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Research Article

A Review of Adherence to Guidelines for the Use of Computed Tomography Pulmonary Angiography (CTPA) for the Diagnosis of Pulmonary Embolism

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Abstract

Introduction/Aim: We investigated the adherence to international guidelines for patient assessment of suspected pulmonary embolism (PE) who proceeded to computed tomography pulmonary angiography (CTPA). We aimed to compare compliance at our institution to other hospitals in Australasia and the established international guidelines for the appropriate use of CTPA.

Design: We conducted a retrospective audit of 100 patients with suspected PE who underwent CTPA between January 2015 and May 2015 in a secondary level hospital. The medical records were reviewed to assess the pre-test probability scores, clinical documentation of pre-test probability and additional clinical information.

Results: PE was observed in 26% of CTPA scans and only 3% of patients had a documented pre-test probability score. 5 other audits from Australasia demonstrated a similarly poor compliance (3 - 12%). D-dimer assays were unnecessarily ordered for 51/58 (88%) of high risk patients. Only 36/58 (62%) of high risk patients were appropriately started on anti-coagulant therapy before CTPA.

Conclusion: There continues to be poor utilization of formal pre-test probability prediction scores in New Zealand and Australia. Additional areas identified for improvement include careful assessment of CXR for alternate explanations for symptoms, appropriate requesting of D-dimer and identification and treatment of high risk patients who require immediate empirical anticoagulant therapy.

Keywords: *Pulmonary Embolism; CTPA; Pre-Test Probability*

Introduction

The diagnosis of acute pulmonary embolism (PE) poses a significant challenge to clinicians [1]. The combination of non-specific clinical features and laboratory investigations, coupled with the significant risk of morbidity and mortality in patients with a missed or delayed diagnosis often prompts clinicians to early investigation. The advent of computed tomography pulmonary angiography (CTPA) scanning has revolutionised the diagnosis of PE. CTPA is considered the definitive test for the diagnosis of PE, with a sensitivity of 83% and specificity of 96% [2-4]. The widespread availability and increased use of CTPA, as well as its decreasing diagnostic yield has prompted some researchers to suggest it is indiscriminately used [5]. Certainly, at our institution there has been a marked increase in the number of CTPA scans ordered and a concerning decline in the positivity rate (Figure 1). This is thought to be at least partly due to poor patient selection.

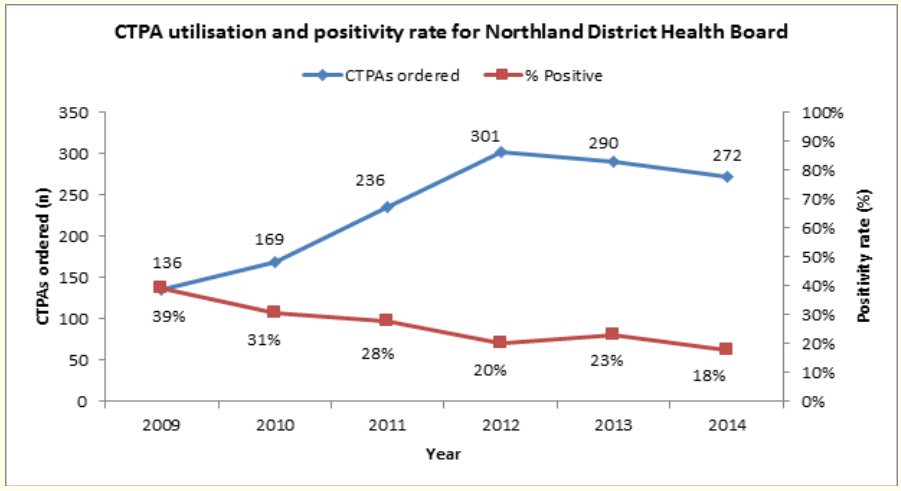

Figure 1: *Five years of data from Whangarei Hospital demonstrate a marked increase (mean increase of 16%/year over 6 years) in the utilization of CTPA, coupled with a reduction in the scan positivity rate. The mean annual increase in annual hospital presentations during this time was 3%.*

The use of CTPA is associated with several well-described drawbacks, especially radiation exposure, contrast-induced complication and cost. Depending on the equipment, protocol and patient, each scan is thought to be equivalent to approximately 3.6 years of background radiation or a 1 in 2000 absolute life-time risk of fatal cancer [6,7]. Contrast induced nephropathy, which occurs in 25% of patients, significantly increases the risk of severe renal failure or death from renal failure within 6 weeks [8,9]. Finally, the cost of a scan represents a notable opportunity cost to the health system. All of these are reasons to advocate for more judicious use of CTPA scans.

Application of pre-test probability scores using clinical decision rules such as the PERC rule, Geneva score and Wells' score can improve patient selection and increase diagnostic yields [10-13]. In patients with a low-risk Wells' score, a negative serum D-dimer finding has a negative predictive value of 99 - 100%, equivalent to that of a CTPA scan [14,15]. These tests have been shown to be considerably underutilized, as demonstrated in five Australasian audits, in which clinicians documented the pre-test probability score in less than 12% of patients [16-20].

The National Institute for Health and Care Excellence (NICE) and the European Society of Cardiology (ESC) guidelines provide a robust, evidence-based framework for the diagnosis and management of suspected PE [2,3].

The aim of this retrospective audit was to examine whether CTPA is appropriately used in the diagnostic work-up of patients with suspected PE by measuring adherence to these international guidelines. We also evaluated other recommendations that have not yet been incorporated into our local algorithm, including the time to CTPA and the accuracy of age-adjusted D-dimer thresholds. We also reviewed whether anticoagulants were empirically administered to high-risk patients before CTPA, an approach that has not been reported in any of the audits performed in Australasia to date.

Current standards: (Table 1)

No.	Criteria	Evidence Grade	Reference
Criteria derived from Whangarei Hosptial "Suspected PE" algorithm			
1	All patients with a suspected PE have a documented Wells' score	1B	ESC guidelines 2104 [3] NICE guidelines 2012 [2] RCR 2007 [7]
2	All low risk patients (Wells' score ≤4) are referred for a D-dimer	1A	ESC, NICE, RCR
3	No low-risk patient with a negative D-dimer (<500 mcg/L) is referred for CTPA	1A	ESC, NICE
4	High-risk patients (Wells' score> 4) should not be referred for a D-dimer	3B	ESC, NICE
5	CTPA positive yield between 15.4 and 37.4%	5	RCR
Evidence-based criteria not included in Whangarei Hospital "Suspected PE" algorithm.			
1	All CTPA scans should be completed within 24 hours of request	N/A	NICE
2	All high-risk patients should immediately start anti-coagulation whilst awaiting CTPA.	2C	ACCP Guideline 2012 [21] Cited by ESC
3	Patients with an adjusted D-Dimer (age×10 mcg/L as upper limit of normal) and are low risk (Wells' ≤4) do not require a CTPA	2A	Cited by ESC
4	All patients with clinically suspected PE should undergo chest X-ray to exclude other causes	5	NICE

Table 1: *Current audit standards and evidence grade.*

ESC: European Society of Cardiology; NICE: National Institute for Health Care Excellence; ACCP: American College of Chest Physicians; RCR: UK Royal College Of Radiologists

Design/Setting

The audit was conducted at Whangarei Hospital, a 246-bed secondary-level hospital in New Zealand. Consistent with the methods used in audits conducted in Australasia, we retrospectively reviewed the clinical information of 100 consecutive in-patients suspected of - acute PE, who underwent CTPA between 8 January 2015 and 15 May 2015. Requests from all departments within the hospital and referrals from affiliated centres were analysed to accurately assess daily practice. Cases were initially identified by searching electronic records. We reviewed the electronic and paper medical records, including the medication charts, of all patients. Patient demographics, diagnostic measures and procedures, time to CTPA, administration of anticoagulants, and the results of CTPA, including alternative diagnoses, were recorded. All CT scans during the study period were performed with a General Electric Lightspeed Ultra 8-slice CT scanner. The D-dimer assay used was the Liatest D-Di Plus immunoturbimetric assay.

The Wells' clinical probability score (Table 2) was retrospectively calculated by reviewing the patient's notes and was assessed by two independent reviewers. Our guidelines categorize patients according to the Wells' criteria using a two-tier system, where a score of ≤ 4 is classified as a low pre-test probability, and a score of > 4 is classified as a high probability [11].

Where a Wells' score was documented in the patient's medical records, that score was recorded. The physician's judgment criterion "an alternative diagnosis is less likely than PE – (3 points)" was inferred for every patient, so that the lowest possible score was 3.

Ethics approval was not required, in accordance with New Zealand Health and Disability Ethics Committee guidelines for quality improvement projects.

Clinical symptoms of Deep Vein Thrombosis (DVT) - minimum of leg swelling and pain with palpation of the deep veins	3 points
An alternative diagnosis is less likely than PE	3 points
Heart rate > 100/min	1.5 points
Immobilization >3 days or surgery in previous four weeks	1.5 points
Previous DVT or PE	1.5 points
Haemoptysis	1 point
Malignancy (on treatment, treated in the last 6 months, or palliative)	1 point
Total	≤ 4=low risk, > 4=high risk.

Table 2: *The two-tier Wells' score for pulmonary embolism [11].*

Results

The mean age of the 100 patients included in our cohort was 64 years, and 61% were female (Table 3).

Hospital (country)	Whangarei (NZL) 2015	Hutt Valley (NZL) 2015 (16)	Orange, NSW (AUS) 2013 (20)	Mackay, QLD (AUS) 2012 (19)	Timaru (NZL) 2012 (17)	Christchurch (NZL) 2006 (18)
Sample size	100	105	169	100	88	100
Mean age (years) Gender	64y Female 61%	64y Female 60%	63y Female 55%	56y Female 60%	67y Female 53%	60y Female 58%
Proportion of patients with a documented risk score (%)	3	12	7	9	3	4
Proportion of positive CTPA scans (%)	26	15	6	5	14	31

Table 3: *Summary of audits completed in Australasia that assessed the appropriate use of CTPA .*

NZL: New Zealand; AUS: Australia; NSW: New South Wales; QLD: Queensland

Of the 100 scans reviewed, 52% were ordered through the Emergency Department (ED), 32% by the General Medicine Department, and the remaining 16% were referred from Surgical Services (General Surgery, Orthopaedics, and Obstetrics and Gynaecology). One scan ordered by the intensive care unit was also included in the latter category.

Only 3% of patients had a documented Wells' score. Based on the retrospective calculation of the Wells' scores, 42 patients were categorized as low-risk for PE and 58 were classified as high risk. Of the low-risk patients, 39 (93%) were referred for D-dimer tests. In all of these patients, the D-dimer concentrations were above the threshold for imaging and they were sent for CTPA, as appropriate. Three (7%) patients with low clinical probability were sent for CTPA without a D-dimer test. Conversely 51 (88%) patients with a high clinical probability underwent D-dimer tests.

Overall, 26% of scans revealed evidence of PE. The positive scan rates were 23%, 28%, and 36% for scans ordered in the Emergency, General Medicine, and Surgical Departments respectively. Only one patient categorized as low-risk based on the Wells' score was diagnosed with PE. By contrast, 25 (43%) patients categorized as high risk were diagnosed with PE (Figure 2).

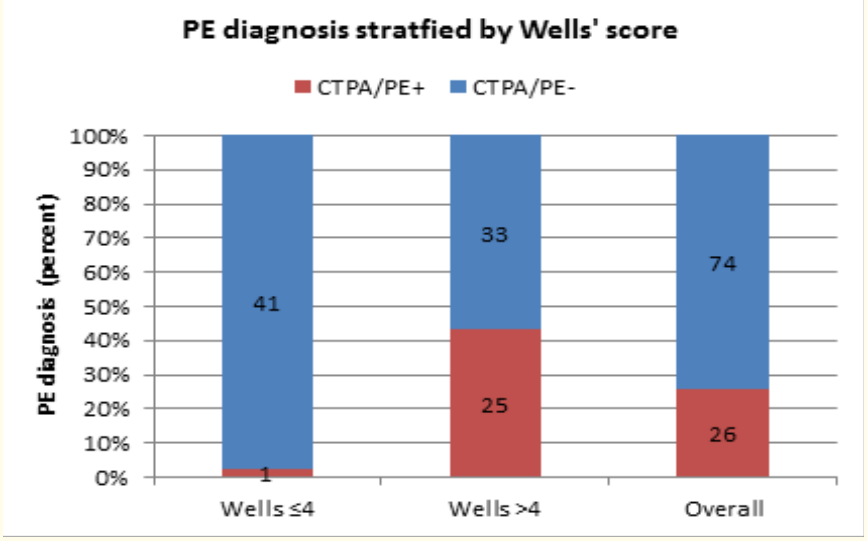

Figure 2: *Proportions of patients diagnosed with pulmonary embolism divided by Wells' score and in all patients. PE+: evidence of PE; PE−: no evidence of PE.*

CTPA revealed an alternative cause of the symptoms in 41/74 (55%) patients in whom PE was excluded. Respiratory infection was the most common finding (27 patients), followed by pleural effusion (three patients), heart failure (three patients), and atelectasis (two patients). Chest X-rays were performed in 98% of patients before CTPA.

CTPA was performed within 24 hours of being ordered in 94% of patients. In total, 42% of patients were started on low-molecular-weight heparin (LMWH) before the results of CTPA were reported, including six (14%) low-risk patients and 36 (62%) high-risk patients (Figure 3).

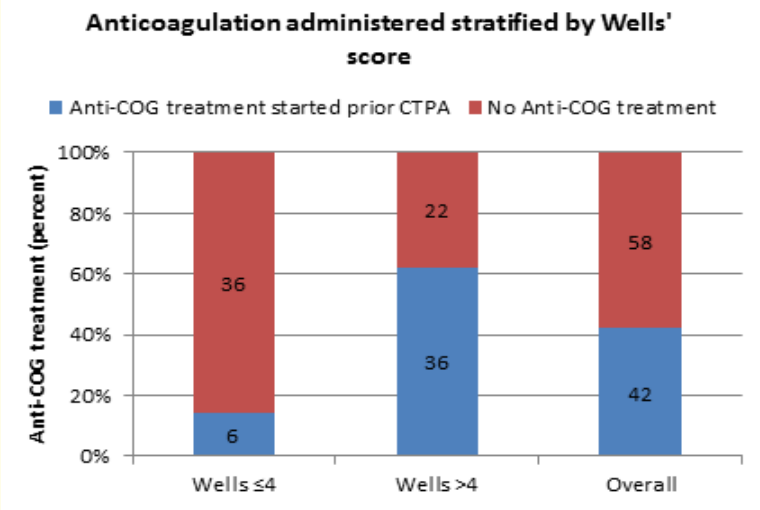

Figure 3: *Proportions of patients who received anticoagulant therapy divided by Wells' score and in all patients. COG: coagulant.*

Discussion

This audit has further documented an ongoing trend that is seen in 5 previous studies in New Zealand and Australia which demonstrates poor documentation of pre-test probability scoring in the diagnostic work-up of PE. The Wells' score was reported for only 3 - 12% of patients despite the universal recommendation regarding its importance. Considering the ubiquitously poor use, several studies have examined the efficacy of interventions, including educational sessions, promotional material and mandatory risk assessment forms or electronic tools. These interventions improved the documented rates to 55% - 83% [22,23]. These studies also noted that as the appropriateness of the diagnostic work-up increased, there was a corresponding decrease in unnecessary and inappropriate CTPAs.

It is unclear why this validated score is under utilised by clinicians despite its proven efficacy. One thought may be that clinicians rather rely on 'gut feeling' for assessment. Studies have aimed to assess accuracy of unstructured clinical gestalt compared to clinical decision rules such as the Wells' score [24], with one concluding that it may even be superior in performance [25]. Despite the documentation shortcomings, 26% of the CTPAs at our centre were positive for PE, a rate that is within acceptable international standards [7]. Superficially, our data would seem to support this conclusion, however we would caution against this interpretation. The majority of previous audits from Australasia do not meet international standards for positivity, and coupled with a low Wells' score calculation would suggest that clinical gestalt in these settings is failing. Clinical gestalt is variable and difficult to teach [26]. Gestalt determination of pre-test probability, as could be expected, increases with clinical experience [27], with positive likelihood ratios ranging from 1.4 to 29 [28]. Even the study suggesting gestalt as being superior to standardised scoring excluded 25% of eligible patients due to a lack of documented gestalt assessment [25]. This would seem to suggest that clinicians are not reliably documenting any pre-test probability assessment prior to referral for CTPA. We do agree that physician judgement is beneficial, and this is reflected in its inclusion and weighting within the Wells' score [29,30].

We hypothesise that this initial lack of standardised assessment follows through with subsequent inconsistencies in ordering of investigations and treatment. This audit revealed that the D-dimer was unnecessarily ordered in 88% (51/58) of patients with a high pre-test probability for PE. Guidelines suggest that D-dimer in high-risk patients is not useful as a high false positive rate reduces its exclusionary ability [2, 3]. Indeed, all of the D-dimers ordered for this cohort of high risk patients were found to be elevated (> 500 mcg/L) and would not contribute to the clinical decision-making process.

The CXR has been highlighted as an effective adjunct in the clinical decision-making process because abnormal findings are associated with a lower likelihood of PE [31]. NICE guidelines now recommend that CXR be included in work-up of all patients with suspected PE Tan., *et al*. noted in their study that alternative diagnoses were seen on the CTPA in 52 cases, and that 43 (83%) of these diagnoses were visible on CXR [19]. CXR was performed in 98% of patients in our cohort prior to CTPA. Respiratory infection the most common alternate finding (27%), many of which may have been seen on initial CXR.

Time to heparin administration has been shown to be an independent predictor of mortality, with a demonstrable increase in mortality in ED patients with PE who did not receive heparin until after hospital admission, compared with patients who received heparin in the ED [32]. A delay in starting anticoagulant therapy is also associated with increased rates of short-term adverse events and recurrence [33,34]. Only 36 (62%) patients in the high-risk group were immediately started on anti-coagulant therapy. We hypothesise that a lack of clinician awareness of the consequences of delayed treatment for PE, in conjunction with the overt lack of standardised pre-test probability quantification to prompt clinicians to consider treatment in the high-risk patient are the principle reasons for failing to meet this standard. Inclusion of this into the diagnostic algorithm could improve accuracy and standardization of treatment. We note that other audits have not reported data on this standard, and we propose future assessments include this.

Limitations of the study lie in its retrospective design. Intricacies influencing the clinical decision-making process are difficult to document and interpret from medical records alone. Universal scoring of the subjective criterion "an alternative diagnosis is less likely

than PE" is controversial and possibly contributed to our increased allocation of patients into the high pre-test probability group. Every attempt was made to blind the reviewers to the final diagnosis of the scan prior to calculation of the Wells' score however this was not always possible due to the electronic and paper method used. We believe the objective nature of the score and the use of 2 independent reviewers removes some potential for bias.

Our audit has several strengths that suggest the results may be generalised to other hospitals in Australasia. By comparing our audit with those conducted using similar methods in other hospitals in comparable settings, we have shown strikingly consistent breaches of accepted guidelines, a systematic problem that is unlikely to be isolated to any of our institutions.

Conclusion and Recommendation

These data support those of audits in New Zealand and Australia demonstrating poor utilization of formal pre-test probability prediction for the diagnostic work-up of PE. We hypothesise that this initial lack of standardised assessment follows through with subsequent inconsistencies in ordering of investigations and treatment. In particular, new areas identified for improvement include careful assessment of CXR to look for an alternate explanation for symptoms, appropriate requesting of d-dimer and identification and treatment of high risk patients who require immediate empirical anticoagulant therapy.

Integration of education and mandatory scoring as well as continued audits with dissemination of results should be implemented to align practice with accepted international standards.

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Competing interests/Conflicts of interest

Nil

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