Title

Expanding outpatient management of low-risk pulmonary embolism to the pregnant population: a case series.

Journal

European Heart Journal: Case Reports, 8(9)

Authors

Vinson, David

Roubinian, Nareg

Pai, Ashok

et al.

Publication Date

2024-09-01

DOI

10.1093/ehjcr/ytae441

Peer reviewed

ESC European Society of Cardiology

European Heart Journal - Case Reports (2024) **8**, ytae441
https://doi.org/10.1093/ehjcr/ytae441

CASE SERIES
Cardiovascular imaging

Expanding outpatient management of low-risk pulmonary embolism to the pregnant population: a case series

David R. Vinson [1,2,3]*, Nareg H. Roubinian [1,2,4], Ashok P. Pai [1,2,5], and Jeffrey D. Sperling [1,6]

[1]The Permanente Medical Group, 1800 Harrison St., Oakland, CA 94612, USA; [2]Kaiser Permanente Northern California Division of Research, 4480 Hacienda Dr., Pleasanton, CA 94588, USA; [3]Department of Emergency Medicine, Kaiser Permanente Roseville Medical Center, 1600 Eureka Road, Roseville, CA 95661, USA; [4]Department of Pulmonary and Critical Care Medicine, Kaiser Permanente Oakland Medical Center, Oakland, CA, USA; [5]Department of Hematology and Oncology, Kaiser Permanente Oakland Medical Center, Oakland, CA, USA; and [6]Department of Maternal-Fetal Medicine, Kaiser Permanente Modesto Medical Center, Modesto, CA, USA

Received 22 December 2023; revised 16 March 2024; accepted 19 August 2024; online publish-ahead-of-print 22 August 2024

Background Outpatient treatment of pregnant patients with acute pulmonary embolism (PE) is recommended by some obstetric and haematology societies but has not been described in the literature. Little is known about patient selection and clinical outcomes.

Case summary We report two cases of pregnant patients diagnosed with acute PE. The first, at 9 weeks of gestational age, presented to the emergency department with 12 h of pleuritic chest pain and was diagnosed with segmental PE. She was normotensive and tachycardic without evidence of right ventricular dysfunction. She received multispecialty evaluation, was deemed suitable for outpatient management, and, after 12 h of monitoring, was discharged home on enoxaparin with close follow-up. The second case, at 30 weeks of gestational age, presented to obstetrics clinic with 3 days of dyspnoea. Vital signs were normal except for tachycardia. She was referred to labour and delivery, where she was diagnosed with segmental PE. Her vital signs were stable, and she had no evidence of right ventricular dysfunction. After 6 h of monitoring, she was discharged home on enoxaparin with close follow-up. Neither patient developed antenatal complications from their PE or its treatment.

Discussion This case series is the first to our knowledge to describe patient and treatment characteristics of pregnant patients with acute PE cared for as outpatients. We propose a definition for this phenomenon and discuss the benefits of and provisional selection criteria for outpatient PE management, while engaging with professional society guidelines and the literature. This understudied practice warrants further research.

Keywords Venous thromboembolism • Pulmonary embolism • Pregnancy • Outpatient • Ambulatory care • Risk stratification • Case report

ESC curriculum 9.5 Pulmonary thromboembolism • 9.4 Thromboembolic venous disease

* Corresponding author. Email: drvinson@ucdavis.edu
Handling Editor: Emmanouil Androulakis
Peer-reviewers: Georgios Benetos; Andreas Giannopoulos; Daniel Messiha; Leo Bergau; Jana Kupusovic; Christoph Jensen
Compliance Editor: Nikolaos Spinthakis

Learning points

- Outpatient management of acute pulmonary embolism (PE) in pregnancy can be safe and effective in selected patients.
- Professional societies recommend against outpatient antenatal PE care for those with haemodynamic instability, significant comorbidities or clot burden, or lack of home support.

Introduction

Select non-gravid patients with acute low-risk pulmonary embolism (PE) in the emergency department (ED) and specialty clinics are managed safely and effectively without hospitalization.[1–3] In some settings, primary care physicians diagnose and treat acute PE in outpatient clinics without referral to a specialty clinic, ED, or inpatient ward.[4] Professional society guidelines, including the European Society of Cardiology (ESC) and the American College of Chest Physicians, universally have recommended outpatient PE treatment for non-gravid patients with low-risk characteristics.[5,6]

Pregnant patients, however, have been systematically excluded from outpatient PE research.[7] Little has been published on outpatient PE management during pregnancy.[8] Society guidelines, therefore, have crafted their site-of-care recommendations for antenatal PE based on expert opinion, inferred from non-gravid research. The American College of Obstetricians and Gynecologists (ACOG), the American Society of Hematology (ASH), and the British Thoracic Society have recommended outpatient PE management for lower-risk pregnant patients (*Table 1*).[7,9,10] Several society guidelines do not specifically address the question of site-of-care management.[5] The Hestia study investigators from the Netherlands, on the other hand, cautioned against outpatient management of gravid patients with acute PE, although without providing explanation (*Table 2*).[11]

Objective

Outpatient management of acute antenatal PE has not been described in the literature. Here, we report two cases of pregnant patients diagnosed with PE in the first and third trimesters, respectively, who were treated safely as outpatients. We then discuss three questions about outpatient management of antenatal PE: What is it? Why might it be preferable? Who may be eligible (*Figure 1*)?

Case 1

A healthy 35-year-old woman gravida 2 and para 0 at 9 weeks and 4 days presented to a community-based ED with 12 h of gradual-onset mild-to-moderate pleuritic chest and thoracic back pain. She had no dyspnoea or limb symptoms. Six days earlier, during her first obstetrics appointment, she had been started on prophylactic dose enoxaparin because of two distant, provoked venous thromboembolism (VTE) episodes years prior, the first while taking oestrogen-containing oral contraceptives and the second 4 weeks after COVID-19 (*Tables 3* and *4*). She had had a prior negative inherited thrombophilia evaluation and no other relevant medical history.

On admission, the patient's vital signs were as follows: temperature 36.6°C, blood pressure of 132/69 mmHg, heart rate of 105 b.p.m., respiratory rate of 19 breaths/min, and room-air oxygen saturation of 95%. Her body mass index was 30 kg/m^2. Physical examination was otherwise normal. Bedside ultrasonography confirmed a singleton intrauterine pregnancy. Twelve-lead electrocardiogram, complete blood count, basic chemistry panel, and troponin were unremarkable. Her D-dimer level was elevated at 1.92 mg/L (normal for non-pregnancy < 0.5 mg/L). B-type natriuretic peptide was not ordered.

The emergency physician consulted the on-call obstetrician, who recommended bilateral lower extremity compression ultrasonography: if positive, treat for deep vein thrombosis with presumptive PE, and if negative, proceed to CTPA.[5,13] Ultrasonography was negative. Computed tomography pulmonary angiography identified unilateral segmental PE and absence of right ventricular dilatation (*Figure 2*). Echocardiography was not indicated.[5] Maternal–foetal medicine (MFM)

Table 1 Contraindications for outpatient management of acute pulmonary embolism in pregnant persons according to US professional society guidelines[a]

	American College of Obstetrics and Gynecology (2018)[9]	American Society of Hematology (2018)[7]
Pregnancy parameters	N/A	Advanced gestational age
Maternal comorbidity	Present	Comorbidities that limit tolerance of recurrent venous thromboembolism or are associated with increased risk of bleeding
Symptom burden	N/A	Severe pain requiring analgesia
Physical examination	Haemodynamic instability	Vital sign abnormalities
Venous thromboembolism burden	Large	Extensive
Treatment parameters	N/A	Contraindications to low molecular weight heparin
Home support	N/A	Lacking

N/A, not applicable.

[a]These simple, sensible criteria for ambulatory care mirror those of the 2016 guidelines from the American College of Chest Physicians (CHEST), written for non-gravid patients, who should be 'clinically stable with good cardiopulmonary reserve; no contraindications such as recent bleeding, severe renal or liver disease, or severe thrombocytopenia (i.e. <70 000/mm^3); expected to be compliant with treatment; and the patient feels well enough to be treated at home'.[6]

Table 2 Two popular validated risk scores used to guide site-of-care decision-making among non-gravid patients with acute pulmonary embolism

Hestia contraindications to outpatient management[11]	Pulmonary Embolism Severity Index[12]	Score[d]
Comorbid illness	**Demographic characteristics**	
High risk for bleeding (or active bleeding)[a]	Age	+1 per year
Medical or social reason for hospitalization > 24 h	Male sex	+10
On anticoagulation when diagnosed with PE	**Comorbid illness**	
History of heparin-induced thrombocytopenia	Cancer (active or history of)	+30
Pregnancy	Heart failure (systolic or diastolic)	+10
Clinical findings and needs	Chronic lung disease (includes asthma)	+10
Haemodynamically unstable[b]	**Clinical findings**[e]	
Thrombolysis or embolectomy needed	Pulse ≥ 110/min b.p.m.	+20
>24 h of supplemental oxygen required to maintain SaO2 > 90%	Systolic blood pressure < 100 mmHg	+30
Severe pain needing intravenous analgesia > 24h	Respiratory rate ≥30 breaths per min	+20
Creatinine clearance < 30 mL/min by Cockcroft Gault	Temperature < 36°C	+20
Severe liver impairment[c]	Altered mental status[f]	+60
	Arterial oxygen saturation < 90%[g]	+20

PE, pulmonary embolism.
[a]Gastrointestinal bleeding or surgery ≤ 2 weeks ago, stroke ≤ 1 month ago, bleeding disorder or platelet count < 75×10^9/L, uncontrolled hypertension (systolic blood pressure > 180 mmHg or diastolic blood pressure > 110 mmHg), or by clinician judgment.
[b]Systolic blood pressure < 100 mmHg and heart rate > 100 b.p.m., needing intensive care, or by clinician judgment.
[c]By clinician judgment.
[d]A total point score for a given patient is obtained by summing the patient's age in years and the points for each applicable prognostic variable. Point scores correspond with the following classes that estimate escalating risks of 30-day all-cause mortality: ≤65 Class I, very low risk; 66–85 Class II, low risk; 86–105 Class III, intermediate risk; 106–125 Class IV, high risk; >125 Class V, highest risk.
[e]The most abnormal vital signs in the direction of interest recorded during the diagnostic evaluation and observation period.
[f]Acute or pre-existing disorientation, lethargy, stupor, or coma.
[g]With or without supplemental oxygenation.

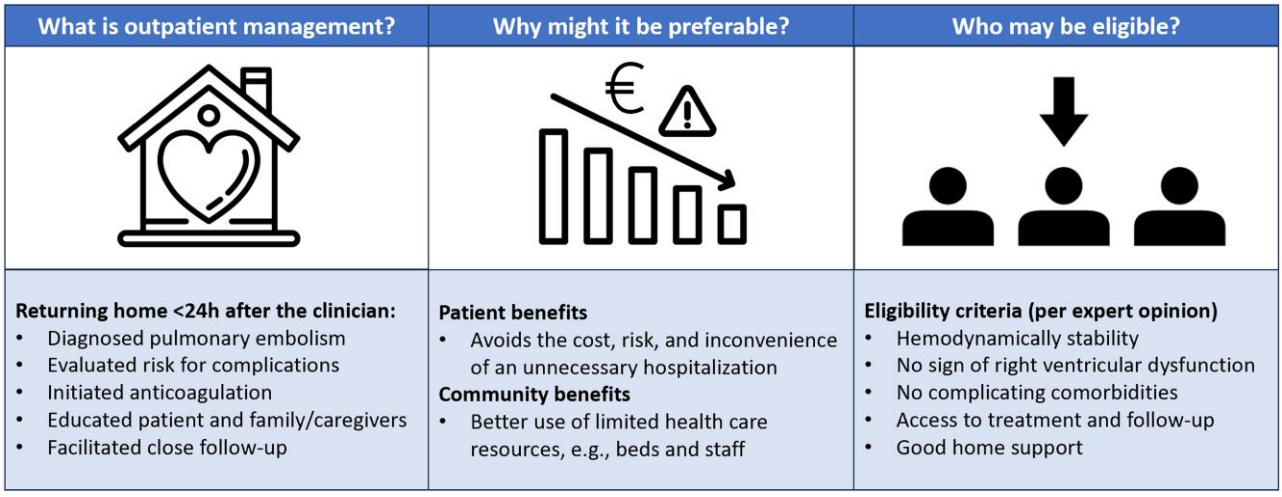

Figure 1 Three principal questions about outpatient management of antenatal pulmonary embolism.

and haematology were consulted, recommending starting therapeutic dose weight-based enoxaparin (1 mg/kg q12 h) in the ED and continuing it throughout pregnancy, with anticoagulation at least 6-week postpartum. An internal medicine physician specializing in inpatient care was consulted. On re-evaluation, the patient was haemodynamically stable, with improved pain, and able to ambulate without difficulty or desaturation. Her resting heart rate varied from 93 to 109 and increased during ambulation to 113 b.p.m. Her PE Severity Index score[12] (55 points = 35 points for age plus 20 points for tachycardia ≥ 110 b.p.m.) placed her in the lowest risk classification (Class I), although her consultants

Table 3 Patient, diagnostic, and treatment characteristics of two pregnant patients with acute pulmonary embolism treated as outpatients

Characteristics	Case 1	Case 2
Patient characteristics		
Age, years	35	37
Gestational age, weeks	9	30
Duration of PE-related symptoms	12 h	3 days
Extremity symptoms	None	None
History of venous thromboembolism	Yes	No
Antecedent prophylactic anticoagulation	For the prior 6 days	None
Diagnostic evaluation		
Site(s) of care	ED	L&D (referred from obstetrics clinic)
Length of stay, hours	12	6
Primary diagnostician, specialty	Emergency medicine	Obstetrics
Consultant(s), specialty	Obstetrics (general), maternal–foetal medicine, haematology, internal medicine	None
Vital signs		
Systolic blood pressure, range (mmHg)	112–135	129–136
Heart rate, range (b.p.m.)	93–113	117–133
Respiratory rate, range (breaths/min)	16–23	Not performed
Pulse oximetry, range (on room air)	95–100%	98–99%
D-dimer, mg/L	1.92 (normal <0.5)	Not performed
12-lead electrocardiogram	Sinus tachycardia	Sinus tachycardia
Compression ultrasonography, proximal lower extremities	Negative	Not performed
Chest radiography	Not performed	Not performed
Troponin, ng/mL	<0.02	Not performed
Computed tomography pulmonary angiography[a]		
Most proximal clot location	Segmental	Segmental
Cardiac abnormalities	None	None
Outpatient eligibility criteria		
For pregnant patients (unvalidated expert opinion)		
Per ACOG guidelines (see *Table 1*)	Eligible	Eligible
Per ASH guidelines (see *Table 1*)	Ineligible	Ineligible
For non-pregnant patients (validated)		
Hestia outpatient contraindications (see *Table 2*)	Ineligible, only because of pregnancy	Ineligible, only because of pregnancy
PE Severity Index (see *Table 2*)	Eligible, Class I (lowest risk)	Eligible, Class I (lowest risk)
Bleeding risk[b]	Low	Low
Treatment		
Anticoagulation (begun before discharge)	Enoxaparin, 1 mg/kg, subcutaneous, q12h	Enoxaparin, 1 mg/kg, subcutaneous, q12h
Follow-up appointments < 10 d, specialty, mode, day after discharge		
Initial	Obstetrics, telephone, 3 d	Maternal–foetal medicine, telephone, 1 d
Second	Obstetrics, clinic, 5 d	Maternal–foetal medicine, clinic, 7 d
Third	Maternal–foetal medicine, clinic, 8 d	
PE-related complications		
Antenatal	None	None
Intra- and postpartum (<6 weeks)	None	Delayed postpartum haemorrhage, required blood products

ACOG, American College of Obstetricians and Gynecologists; ASH, American Society of Hematology; ED, emergency department; L&D, labour and delivery; PE, pulmonary embolism.
[a]Foetal doses of radiation from pulmonary vascular imaging are lower than the background radiation exposure (~1 mGy) to which a foetus is naturally exposed during pregnancy. The American College of Obstetricians and Gynecologists (2018) explains the radiation exposure as follows: 'Although the foetal exposure from ventilation–perfusion is low (~0.32–0.64 mGy), mean foetal doses associated with helical CT are lower (0.0033–0.02 mGy for the first trimester, 0.0079–0.0767 mGy for the second trimester, and 0.0513–0.1308 mGy for the third trimester)'.[9]
[b]Per professional society guidelines.[5–7]

Table 4 Timeline of historical and treatment components of care of two pregnant patients with acute pulmonary embolism treated as outpatients

Historical and management components of care	Timing in relation to seminal events	
	Case 1	Case 2
History of venous thromboembolism	Several years prior to presentation	Not applicable
Prophylactic anticoagulation	6 days prior to presentation	Not applicable
Onset of pulmonary embolism-related symptoms	12 h prior to presentation	3 days prior to presentation
Antecedent outpatient clinic encounter	Not applicable	Several hours prior to presentation
Index diagnostic evaluation	Day 0	Day 0
Discharge to home	12 h after presentation	6 h after presentation
Initial follow-up after the index visit	3 days after presentation	1 day after presentation
Delivery	29 weeks 4 days after presentation	6 weeks 2 days after presentation
Postpartum haemorrhage	10 days after delivery	Not applicable
Completion of anticoagulation	6 weeks after delivery	6 weeks after delivery

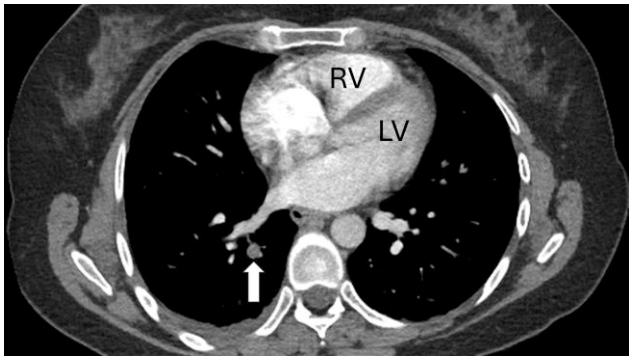

Figure 2 Computed tomography pulmonary angiography (axial view) identified right segmental pulmonary artery filling defect (white arrow) characteristic of pulmonary embolism. The heart had a normal ratio (<0.9) of right ventricular to left ventricular diameters, supporting the absence of right ventricular dilatation. LV, left ventricle; RV, right ventricle.

acknowledged that the index has not been validated in pregnancy (*Table 2*). The internist documented that the patient reported adequate home support and resources. The patient was discharged home from the ED 12 h after presentation.

She had close follow-up over the next 10 days (*Table 3*). At each appointment, she reported symptom improvement. She continued weight-based enoxaparin throughout pregnancy without sequelae. A 39-week delivery was planned for anticoagulation management. She underwent a caesarean delivery for second-stage arrest that was complicated by a delayed postpartum haemorrhage 10 days after delivery. During this episode, her anticoagulation was briefly held, her uterus was evacuated and packed, and she was transfused with multiple blood products. She experienced a quick, complete recovery. She restarted anticoagulation, which she continued for 6-week postpartum before discontinuing (*Tables 3* and *4*).

Case 2

A 37-year-old woman gravida 2 and para 1 at 30 weeks and 3 days presented to obstetrics clinic with 3 days of rapid heart rate and moderate dyspnoea on exertion. She had no chest pain or limb symptoms. Her past medical history was remarkable for mild hypertension, diagnosed during the first trimester, managed without pharmacotherapy, and followed serially with periodic laboratory studies and symptom surveillance. She also had mild normocytic anaemia in pregnancy and had been recently diagnosed with cholestasis of pregnancy with elevated bile acids but minimal symptoms and was currently untreated. In the clinic, her heart rate was 130 b.p.m. and a 12-lead electrocardiogram showed only sinus tachycardia. She was referred to labour and delivery (L&D), where her vital signs were as follows: blood pressure of 130/85 mmHg (within her baseline range), heart rate of 126 b.p.m., and room-air oxygen saturation of 98%. Her body mass index was 37.4 kg/m^2. Physical examination was normal except for a regular tachycardia. Foetal assessment was reassuring. Haematocrit was 29.1%, and platelet count, renal function, liver enzymes, and thyroid stimulating hormone were normal. Troponin and B-type natriuretic peptide were not ordered. Computed tomography pulmonary angiography identified a single segmental PE and absence of right ventricular dilatation. Echocardiography was not ordered. Therapeutic weight-based enoxaparin was begun. Her blood pressure and oxygen saturation remained normal throughout her stay (*Table 3*). The patient was discharged home 6 h after presentation.

She had reassuring appointments with MFM by telephone the next day and in person 1 week after diagnosis. She continued her regular antepartum testing without incident. She underwent induction of labour at 36 weeks and 4 days for cholestasis and had an uneventful vaginal delivery. She continued enoxaparin for an additional 6-week postpartum without event (*Table 4*).

Discussion

This case series is the first to our knowledge to describe patient and treatment characteristics of pregnant patients with acute PE cared for as outpatients. Each received 6–12 h of medical care prior to discharge (*Table 3*). This allowed confirmation of haemodynamic stability and outpatient eligibility, as well as time for patient education on anticoagulation and indications for seeking medical care (*Figure 1*).[2] After discharge, both patients received timely follow-up and completed their antenatal course without complications.

What is outpatient management of antenatal pulmonary embolism?

We provisionally defined outpatient antenatal PE care as clinic-only care or discharge home from the ED or L&D within 24 h of registration. For ambulatory non-gravid patients with acute PE, outpatient management has been variously defined.[14] Some definitions are site-of-care specific (e.g. clinic- or ED-only), while others include a temporal component (often <24 h of observation).[1–3] Professional societies have not defined outpatient care for antenatal PE.[7,9,10] Since L&D is an inpatient unit, an L&D evaluation usually constitutes a hospitalization, except in settings with ED-based or outpatient L&D triage. For this report, we combined site-of-care with duration-of-care parameters to allow a 24-h ED or L&D stay before discharge home, a period of time that serves several important roles, enumerated in *Figure 1*.

Why might outpatient care be preferable in eligible patients?

The evidence for the benefits of outpatient PE management is drawn from studies of non-gravid patients. In that population, outpatient treatment is associated with higher patient satisfaction and social functioning without negative impact on outcomes, sparing patients the inconvenience, costs, and risks associated with unnecessary inpatient care.[1,15] The benefits of outpatient care extend beyond the participating patients to the larger healthcare system. Avoiding tying up ED and hospital beds helps direct limited healthcare resources to sicker patients who need them (*Figure 1*). These advantages undergird professional society recommendations for outpatient PE treatment of pregnant and non-pregnant patients with low-risk characteristics.[5–7,9]

Who may be eligible for outpatient care?

Eligibility criteria for outpatient PE management have not been studied in gravid patients as they have in their non-gravid counterparts.[1,2] Given the scarcity of research, eligibility recommendations from society guidelines represent reasonable expert opinion inferred from non-pregnant populations (*Table 1*). Home-going pregnant patients should have low-risk characteristics and be able to be cared for at home, with ready access to needed pharmacotherapy, timely follow-up care, and availability of emergency care, if needed (*Figure 1*).[6,16]

Both cases in this series had low-risk characteristics, lacking nearly all the higher-risk characteristics for non-gravid patients delineated in the PE Severity Index and Hestia criteria, pregnancy excepted (*Tables 2* and *3*), as well as meeting outpatient eligibility criteria of ACOG (*Tables 1* and *3*). According to ASH guidelines, both patients also had two contraindications to outpatient care: advanced maternal age and an abnormal vital sign, namely, sinus tachycardia (*Table 1*).[7] We agree with the treating physicians that advanced age alone (here 35 and 37 years, respectively) was not a sufficient reason to forgo outpatient management. We also agree that isolated tachycardia in an otherwise low-risk patient may not routinely require inpatient care. Heart rates are known to elevate throughout pregnancy, but not normally to the extent illustrated here: up to 113 in the first-trimester case and 133 in the third-trimester case.[17,18] Reassuringly, their tachycardia was not accompanied by indications of right heart enlargement or dysfunction on 12-lead electrocardiography, CTPA, or serum biomarkers. In addressing non-gravid patients with acute PE, the ESC guidelines recommended outpatient treatment for low-risk patients, i.e. haemodynamic stable patients in PE Severity Index Classes I–II with the absence of radiologic and biomarker evidence of right ventricular strain (*Table 5*),[5] criteria that could be adapted for the pregnant population.

Other promising risk scores already designed for the unique physiology of pregnancy are vital sign scoring systems that alert clinicians of impending clinical deterioration among gravid patients, e.g. the new Maternal Early Warning Score (MEWS).[18] These have not been well tested among patients with antenatal PE, but their counterpart scores used in non-gravid populations perform well in predicting early deterioration in acute PE.[19] The absence of worrisome vital sign parameters in MEWS, for example, could objectively corroborate clinical impressions that low-risk patients were eligible for outpatient care.

In both of our cases, outpatient management was a safe course of action. The safety of outpatient care is best assessed by lack of short-term cardiopulmonary decompensation within the first 5–10 days.[3,20] A PE-related complication beyond this early treatment period is unlikely to have been prevented or mitigated by 2–3 days of initial hospitalization. Neither patient had an early complication following discharge, nor throughout the remainder of their pregnancy. Case 1 experienced a delayed postpartum haemorrhage, which occurred 5 months after PE diagnosis and was unrelated to initial site-of-care selection.

Several health system characteristics facilitated outpatient care of these two pregnant patients with acute PE. First, the diagnosticians had prognostic testing capabilities and specialists at hand to assist with risk stratification and site-of-care decision-making. Second, patients were health plan members with ready access to necessary pharmacotherapy and timely follow-up care with outpatient clinicians, as well as around-the-clock access to call centre advice nurses and ED care if needed. Moreover, the system had experience with outpatient PE treatment of non-gravid patients from the ED and primary care clinics.[3,4] Healthcare settings without these characteristics might not be as prepared for outpatient management of antenatal PE.

Home vital sign monitoring devices might bolster a health system's ability to ensure their patients' continued low-risk status in the days following discharge. Although not studied, home monitoring tools could serve as adjuncts to symptom self-surveillance, detecting early changes in pulse oximetry and heart rate, as had been done successfully during home treatment of patients with COVID-19. Device-detected vital sign changes have helped alert diagnosticians to the development of post-operative PE. There may be a similar role for vital sign monitoring devices to help detect PE expansion and recurrence.

Research on outpatient antenatal pulmonary embolism management

The paucity of described cases of outpatient antenatal PE care in the literature prevented us from undertaking comparisons. Little has been published on outpatient treatment in pregnant patients. The 2018 ASH guidelines[7] identified only one peer-reviewed study, a 2007 multicentre prospective UK observational study of 110 gravid patients with acute VTE, 16 of whom were treated as outpatients.[8] The investigators did not specify if any of these 16 outpatients had acute PE. Moreover, characteristics of the outpatient sub-cohort were not

Table 5 European Society of Cardiology classification of pulmonary embolism severity and the risk of early (in-hospital or 30 day) death[5]

Early mortality risk	Indicators of risk			
	Haemodynamic instability[a]	Clinical parameters of PE severity and/or comorbidity: PESI Classes III and V or sPESI ≥ 1	RV dysfunction on TTE or CTPA[b]	Elevated cardiac troponin levels[c]
High	+	[+][d]	+	[+]
Intermediate				
Intermediate-high	–	+[e]	+	+
Intermediate-low	–	+[e]	One [or none] positive	
Low	–	–	–	Assessment optional, if assessed, negative

Copyright Oxford University Press. Used with permission.
BP, blood pressure; CTPA, computed tomography pulmonary angiography; H-FABP, heart-type fatty acid-binding protein; NT-proBNP, N-terminal pro B-type natriuretic peptide; PE, pulmonary embolism; PESI, Pulmonary Embolism Severity Index; RV, right ventricular; sPESI, simplified Pulmonary Embolism Severity Index; TTE, transthoracic echocardiogram.
[a]One of the following clinical presentations (see table 4 in Konstantinides *et al.*[5]): cardiac arrest, obstructive shock (systolic BP < 90 mmHg or vasopressors required to achieve a BP of ≥90 mmHg despite an adequate filling status, in combination with end-organ hypoperfusion), or persistent hypotension (systolic BP < 90 mmHg or a systolic BP drop of ≥40 mmHg for >15 min, not caused by new-onset arrhythmia, hypovolaemia, or sepsis).
[b]Prognostically relevant imaging (TTE or CTPA) findings in patients with acute PE, and the corresponding cut-off levels, are graphically presented in Figure 3 in Konstantinides *et al.*[5], and their prognostic value is summarized in Supplementary Data Table 3 in Konstantinides *et al.*[5]
[c]Elevation of further laboratory biomarkers, such as NT-proBNP ≥ 600 ng/L, H-FABP ≥ 6 ng/mL, or copeptin ≥ 24 pmol/L, may provide additional prognostic information. These markers have been validated in cohort studies, but they have not yet been used to guide treatment decisions in randomized controlled trials.
[d]Haemodynamic instability, combined with PE confirmation on CTPA and/or evidence of RV dysfunction on TTE, is sufficient to classify a patient into the high-risk PE category. In these cases, neither calculation of the PESI nor measurement of troponins or other cardiac biomarkers is necessary.
[e]Signs of RV dysfunction on TTE (or CTPA) or elevated cardiac biomarker levels may be present, despite a calculated PESI of I and II or an sPESI of 0. Until the implications of such discrepancies for the management of PE are fully understood, these patients should be classified into the intermediate-risk category.

presented, precluding an assessment of whether those selected for outpatient care had low-risk characteristics. Treatment was often provided by an obstetrician or haematologist or both. Emergency physicians were not involved, unless they fell in the category of generalists, who saw 26% of the cohort. The nature of follow-up was not reported. None of the 110 patients experienced recurrent VTE or death, although the time course was not described. Besides this one study, the ASH guidelines also identified a short abstract in the literature, a small single-centre Canadian study of 22 pregnant patients with acute VTE, 16 of whom were treated as outpatients.[7] As with the UK study, this also failed to specify the number of patients who had PE and not isolated DVT.

Far more research is needed on this understudied topic of PE management. In light of the dearth of evidence in support of outpatient care of antenatal PE, ASH recommended that 'studies examining rates of hospital admission after initiation of outpatient therapy in pregnant patients should be undertaken' to help inform decision-making 'to identify pregnant patients who require hospital admission for initial management'.[7] We hope this case series is the first of many studies addressing this important gap in the literature and helping expand safe outpatient PE management to the low-risk pregnant population.

Patient's perspective

Case 1

I received very thorough care in the ER, including evaluations by several different specialists. The team was careful to make sure I was in good condition and explained everything to me, plus they booked follow-up appointments before letting me go. I'm glad I didn't have to stay. I was ready to go home and recover where I would be much more comfortable.

Lead author biography

David R. Vinson is a senior emergency physician with The Permanente Medical Group, an adjunct investigator with the Kaiser Permanente Division of Research, and a co-chair of the CREST Network in Oakland, California (https://www.kpcrest.net). His primary research seeks to improve the care of patients with pulmonary embolism and of patients with atrial fibrillation and flutter. He also enjoys mentoring undergraduates, medical students, residents, and junior faculty via collaborative research projects.

Acknowledgements

We would like to thank our two patients for their enthusiastic participation and The Permanente Medical Group for their strong support of clinical research.

Consent: The authors confirm, in line with COPE guidance, that written consent for the submission and publication of this case series has been obtained from both patients.

Conflict of interest: None declared.

Funding: This work was supported by the Kaiser Permanente Northern California Community Health Programme (2023 #212226).

Data availability

Additional data underlying this article will be shared on reasonable request to the corresponding author.

References

1. Roy PM, Penaloza A, Hugli O, Klok FA, Arnoux A, Elias A, et al. Triaging acute pulmonary embolism for home treatment by Hestia or simplified PESI criteria: the HOME-PE randomized trial. *Eur Heart J* 2021;**42**:3146–3157.
2. Vinson DR, Aujesky D, Geersing GJ, Roy PM. Comprehensive outpatient management of low-risk pulmonary embolism: can primary care do this? A narrative review. *Perm J* 2020;**24**:19.163.
3. Vinson DR, Mark DG, Chettipally UK, Huang J, Rauchwerger AS, Reed ME, et al. Increasing safe outpatient management of emergency department patients with pulmonary embolism: a controlled pragmatic trial. *Ann Intern Med* 2018;**169**:855–865.
4. Vinson DR, Hofmann ER, Johnson EJ, Rangarajan S, Huang J, Isaacs DJ, et al. Management and outcomes of adults diagnosed with acute pulmonary embolism in primary care: community-based retrospective cohort study. *J Gen Intern Med* 2022;**37**:3620–3629.
5. Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, et al. 2019 ESC guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). *Eur Heart J* 2020;**41**:543–603.
6. Stevens SM, Woller SC, Kreuziger LB, Bounameaux H, Doerschug K, Geersing GJ, et al. Antithrombotic therapy for VTE disease: second update of the CHEST guideline and expert panel report. *Chest* 2021;**160**:e545–e608.
7. Bates SM, Rajasekhar A, Middeldorp S, McLintock C, Rodger MA, James AH, et al. American Society of Hematology 2018 guidelines for management of venous thromboembolism: venous thromboembolism in the context of pregnancy. *Blood Adv* 2018;**2**:3317–3359.
8. Voke J, Keidan J, Pavord S, Spencer NH, Hunt BJ, British Society for Haematology Obstetric Haematology Group. The management of antenatal venous thromboembolism in the UK and Ireland: a prospective multicentre observational survey. *Br J Haematol* 2007;**139**:545–558.
9. American College of Obstetricians and Gynecologists. ACOG practice bulletin no. 196: thromboembolism in pregnancy. *Obstet Gynecol* 2018;**132**:e1–e17.
10. Howard L, Barden S, Condliffe R, Connolly V, Davies CWH, Donaldson J, et al. British Thoracic Society guideline for the initial outpatient management of pulmonary embolism (PE). *Thorax* 2018;**73**:ii1–ii29.
11. Zondag W, Mos IC, Creemers-Schild D, Hoogerbrugge AD, Dekkers OM, Dolsma J, et al. Outpatient treatment in patients with acute pulmonary embolism: the Hestia study. *J Thromb Haemost* 2011;**9**:1500–1507.
12. Aujesky D, Roy PM, Verschuren F, Righini M, Osterwalder J, Egloff M, et al. Outpatient versus inpatient treatment for patients with acute pulmonary embolism: an international, open-label, randomised, non-inferiority trial. *Lancet* 2011;**378**:41–48.
13. Leung AN, Bull TM, Jaeschke R, Lockwood CJ, Boiselle PM, Hurwitz LM, et al. An official American Thoracic Society/Society of Thoracic Radiology clinical practice guideline: evaluation of suspected pulmonary embolism in pregnancy. *Am J Respir Crit Care Med* 2011;**184**:1200–1208.
14. Shan J, Isaacs DJ, Bath H, Johnson EJ, Julien D, Vinson DR. "Outpatient management" of pulmonary embolism defined in the primary literature: a narrative review. *Perm J* 2021;**25**:20.303.
15. Roy PM, Corsi DJ, Carrier M, Theogene A, de Wit C, Dennie C, et al. Net clinical benefit of hospitalization versus outpatient management of patients with acute pulmonary embolism. *J Thromb Haemost* 2017;**15**:685–694.
16. Kabrhel C, Vinson DR, Mitchell AM, Rosovsky RP, Chang AM, Hernandez-Nino J, et al. A clinical decision framework to guide the outpatient treatment of emergency department patients diagnosed with acute pulmonary embolism or deep vein thrombosis: results from a multidisciplinary consensus panel. *J Am Coll Emerg Physicians Open* 2021;**2**:e12588.
17. Green LJ, Mackillop LH, Salvi D, Pullon R, Loerup L, Tarassenko L, et al. Gestation-specific vital sign reference ranges in pregnancy. *Obstet Gynecol* 2020;**135**:653–664.
18. Gerry S, Bedford J, Redfern OC, Rutter H, Chester-Jones M, Knight M, et al. Development of a national maternity early warning score: centile based score development and Delphi informed escalation pathways. *BMJ Med* 2024;**3**:e000748.
19. Bavalia R, Stals MAM, Mulder FI, Bistervels IM, Coppens M, Faber LM, et al. Use of the National Early Warning Score for predicting deterioration of patients with acute pulmonary embolism: a post-hoc analysis of the YEARS study. *Emerg Med J* 2023;**40**:61–66.
20. Kabrhel C, Sacco W, Liu S, Hariharan P. Outcomes considered most important by emergency physicians when determining disposition of patients with pulmonary embolism. *Int J Emerg Med* 2010;**3**:239–264.