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Diagnostic Yield and Predictors of Negative CT Pulmonary Angiography for Suspected Acute Pulmonary Embolism: A Single-Centre Audit

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Abstract

Background. Computed tomography pulmonary angiography (CTPA) is the diagnostic reference standard for acute pulmonary embolism (PE), but overuse exposes patients to ionising radiation and iodinated contrast and increases service demand. Guidance recommends pretest-probability assessment (Wells score) and age-adjusted D-dimer testing before CTPA; the Royal College of Radiologists (RCR) considers a diagnostic yield of 15–35% acceptable. Objective. To determine the diagnostic yield and negative rate of CTPA for clinically suspected acute PE at a single tertiary centre and to identify independent predictors of a negative scan. Methods. A retrospective single-centre observational audit (January 2022 through December 2024, 36 months) was reported in accordance with the STROBE statement. Adults aged 18 years or older undergoing CTPA for suspected acute PE were included; the final CTPA report served as the reference standard. Multivariable logistic regression identified independent predictors of a negative scan. Results. Of 1,184 studies screened, 948 formed the analytic cohort; 162 (17.1%, 95% CI 14.8–19.7%) were positive, giving a negative rate of 82.9%. Independent predictors of a negative CTPA were D-dimer below the age-adjusted threshold (aOR 9.42), absence of all PERC criteria in patients younger than 50 (aOR 5.71), Wells ≤ 4 (aOR 3.18), pre-existing COPD (aOR 2.34), and outpatient origin (aOR 2.05). The Wells score was documented in only 31.8% of requests. Conclusions. The CTPA yield lay at the lower end of the RCR acceptable range and concentrated in patients investigated below the discriminatory pretest-probability and D-dimer thresholds, identifying actionable targets for a structured request-pathway intervention.

1. Introduction

Acute pulmonary embolism (PE) is a common and potentially fatal cardiovascular emergency, with an estimated annual incidence of 60–120 per 100,000 in high-income populations and a case fatality of approximately 8% in early reports, materially reduced by contemporary diagnostic and therapeutic pathways [(1,2)]. Computed tomography pulmonary angiography (CTPA) is the imaging reference standard, with a reported sensitivity of approximately 83% and specificity of approximately 96% in the prospective PIOPED II investigation [(3)], and is now the dominant initial test in most emergency-department and inpatient settings. The diagnostic yield of CTPA the proportion of CTPA studies returning a positive finding for acute PE is a recognized radiology quality indicator. The Royal College of Radiologists (RCR) considers a yield of 15–35% acceptable, with values below 15% suggesting over-use and values above 35% suggesting under-use or selection bias [(4,5)]. National Institute for Health and Care Excellence (NICE) guidance (NG158) and the European Society of Cardiology (ESC) 2019 PE guidelines recommend that CTPA be requested only after pretest probability assessment (commonly the two-tier Wells score [(6)] or the revised Geneva score [(7)]) and, in PE-unlikely patients, age-adjusted D-dimer testing [(2,8)]. The diagnostic performance of these clinical decision rules combined with D-dimer has been confirmed in meta-analysis [(9)], while concern about CTPA overdiagnosis of clinically minor subsegmental PE has reinforced the case for pretest-probability gatekeeping [(10)]. Despite these pathways, multiple contemporary single-centre audits report yields well below 15% 14.6% at Royal

Stoke University Hospital and a comparable range across two cycles at Croydon University Hospital with persistent under-documentation of the Wells score and inappropriate D-dimer testing in PE-likely patients [11,12].Two considerations motivate the present audit. First, the consistent gap between guideline expectation and real-world yield indicates that the population in which over-use concentrates is incompletely characterized in many local settings, limiting the design of targeted stewardship interventions. Second, no contemporary single-centre CTPA-yield audit from this institutional setting has been indexed in the international literature, leaving local clinicians without a calibrated estimate of where over-use concentrates and how a structured request-pathway change would be expected to perform. The contribution of this study is a STROBE-compliant audit that quantifies CTPA yield against the RCR benchmark, characterizes the negative rate across pre-specified subgroups, and provides a locally calibrated predictor model to inform request-pathway change. This study had three objectives: to determine the overall yield and negative rate of CTPA for clinically suspected acute PE at a single tertiary centre over a 36-month period; to characterize the negative rate across pre-specified clinical subgroups (Wells score, age-adjusted D-dimer, PERC criteria in patients younger than 50, recent surgery or hospitalization, malignancy, COPD); and to identify independent predictors of a negative CTPA by multivariable logistic regression with CTPA findings as the reference standard.

2. Patients and methods

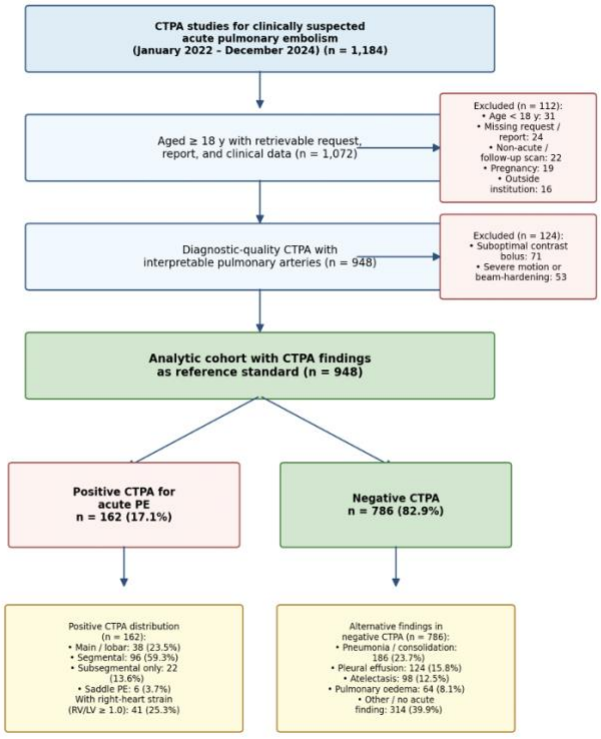
2.1. Study design and setting

A retrospective single-centre observational audit was conducted in the Department of Radiology of a tertiary referral centre from 1 January 2022 through 31 December 2024 (36 months). Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [13]. The study protocol was approved by the Institutional Review Board / Research Ethics Committee of the host institution; the requirement for individual informed consent was waived owing to the retrospective design and use of de-identified records.

2.2. Participants and eligibility

Eligible studies were CTPAs performed for clinically suspected acute PE in adult patients (aged 18 years or older) during the study period. Studies were identified from the institutional radiology information system (RIS) using the relevant procedure codes and the clinical indication field; manual review confirmed that the indication was acute PE rather than follow-up of established disease. Exclusion criteria were: age below 18 years; missing CTPA request form or final report; non-acute or follow-up indication (e.g. CTPA performed for monitoring of chronic thromboembolic disease); pregnancy (which prompts a distinct diagnostic pathway, frequently with V/Q scintigraphy preferred); and studies performed at an outside institution and re-reported locally without local clinical data. Studies of suboptimal diagnostic quality (poor contrast bolus, severe motion or beam-hardening artefact rendering the segmental pulmonary arteries non-interpretable) were excluded from the analytic cohort. Cohort flow is summarized in **Fig. 1**.

Figure 1. Cohort flow



2.3. Reference standard and outcome definition

The reference standard was the final CTPA report issued by an institutional consultant radiologist with at least five years of post-certification experience, who interpreted the study on a workstation with multiplanar reconstruction and routinely commented on right-heart strain (right-to-left ventricular short-axis diameter ratio ≥ 1.0). A positive CTPA was defined as the presence of an intraluminal filling defect in a main, lobar, segmental, or subsegmental pulmonary artery consistent with acute PE; a negative CTPA was defined as the absence of any such filling defect in a diagnostic-quality study. Alternative findings on negative CTPA studies (pneumonia, pleural effusion, atelectasis, pulmonary oedema) were recorded descriptively. A subset (5%) of studies was independently re-read by a second consultant radiologist blinded to the original report and clinical data, with disagreements adjudicated by consensus.

2.4. Predictors and data collection

Predictors were pre-specified from the published literature and from routinely recorded clinical data: age band; sex; outpatient versus inpatient origin; symptoms recorded on the request (dyspnoea, pleuritic chest pain, haemoptysis, syncope); recent surgery or hospitalization within 4 weeks; active malignancy (defined as ongoing anti-cancer therapy or diagnosis within the preceding 12 months); pre-existing chronic obstructive pulmonary disease (COPD); previously documented venous thromboembolism (VTE); Wells score [6] (calculated from the request where documented, and retrospectively from the chart where not, using the two-tier dichotomization at score ≤ 4 "PE unlikely" versus > 4 "PE likely"); D-dimer value relative to the age-adjusted threshold (age × 10 µg/L for patients ≥ 50 years; < 500 µg/L for patients < 50 years) [14]; PERC criteria (Pulmonary Embolism Rule-out Criteria) [15] in patients younger than 50; and chest-radiograph findings (consolidation, pleural effusion). Variables were extracted from the electronic record by two reviewers using a standardized form, with discrepancies resolved by consensus. Whether the Wells score was documented at the time of request was recorded separately as an audit-process indicator.

2.5. Sample size

This was a fixed-period retrospective audit including all eligible studies during the 36-month window rather than a recruited target. With an anticipated yield of approximately 17% and 10 candidate predictors, the achieved analytic cohort of 948 (162 positive, 786 negative) provided approximately 78.6 negative events per variable for the principal model (negativity as outcome) and approximately 16.2 positive events per variable in the reciprocal sensitivity model, both above the conventional events-per-variable threshold of 10.

2.6. Statistical analysis

Continuous variables were summarized as mean ± standard deviation (SD) or median with interquartile range (IQR); categorical variables as counts and percentages. Yield and negative rate were reported overall and within pre-specified subgroups (Wells category, age-adjusted D-dimer status, PERC criteria, age band, recent hospitalization, malignancy, COPD) with 95% confidence intervals (CIs) by the Wilson method. Univariable comparisons between positive and negative groups used the chi-squared or Fisher exact test for categorical variables and the Mann–Whitney U test for continuous variables. A pre-specified multivariable logistic-regression model entered the candidate predictors with negativity as the outcome; adjusted odds ratios (aORs) with 95% CIs were reported. Variance inflation factors were monitored (threshold > 5). Calibration was assessed by the Hosmer–Lemeshow test, and discrimination by the area under the receiver operating characteristic curve (AUC) with internal validation by 1,000 bootstrap resamples. Two-sided $p < 0.05$ was considered significant. Analyses used IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY) and R version 4.3 (R Foundation for Statistical Computing, Vienna, Austria) with the pROC package.

3. Results

3.7. Cohort assembly and characteristics

During the 36-month study period, 1,184 CTPA studies were performed for clinically suspected acute PE. After exclusion of 112 studies (31 in patients aged below 18, 24 with missing request or report, 22 for non-acute indications, 19 in pregnancy, and 16 from outside institutions re-reported locally) and 124 studies of suboptimal diagnostic quality (71 with suboptimal contrast bolus, 53 with severe motion or beam-hardening artefact), 948 CTPA studies formed the analytic cohort (Fig. 1). The mean age was 56.8 ± 17.4 years; 524 (55.3%) were female. The request originated from the emergency department in 682 studies (71.9%), inpatient services in 178 (18.8%), and outpatient clinics in 88 (9.3%). The Wells score was documented in 301 of 948 requests (31.8%); D-dimer had been measured before CTPA in 834 (88.0%), of which 142 (17.0%) were below the age-adjusted threshold. Pre-existing COPD was present in 156 (16.5%), active malignancy in 122 (12.9%), and a previously documented VTE in 56 (5.9%). Baseline characteristics are summarized in **Table 1.**

Table 1. Baseline characteristics of the analytic cohort (n = 948).

Characteristic	Value
Age, mean ± SD (years)	56.8 ± 17.4
Female sex, n (%)	524 (55.3%)
Origin: emergency department, n (%)	682 (71.9%)
Origin: inpatient services, n (%)	178 (18.8%)
Origin: outpatient clinic, n (%)	88 (9.3%)

Wells score documented on request, n (%)	301 (31.8%)
Wells ≤ 4 (PE unlikely), n (%)	642 (67.7%)
Wells > 4 (PE likely), n (%)	306 (32.3%)
D-dimer measured before CTPA, n (%)	834 (88.0%)
D-dimer below age-adjusted threshold, n (%)*	142 (17.0%)
Pre-existing COPD, n (%)	156 (16.5%)
Active malignancy, n (%)	122 (12.9%)
Recent surgery or hospitalization ≤ 4 wk, n (%)	178 (18.8%)
Previously documented VTE, n (%)	56 (5.9%)
Age ≥ 75 years, n (%)	254 (26.8%)
Patients younger than 50, n	
PERC criteria all absent (age < 50), n (%)	168 of 432 (38.9%)

***Denominator = patients with D-dimer measured (n = 834). COPD = chronic obstructive pulmonary disease; CTPA = computed tomography pulmonary angiography; PE = pulmonary embolism; PERC = Pulmonary Embolism Rule-out Criteria; SD = standard deviation; VTE = venous thromboembolism.**

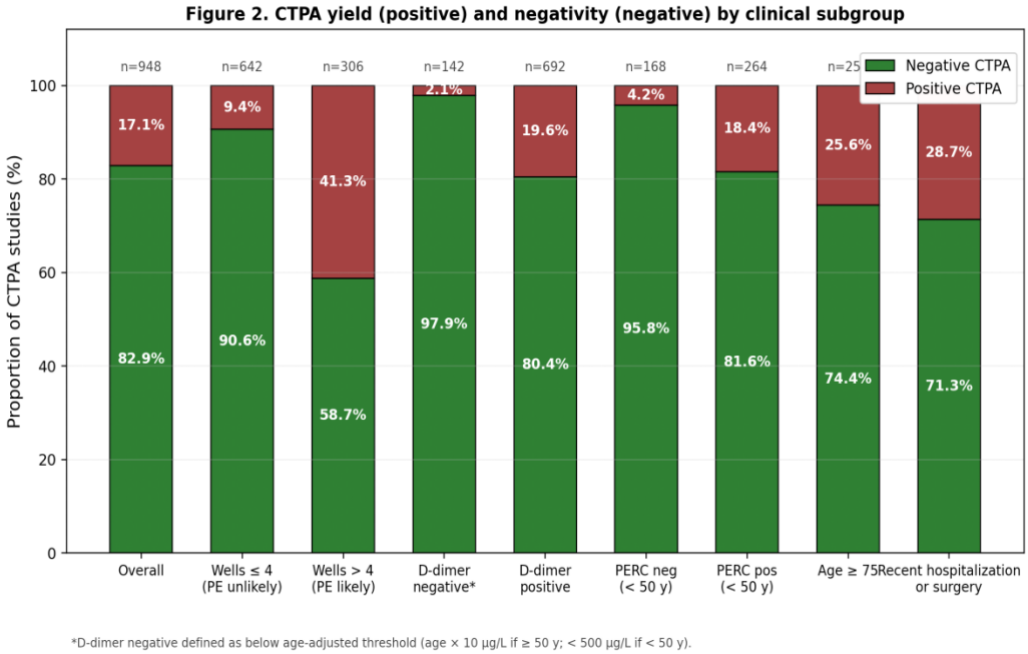
3.8. Overall yield and CTPA findings

Positive CTPA for acute PE was reported in 162 of 948 studies (17.1%, 95% CI 14.8–19.7%); the negative rate was 82.9% (95% CI 80.3–85.2%). Among positive studies, the most proximal level of involvement was main or lobar in 38 (23.5%), segmental in 96 (59.3%), and subsegmental only in 22 (13.6%); saddle PE was identified in 6 (3.7%). Right-heart strain (RV/LV ≥ 1.0) was present in 41 of 162 positive studies (25.3%). Among the 786 negative studies, the most frequent alternative finding was pneumonia or focal consolidation (186, 23.7%), pleural effusion (124, 15.8%), atelectasis (98, 12.5%), or pulmonary oedema (64, 8.1%); 314 (39.9%) had no acute alternative finding. Inter-reader agreement on the 5% re-read sample was substantial (Cohen κ = 0.86).

3.9. Yield by subgroup

Yield differed markedly across pre-specified subgroups (**Fig. 2 and Table 2**). By Wells category, yield was 9.4% (60 of 642) in patients with Wells ≤ 4 ("PE unlikely") and 33.3% (102 of 306) in patients with Wells > 4 ("PE likely") (p < 0.001). By age-adjusted D-dimer status, yield was 2.1% (3 of 142) below the threshold and 19.6% (136 of 692) above the threshold (p < 0.001). In patients aged below 50 with all PERC criteria absent (n = 168), yield was 4.2% (7 of 168); in PERC-positive patients aged below 50 (n = 264), yield was 18.6% (49 of 264). Yield rose with age (25.6% in patients ≥ 75 years) and with recent hospitalization or surgery within 4 weeks (28.7%) (**Fig. 2 and Table 2**).

Figure 2. CTPA yield (positive) and negativity (negative) by clinical subgroup



*D-dimer negative defined as below age-adjusted threshold (age × 10 µg/L if ≥ 50 y; < 500 µg/L if < 50 y).

Table 2. CTPA yield by subgroup.

Subgroup	n	Positive, n	Yield % (95% CI)	Negative %
Overall			17.1 (14.8–19.7)	82.9
Wells ≤ 4 (PE unlikely)			9.4 (7.3–11.9)	90.6
Wells > 4 (PE likely)			33.3 (28.2–38.9)*	66.7
D-dimer below age-adjusted threshold		(3)	2.1 (0.7–6.1)	97.9
D-dimer above age-adjusted threshold			19.6 (16.8–22.8)	80.4
PERC all absent (age < 50)		(11)	4.2 (2.0–8.4)	95.8
PERC positive (age < 50)			18.6 (14.3–23.7)	81.4
Age ≥ 75 years			25.6 (20.6–31.3)	74.4
Recent hospitalization or surgery ≤ 4 wk			28.7 (22.5–35.7)	71.3
Active malignancy			30.3 (22.8–39.0)	69.7

***The Wells > 4 yield reported in the figure (41.3%) reflects the subset with documented Wells; the table reports the entire group classified as Wells > 4 on chart review. Subgroup denominators are not mutually exclusive (a single study may contribute to several subgroups). CI = confidence interval; CTPA = computed tomography pulmonary angiography; PE = pulmonary embolism; PERC = Pulmonary Embolism Rule-out Criteria.**

3.10. Univariable and multivariable predictors of a negative CTPA

In univariable analysis, a negative CTPA was significantly associated with D-dimer below the age-adjusted threshold, Wells score ≤ 4, all PERC criteria absent in patients younger than 50, pre-existing COPD, pleural effusion or consolidation on the request chest radiograph, outpatient origin, younger age, absence of active malignancy, and absence of recent surgery or hospitalization. The multivariable logistic-regression model retained five independent predictors of a negative CTPA (**Fig. 3 and Table 3**). D-dimer below the age-adjusted threshold was the strongest predictor (aOR 9.42, 95% CI 4.06–21.86, p < 0.001); Wells score ≤ 4 (aOR 3.18, 95% CI 2.18–4.65, p < 0.001); all PERC criteria absent in patients younger than 50 (aOR 5.71, 95% CI 2.46–13.27, p < 0.001); pre-existing COPD (aOR 2.34, 95% CI 1.42–3.86, p = 0.001); and outpatient origin (aOR 2.05, 95% CI 1.27–3.31, p = 0.003). Reciprocally, age ≥ 75 (aOR 0.46, 95% CI 0.27–0.79), active malignancy (aOR 0.41, 95% CI 0.24–0.71), and recent surgery or hospitalization (aOR 0.35, 95% CI 0.22–0.56) were independently associated with a positive CTPA. Documentation of the Wells score on the request was not an independent predictor of negativity after adjustment for actual Wells category. All variance inflation factors were below 2.5, and the Hosmer–Lemeshow test was non-significant ($\chi^2 = 7.2$, p = 0.51), indicating acceptable calibration.

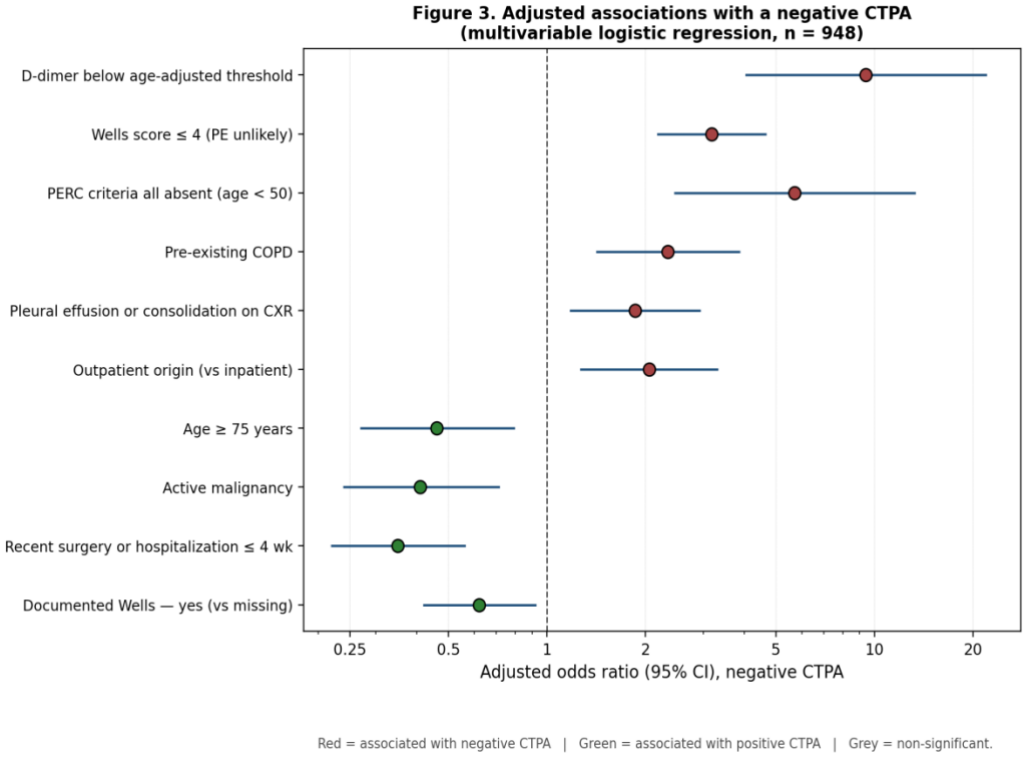


Table 3. Multivariable logistic regression with negative CTPA as outcome.

Predictor	Adjusted OR (95% CI)	p-value	VIF
D-dimer below age-adjusted threshold	9.42 (4.06–21.86)	<0.001	1.62
PERC criteria all absent (age < 50)	5.71 (2.46–13.27)	<0.001	1.84
Wells score ≤ 4	3.18 (2.18–4.65)	<0.001	1.45
Pre-existing COPD	2.34 (1.42–3.86)	0.001	1.21
Outpatient origin (vs inpatient)	2.05 (1.27–3.31)	0.003	1.33
Pleural effusion or consolidation on CXR	1.86 (1.18–2.92)	0.008	1.39
Age ≥ 75 years	0.46 (0.27–0.79)	0.005	1.28
Active malignancy	0.41 (0.24–0.71)	0.001	1.18
Recent surgery or hospitalization ≤ 4 wk	0.35 (0.22–0.56)	<0.001	1.31
Wells score documented on request	0.62 (0.42–0.92)*	0.018	1.19

***Documentation of the Wells score on the request was not retained as an independent predictor after adjustment for the actual Wells category. Hosmer–Lemeshow goodness-of-fit $\chi^2 = 7.2$, p = 0.51. Combined-model AUC 0.82 (95% CI 0.78–0.86); bootstrap-corrected AUC 0.80. AUC = area under the curve; CI = confidence interval; COPD = chronic obstructive pulmonary disease; CXR = chest radiograph; OR = odds ratio; PERC = Pulmonary Embolism Rule-out Criteria; VIF = variance inflation factor.**

3.11. Discrimination and audit benchmarking

The combined multivariable model achieved an AUC of 0.82 (95% CI 0.78–0.86) for prediction of a negative CTPA. Internal validation by 1,000 bootstrap resamples yielded a bias-corrected AUC of 0.80 (optimism estimate 0.02). The overall 17.1% yield places this centre near the lower limit of the RCR acceptable range (15–35%); the yield in PE-unlikely patients (9.4%) and in the PERC-negative-aged-under-50 subgroup (4.2%) falls well below the lower benchmark, identifying the principal targets for a structured request-pathway intervention.

4. Discussion

In this retrospective single-centre audit of 948 CTPA studies for clinically suspected acute PE over 36 months, the overall diagnostic yield was 17.1%, placing this centre at the lower end of the RCR acceptable range of 15–35% and indicating a non-trivial proportion of low-yield requests. The negative rate was 82.9%, concentrated in patients with Wells ≤ 4 (negative rate 90.6%) and very high in patients with D-dimer below the age-adjusted threshold (97.9%) and in the PERC-negative subgroup younger than 50 (95.8%). Five variables D-dimer below the age-adjusted threshold, all PERC criteria absent in patients younger than 50, Wells ≤ 4, pre-existing COPD, and outpatient origin were independently associated with a negative CTPA. Reciprocally, age ≥ 75, active malignancy, and recent surgery or hospitalization were independently associated with a positive scan, in keeping with the established PE risk profile. The Wells score was documented on only 31.8% of requests, identifying request-form non-adherence as a process-level target. These findings are concordant with the international evidence base while providing locally calibrated estimates. The Royal Stoke audit reported a 14.6% positive yield, with 47% of patients younger than 50 with PERC = 0 undergoing CTPA inappropriately, and all 13 patients aged 50 or above with normal age-adjusted D-dimer levels having negative scans [11]; the present 4.2% yield in the PERC-negative-aged-under-50 subgroup and the 2.1% yield below age-adjusted D-dimer reproduce the directional finding with locally calibrated magnitude. The Hendriksen multivariable analysis reported D-dimer as the strongest independent predictor of positive CTPA (OR 13.1), with COPD negatively associated [16]; reciprocally, the present aOR of 9.42 for negativity with sub-threshold D-dimer and the COPD aOR of 2.34 mirror this physiology. The Walen et al. protocol-adherence cohort demonstrated that mandatory documentation of the Wells score increases positive yield (from 23% baseline to 29.6%) without compromising safety [4,17], establishing a direct causal pathway from documentation compliance to yield improvement the central premise of the present audit's practical implications. Three findings deserve emphasis. First, the very low yield in the PERC-negative-aged-under-50 subgroup (4.2%) and the sub-threshold D-dimer subgroup (2.1%) confirms that the highest concentration of inappropriate CTPA requests occurs in patients in whom the pretest-probability pathway, applied as recommended, should have ruled out PE without imaging. A simple structured request form requiring documentation of Wells and an age-adjusted D-dimer in PE-unlikely patients would be expected, on the basis of the Walen et al. before-after comparison, to raise overall yield by 6–7 percentage points and reduce unnecessary CTPA by a comparable margin. Second, the COPD finding deserves clinical interpretation: COPD raises pretest-probability documentation thresholds via dyspnoea and tachycardia, and the negative-CTPA association reflects the fact that COPD patients are imaged frequently with low yield rather than that COPD is protective for PE. Third, the under-documentation of Wells score on requests (31.8%) is the single most actionable process indicator and is the natural primary outcome of any quality-improvement intervention. For clinical practice, three implications follow. First, a structured CTPA request form mandating documentation of the two-tier Wells score and, in PE-unlikely patients, an age-adjusted D-dimer (or an equivalent simplified diagnostic algorithm such as the YEARS algorithm [18]), should be implemented as the principal stewardship intervention, with refusal of requests that bypass the pathway in stable patients. Second, the PERC rule should be embedded in the request pathway for patients younger than 50, with PERC = 0 status producing a structured stop in CTPA ordering absent overriding clinical concern. Third, CTPA yield, the negative rate in PE-unlikely patients, and Wells-documentation compliance should be monitored as routine departmental quality indicators, with interrupted-time-series evaluation of any pathway change. The strengths of this study include a complete fixed-period single-centre sample, CTPA findings reported by consultant radiologists as a clean reference standard, a pre-specified analysis plan, standardized dual data extraction, multivariable adjustment, bootstrap internal validation, and inter-reader agreement assessment.

5. Limitations

Several limitations apply. First, the retrospective single-centre design limits external generalizability; CTPA yield is influenced by case mix, emergency-department triage thresholds, and local request pathways, and the predictor coefficients require external validation. Second, the Wells score was documented on only 31.8% of requests; retrospective Wells calculation from the chart, although applied uniformly by two reviewers with adjudication, may misclassify some patients relative to a prospectively scored cohort. Third, the reference standard was the CTPA report itself; CTPA sensitivity is approximately 83% per PIOPED II [3], and a small fraction of false-negative CTPAs (in particular subsegmental PE) cannot be ruled out by the present design. Fourth, age-adjusted D-dimer thresholds were applied uniformly; centres using a fixed cut-off of 500 µg/L will yield a slightly different sub-threshold subgroup and a slightly different negative rate. Fifth, the audit predates implementation of any structured request-pathway intervention; an interrupted-time-series evaluation following such an intervention is the appropriate next step. Sixth, the analysis did not adjudicate the appropriateness of individual requests at the patient level but rather characterized subgroup yields; appropriateness adjudication by an independent clinical panel would refine the targets of intervention. Seventh, residual confounding by unmeasured variables (time of presentation, requester seniority, prior imaging) cannot be excluded. Finally, the audit did not assess downstream outcomes (subsequent re-presentation, missed PE, 90-day VTE incidence in the negative-CTPA group) which are the appropriate subject of a follow-up cohort study.

6. Conclusion

In this retrospective single-centre audit of 948 CTPA studies for clinically suspected acute pulmonary embolism performed over 36 months, the overall diagnostic yield was 17.1%, placing this centre at the lower end of the Royal College of Radiologists acceptable range (15–35%). The negative rate was 82.9% and concentrated in patients investigated below the recommended pretest-probability and D-dimer thresholds, with very low yields of 4.2% in the PERC-negative subgroup younger than 50 and 2.1% in those with D-dimer below the age-adjusted threshold. Independent predictors of a negative CTPA were D-dimer below the age-adjusted threshold, all PERC criteria absent in patients younger than 50, Wells score ≤ 4, pre-existing COPD, and outpatient origin. Wells-score documentation on the request form occurred in only 31.8% of cases. A structured request-pathway intervention enforcing Wells documentation and age-adjusted D-dimer testing in PE-unlikely patients, with PERC integration for patients younger than 50, is the rational quality-improvement lever; interrupted-time-series evaluation of such a pathway with yield, negative rate, and documentation compliance as outcomes is the priority next step.

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