, emergency medical services; MAPLE, Management of Acute Pulmonary Embolism; VTE, venous thromboembolism.

TABLE 1 Characteristics of emergency department patients with acute pulmonary embolism, stratified by emergency medical services transport and prearrival pulmonary embolism diagnosis.

	Patients with acute PE who presented to the ED *n* = 2996			
	Means of arrival			
		EMS *n* = 644 (21.5)		
		Setting of diagnosis		
	Non-EMS *n* = 2352 (78.5)	Total *n* = 644	During ED encounter *n* = 630 (97.8)	Outpatient setting < 12 h before ED arrival *n* = 14 (2.2)
Characteristics				
Age, y, median (IQR)	64 (52–75)	73 (61–82)*	73 (61–82)	76.5 (60–81)
Sex, male	1182 (50.3)	303 (47.1)	296 (47.1)	7 (50.0)
Race and ethnicity				
White	1668 (70.9)	474 (73.6)*	465 (73.8)	9 (64.3)
Black	289 (12.3)	95 (14.6)	92 (14.6)	3 (21.4)
Hispanic	248 (10.5)	43 (6.7)	41 (6.5)	2 (14.3)
Asian	116 (4.9)	21 (3.3)	21 (3.3)	0
Other	31 (1.3)	11 (1.7)	11 (1.8)	0
Comorbidities				
Obesity (body mass index ≥30 kg/m^2)	1083 (46.1)	276 (42.9)	271 (43.1)	5 (35.7)
Cancer (history or active)	686 (29.2)	181 (28.1)	178 (28.3)	3 (21.4)
Chronic lung disease	594 (25.3)	216 (33.5)*	208 (33.1)	8 (57.1)
History of venous thromboembolism	391 (16.6)	102 (15.8)	100 (15.9)	2 (14.3)
Coronary artery disease	295 (12.5)	140 (21.7)*	137 (21.8)	3 (21.4)
Heart failure (diastolic or systolic)	203 (8.6)	97 (15.1)*	95 (15.1)	2 (14.3)
Cerebrovascular disease	135 (5.7)	101 (15.7)*	100 (15.9)	1 (7.1)
Smoking	139 (5.9)	39 (6.1)	39 (6.2)	0 (0)
Chronic severe renal failure	38 (1.6)	31 (4.8)*	27 (4.3)	4 (28.6)
Vital signs				
Systolic blood pressure, mm Hg				
≥100	2037 (86.6)	477 (74.1)*	465 (73.9)	12 (85.7)
<100 and ≥90	228 (9.7)	99 (15.4)	98 (15.6)	1 (7.1)
<90	86 (3.7)	68 (10.6)	67 (10.7)	1 (7.1)
Missing	1 (0)	0	0	0
Pulse, beats/min				
<100	1320 (56.1)	289 (44.9)*	278 (44.2)	11 (78.6)
≥100 and < 110	375 (15.9)	114 (17.7)	113 (18)	1 (7.1)
≥110	657 (27.9)	241 (37.4)	239 (38)	2 (14.3)
Respiratory rate, breaths/min				
<24	1567 (66.6)	325 (50.5)*	315 (50.1)	10 (71.4)
≥24 and <30	578 (24.6)	235 (36.5)	232 (36.9)	3 (21.4)
≥30	202 (8.6)	82 (12.7)	81 (12.9)	1 (7.1)
Missing	5 (0.2)	2 (0.3)	2 (0.3)	0 (0)
Oxygen saturation				
≥94	1564 (66.5)	298 (46.3)*	289 (45.9)	9 (64.3)
<94 and ≥90	470 (20)	141 (21.9)	139 (22.1)	2 (14.3)
<90	317 (13.5)	205 (31.8)	202 (32.1)	3 (21.4)
Missing	1 (0)	0	0	0

(Continues)

TABLE 1 (Continued)

	Patients with acute PE who presented to the ED $n = 2996$			
	Means of arrival			
		EMS $n = 644$ (21.5)		
		Setting of diagnosis		
	Non-EMS $n = 2352$ (78.5)	Total $n = 644$	During ED encounter $n = 630$ (97.8)	Outpatient setting < 12 h before ED arrival $n = 14$ (2.2)
Temperature, °C				
<36	30 (1.3)	21 (3.3)*	21 (3.3)	0
≥36	2281 (97)	603 (93.6)	589 (93.6)	14 (100)
Missing	41 (1.7)	20 (3.1)	20 (3.2)	0
Syncope or presyncope				
Yes	88 (3.7)	103 (16)*	103 (16.4)	0
Altered mental status				
Yes	60 (2.6)	95 (14.8)*	95 (15.1)	0
Laboratory tests				
Troponin, ng/mL				
Normal	1414 (60.1)	370 (57.5)*	366 (58.2)	4 (28.6)
Abnormal	346 (14.7)	172 (26.7)	170 (27)	2 (14.3)
No measure	592 (25.2)	102 (15.8)	94 (14.9)	8 (57.1)
B-type natriuretic peptide, pg/mL				
<100	660 (28.1)	136 (21.1)*	136 (21.6)	0
100–500	351 (14.9)	161 (25)	158 (25.1)	3 (21.4)
≥500	112 (4.8)	57 (8.9)	57 (9.1)	0
No measure	1229 (52.3)	290 (45)	279 (44.4)	11 (78.6)
PE Severity Index [a]				
Class I–II (lower risk)	1035 (44)	134 (20.8)*	130 (20.6)	4 (28.6)
Class III–V (higher risk)	1317 (56)	510 (79.2)	500 (79.5)	10 (71.4)

Note: No. (%) throughout, except for age.
Abbreviations: ED, emergency department; EMS, emergency medical services; IQR, interquartile range; PE, pulmonary embolism.
*$p < 0.001$; all other comparisons $p > 0.05$. p values calculated at a category level (eg, race and ethnicity, vital signs, laboratory tests, PE Severity Index) for all variables except for individual comorbidities and age. p values were calculated for variables between the EMS arrival cohort and non-EMS arrival cohort.
[a]The PE Severity Index is a well-validated, widely employed index that predicts the risk of 30-day all-cause mortality in patients with acute PE. It is composed of 11 weighted variables and stratifies patients into 5 risk classes, each higher class with an increasing incidence of 30-day all-cause mortality (Table S1).

outpatient diagnosis of PE with other active, ongoing medical issues. Cause of death was not documented in the electronic health record.

4 | LIMITATIONS

This study is limited by its retrospective nature and small sample size of the EMS subgroup that had a recent outpatient PE diagnosis. The study was underpowered to compare the 2 EMS transport groups. Generalizability may also be limited, as the MAPLE cohort included health care plan members who had ready access to primary care, diagnostic studies, specialty consultation, and follow-up care. Additionally, we were unable to control for unmeasured potential confounding variables outside of PE Severity Index class and Charlson Comorbidity score. Lastly, the study predated the introduction of direct oral anticoagulants, which may have facilitated discharge.[26,27] Although the data of this secondary analysis are 8–10 years old, the home discharge rate directly from the ED was 7.5%.[18] A more recent analysis of 740 US sites found that 4.1% of patients diagnosed with acute PE were discharged home from the ED.[28] As such, the similarity in practice pattern may help mitigate the difference in time periods.

5 | DISCUSSION

In this secondary analysis of a large, community based retrospective cohort study, we found that ED patients with acute PE who had arrived by EMS (about 20%) were less likely to be discharged within 24 h

TABLE 2 Discharge within 24 h and 30-day all-cause mortality by means of arrival and setting of diagnosis among emergency medical services arrivals.

	Discharge within 24 h from ED registration			30-day all-cause mortality		
	n (%)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)	*n* (%)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
Means of arrival						
Non-EMS (*n* = 2352)	620 (26.4)	Reference		72 (3.1)	Reference	
EMS (*n* = 644)	59 (9.2)	0.35 (0.27–0.45)	0.51 (0.39–0.66)	56 (8.7)	2.80 (2.00–3.92)	1.90 (1.34–2.67)
Setting of diagnosis						
In the ED (*n* = 630)	57 (9.1)	Reference		55 (8.7)	Reference	
Outpatient setting <12 h before ED arrival (*n* = 14)	2 (14.3)	1.58 (0.43–5.83)	Not calculated	1 (7.1)	0.82 (0.12–5.50)	Not calculated

Note: Adjusted RR was calculated from modified Poisson regression, adjusted for PE Severity Index class, Charlson Comorbidity score, race/ethnicity, syncope/presyncope, troponin, and B-type natriuretic peptide.
Abbreviations: CI, confidence interval; ED, emergency department; EMS, emergency medical services; RR, relative risk.

of ED registration and more likely to die within 30 days. They were significantly different than their non-EMS counterparts, both in baseline patient characteristics (eg, older and sicker) and in site-of-care management. Our finding mirrors the reality that the overall EMS population is more commonly hospitalized than those arriving at the ED by other means.[10,29,30] The 2018 National Hospital Ambulatory Care Survey found 3-fold higher hospitalization for patients arriving by EMS (30.2% vs 9.9%).[15] This survey was broad, and its analysis was limited to age, sex, race, ethnicity, and insurance type. An additional survey of a sample of nationwide ED visits from 2015–2019 found EMS arrival to be associated with higher mortality even when controlling for age, sex, race or ethnicity, insurance status, and number of chronic medical conditions.[31] However, neither of these studies include detailed information on specific patient complaint or diagnosis.

Correlation of EMS arrival with outcomes in disease-specific ED populations has not been commonly undertaken. Our study is unique in that it is the first detailed analysis of the relationship between means of arrival, discharge home within 24 h, and 30-day mortality in patients with acute PE. EMS arrival has also been found highly predictive of adverse outcomes in ED patients with acute heart failure. A recent multicenter study of 26,189 ED encounters of adult patients with acute heart failure used machine learning to identify predictors of 30-day serious adverse events.[32] Of the 71 variables in the final model, arrival by EMS was the second most influential for predicting adverse events.

Means of transport is one of the first characteristics known about a patient upon ED arrival and can be useful as a general prognostic marker. In the parent MAPLE study, EMS arrival was shown to be inversely associated with discharge home from the ED when controlling for other known predictors of PE severity (adjusted odds ratio 0.38 [95% CI, 0.20–0.73]).[18] Means of arrival, however, has uncommonly been included in ED PE studies. To our knowledge, the differential hospitalization of PE patients stratified by means of ED arrival has not been previously described.[5,22,33–35]

At first glance, it is unsurprising that patients who arrived via EMS were sicker and had higher rates of 30-day all-cause mortality. However, after adjusting for PE Severity Index class, Charlson Comorbidity score, troponin, BNP, and syncope or presyncope,[36] patients with acute PE who arrived by EMS were still less likely to be discharged within 24 h and more likely to die within 30 days. We found that EMS was an independent predictor of our 2 primary outcomes. This calls for further investigation into the interplay between EMS arrival and patients with specific high-risk conditions, such as acute PE. Physicians in the ED should be wary of patients who arrive by EMS with acute PE, cautious to discharge these patients quickly, and should treat EMS arrival as an independent predictor of acuity.

We found that few EMS patients (<3%) arrived with a PE diagnosis made recently in the outpatient clinic setting. These patients had been transported from a variety of locations, including home, clinic, and outpatient radiology. We had hypothesized that these patients would be a distinctive lower risk subset of EMS arrivals as they had been selected by their outpatient clinicians as stable enough to undergo outpatient diagnostic evaluation.[16] The absence of documented clinical decompensation supported this, though documentation may have been incomplete. The study results, however, failed to confirm our hypothesis. The small number of cases (*n*=14) may have weakened our ability to detect statistically significant differences. Interestingly, a third patient in this subgroup was discharged at 24.3 h, and a fourth patient was offered discharge but declined for unclear reasons on chart review. Had these 2 patients been counted in our discharged group, the proportion of patients discharged would have doubled.

Some of these 14 patients may not have had alternative means of transport, in which case EMS transport for a patient with a new diagnosis of PE would be appropriate. However, if available, private auto is a reasonable means of transportation for stable patients. There were 344 other patients (96.1% of those with a pre-ED PE diagnosis) in the larger MAPLE cohort with a clinic-based PE diagnosis who were transported to the ED by private automobile.[10] Over a third of these were discharged home after either a brief ED or outpatient observation stay. Had some of the EMS patients in our study been as clinically stable upon EMS arrival as they were during the antecedent outpatient medical evaluation, it would have been unlikely for them to suddenly decompensate in the brief interval between diagnostic imaging and ED arrival by private auto. In low-risk cases, avoiding unnecessary ambulance transport can reduce the expense and potential harm that ambulance transport can entail.[37,38]

In conclusion, this retrospective cohort study in a US integrated health care system found that 20% of ED patients with acute PE arrived by EMS. These patients were significantly less likely to undergo discharge within 24 h and more likely to die within 30 days. Emergency clinicians may be able to use means of arrival as a predictor of acuity and probable care needs for their patients with acute PE. Of the EMS arrivals, we discovered that very few arrived with a recent PE diagnosis made in the outpatient setting. Larger studies are needed to better evaluate this unique subpopulation.

AUTHOR CONTRIBUTIONS

Concept and design: Samuel Gray Rouleau and David Russell Vinson. Data collection: Samuel Gray Rouleau and David Russell Vinson. Data analysis: Samuel Gray Rouleau and Jie Huang. Manuscript drafting: Samuel Gray Rouleau, Aidan Richard Campbell, and David Russell Vinson. Supervision: David Russell Vinson and Mary Evelyn Reed.

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CONFLICT OF INTEREST STATEMENT

There are no conflicts of interest to report.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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