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ORIGINAL ARTICLE

A prospective audit of requests for CT Pulmonary Angiography (CTPA) in haemodynamically stable non-pregnant medical patients with suspected PE

Joëlle Azzopardi, Gabriel Degiorgio, Julian Cassar, Paula Grech, Gabriel Borg, Kyra Bartolo, Brendan Caruana Montaldo

Introduction

Pulmonary embolism (PE) is a common and occasionally fatal disease, therefore investigation must be targeted and accurate. Unnecessary investigation presents an increased risk of harm to the patient. On occasion, CT Pulmonary Angiography (CTPA) is not requested according to established guidelines.

Aim

This study aimed to address the criteria by which CTPAs were being requested. Approval was obtained from data protection and ethics committees. Anonymous data was collected from hospital software and patients' case notes between Aug-Sept 2017.

Methods

106 patients were recruited. Hospital notes were examined for demographics, reason for presentation, documentation of pre-test probability (PTP) testing, arterial blood gases (ABGs), electrocardiogram (ECG), indication for CTPA, and any complications. Hospital software provided data on blood investigations including D-dimer, CXR, time of CTPA order, and department ordering CTPA.

Results

Dyspnoea, followed by a raised D-dimer, was the most common trigger for ordering CTPA (45.3%). A large majority (60.4%) of patients undergoing CTPA did not have ABGs taken. One fifth (21.7%) of CTPAs were positive. A PTP score was only documented in 10.4% of patients and was equally divided between Wells and Geneva scores. The Wells score was retrospectively calculated, with only 9.4% having a score >4 indicating likely PE. 1 patient had anaphylaxis to contrast and 5 developed contrast-induced nephropathy.

Conclusions

A basis for requesting a CTPA needs to be established, utilising the well-validated Wells Score, and D-dimer where indicated. A suspicion of PE should trigger a request for an ABG. CTPA is not without morbidity, and therefore should only be requested according to evidence-base.

Joëlle Azzopardi* MD (Melit.) MRCP (UK) MA Bioethics (Melit.) MRCP Resp (UK)
Gozo General Hospital,
Ministry for Health,
Gozo, Malta.
joelle.azzopardi@gov.mt

Gabriel Degiorgio MD
Department of Medicine
Mater Dei Hospital,
Ministry for Health,
Msida, Malta.

Julian Cassar MD MRCP
Department of Medicine
Mater Dei Hospital,
Ministry for Health,
Msida, Malta.

Paula Grech MD MRCP
Department of Medicine
Mater Dei Hospital,
Ministry for Health,
Msida, Malta.

Gabriel Borg MD
Department of Primary Care
Malta

Kyra Bartolo MD MRCP
Department of Medicine
Mater Dei Hospital,
Ministry for Health,
Msida, Malta.

Brendan Caruana Montaldo MD FACP
Department of Medicine
Mater Dei Hospital,
Ministry for Health,
Msida, Malta.
*Corresponding author

Introduction

Pulmonary embolism (PE) is a common and occasionally fatal disease, therefore investigation must be targeted and accurate. It can manifest in a variety of ways, ranging from no symptoms or seemingly innocuous ones, to sudden death. The gold standard for investigation of PE is CT Pulmonary Angiogram (CTPA), albeit this is not without its risks, namely radiation exposure, risk of contrast nephropathy and anaphylaxis. Hence, unnecessary investigation presents an increased risk of harm to the patient. On occasion, CTPAs are requested arbitrarily rather than according to established guidelines.

A high clinical suspicion is required to diagnose PE. Furthermore, effective scoring systems and algorithms have been developed to help guide physicians along the most appropriate management path. Once recognised, PE remains a highly treatable condition.

Aims

This study aimed to address the criteria by which CTPAs were being requested by medical or emergency doctors in a local hospital, and whether these were in accordance with the European Society of Cardiology (ESC) guidelines.[1] The primary aim of the audit was to assess whether CTPAs were being ordered appropriately. Secondary aims included whether scoring systems to stratify risk of PE were being used (Geneva or Wells Scores), whether supplementary investigations such as electrocardiogram (ECG), chest x-ray (CXR), arterial blood gases (ABGs) and D-Dimer were being requested and to identify any CTPA-related complications.

Methodology

Patient Population

All patients admitted from the Emergency Department to the Medical Department who underwent CTPA, within a 5-week period (between August and September 2017), were recruited prospectively, bringing the total to 106 subjects.

Questionnaire Design

An extensive literature review was carried out, so as to create a template by which data would be scrutinised. Criteria which should be met for every patient suspected of having PE were documented in a tick-the-box fashion. Pre-test probability testing was given its due importance in the questionnaire, as was the D-dimer result. The performing department was clearly documented, together with demographic data on each patient.

Data Collection

Approval was obtained from the data protection and University of Malta Research Ethics Committee. Data was collected prospectively from hospital software and case notes. Case notes were examined for demographics, reason for presentation, patient assessment, documentation of pre-test probability (PTP) testing, ABGs, ECG, indication for CTPA, any complications, and further management. Hospital software provided data on blood investigations including serum chemistries, troponin, D-dimer and pro-BNP; CXR; time of CTPA order; and department ordering CTPA.

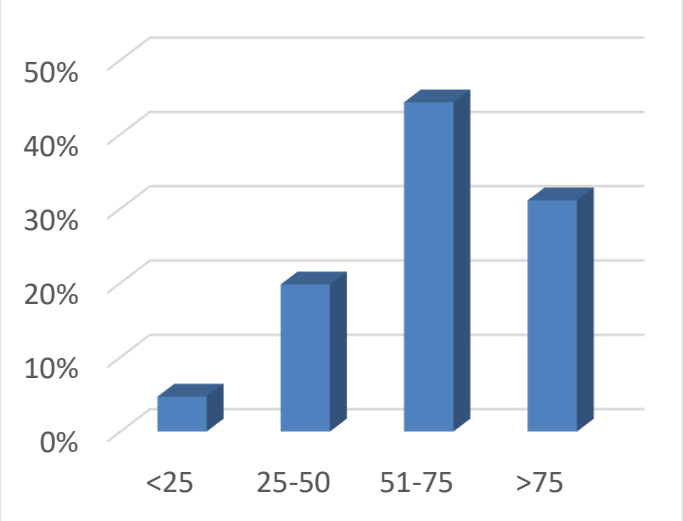
Results

Demographics

106 patients were recruited, of which 60.4% were female. A good proportion were over 50

years of age (*Figure 1*). The mean age of the study population was 63.8 years, with a median age of 68 years.

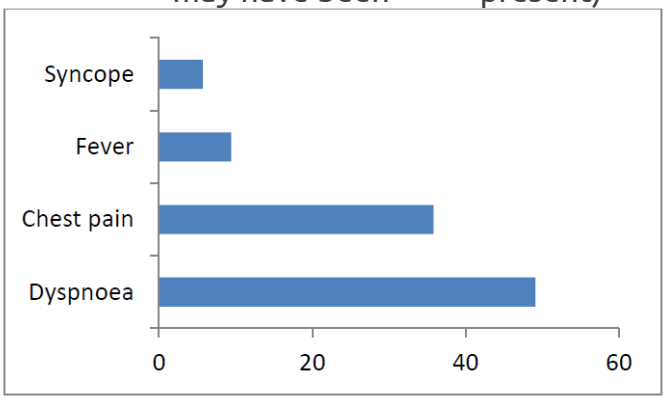
Figure 1 Percentage distribution of age groups of subject population



Presentation to Accident & Emergency (A+E)

Dyspnoea was the most common reason for presentation to A+E, being present in almost half (49.1%) of patients (*Figure 2*). Other reasons for presentation to hospital included cough, lethargy, palpitations and lower limb swelling.

Figure 2 Presenting symptoms of subjects undergoing CTPA (>1 symptom may have been present)



Performing department and overview of CTPA outcome

The CTPA scans taken into consideration were all those requested from A+E or medical specialities. *Figure 3* shows that the majority were requested by the A+E department. Just over a fifth (21.7%) of CTPAs were positive for PE. Analysis of CTPA results requested by the individual department revealed that just under a third (29.0%) of scans ordered from A+E were positive, while only over one tenth (11.4%) ordered from the medical wards were positive (*Figure 4*).

Figure 3 Department requesting CTPA

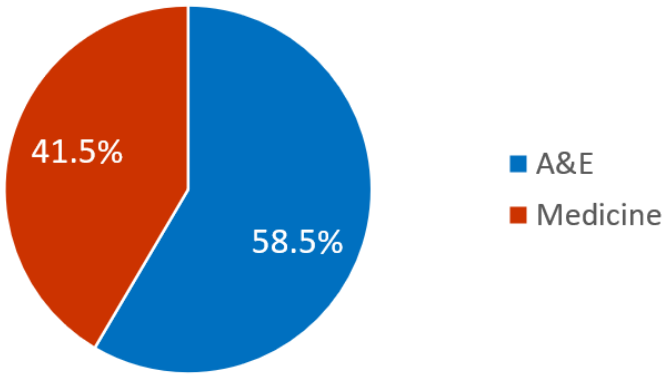
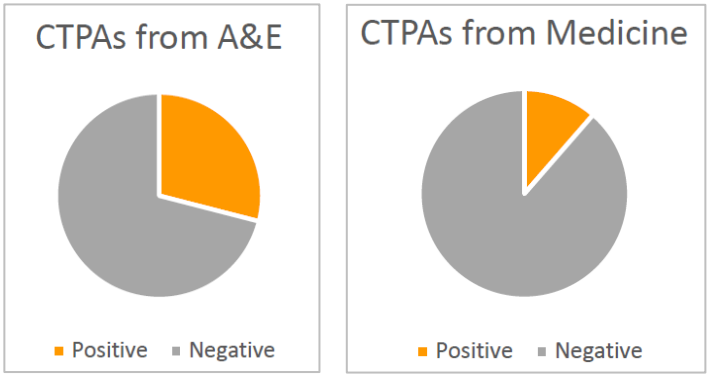


Figure 4 Proportion of CTPAs positive for PE by requesting department



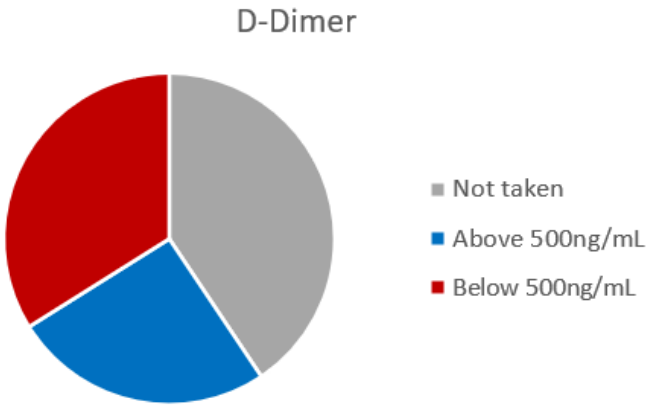
CTPA – date, timing and primary indication

The majority of patients had 2 or more symptoms that raised the suspicion for PE. The most common primary indication for CTPA was tachypnoea or sudden onset dyspnoea, present in almost two thirds (62.3%) of patients. Raised D-dimer was the second most common indication for CTPA, present in just under half of patients (45.3%). In a third (33.0%) the primary indication was pleuritic chest pain while 19.8% of patients demonstrated oxygen desaturation. Haemoptysis was an indication in only 3.8% of patients. Other reasons for performing CTPA included tachycardia, syncope and new RBBB.

Serum investigations

Complete blood count was measured in all subjects, and renal function in 99%. D-Dimer was considered in only 59.4% of patients. The cut-off for a normal D-Dimer was taken to be 500ng/mL. It was elevated in 42.9% of patients in whom it was checked, implying that a good majority of those undergoing CTPA had a normal D-Dimer. Furthermore, 43.5% of patients with confirmed PE did not have a D-Dimer taken (*Figure 5*).

Figure 5 Proportion of those undergoing CTPA having a raised D-dimer, normal D-dimer, or not having had a D-dimer taken.



Of those subjects with an elevated D-Dimer, 40.7% were found to have a PE on CTPA. A positive CTPA was reported in only 5.6% of subjects with a normal D-Dimer, applauding the sensitivity of D-Dimer.

ABG analysis was found to be grossly underutilised in the study population, being drawn in only 39.6%. The majority (83.3%) were found to have resting hypoxaemia (PaO2 <80mmHg). The correlation of hypoxic patients also having a confirmed PE was of 76.9%. This is to be expected as PE tends to cause Type 1 Respiratory Failure.

ECG

The most frequently encountered ECG changes in patients with PE are tachycardia, non-specific ST and T waves changes, right heart strain and right bundle branch block (RBBB).

Every patient in the study had an ECG taken during the in-patient stay, and this was normal in half of subjects (50.9%). Sinus tachycardia was the most common abnormality, present in 21.7%, while a bundle branch block was evident in 7.5%. Other ECG changes included ST changes, atrial fibrillation and heart strain pattern.

CXR

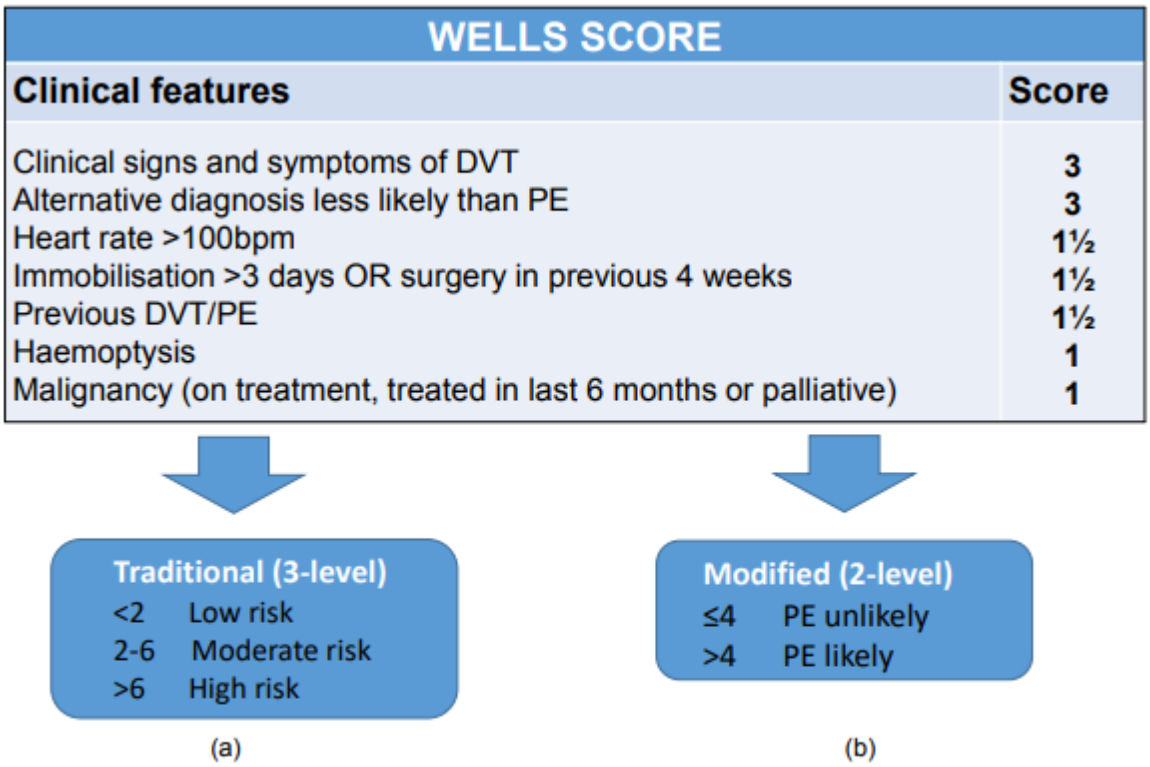
Every subject recruited in the study underwent a chest x-ray. The large majority (70.8%) were normal, while a small proportion revealed consolidation (7.5%), pleural effusion (6.6%) or pulmonary venous congestion (5.7%). Other changes included lung metastases, pleural plaques and interstitial lung disease.

Scoring system

The Wells [2-3] and Geneva[4] scores are the two most widely accepted scoring systems for PE. The modified (2-tier) Wells Score was selected for this audit (*Figure 6*). A score was only documented in 10.4% of patients. Of these, the Wells score was documented in 54.5%, and the Geneva score in 45.5%.

The data collectors retrospectively calculated a Wells Score on each individual in the study. The score was agreed upon by 2 data collectors separately. The majority of patients (34%) had a Wells score of zero (*Table 1*).

Figure 6 Traditional vs Modified Wells Score



(a) Traditional 3-level Wells' score stratification for risk of PE
(b) Modified 2-level Wells' score stratification system utilised in this study

According to the ESC Guidelines[1], a Wells Score of ≤4 implies that PE is unlikely and therefore a D-dimer should be taken. 90.6% of the study population had a Wells Score of ≤4. Of these, just under a quarter (22.6%) had a positive D-dimer and therefore correctly underwent CTPA, with a pick-up rate for PE of 41.7%. In the sub-group where PE was unlikely (Wells ≤4) and a D-dimer of <500ng/ml which excludes PE, unfortunately all 36 patients nonetheless underwent CTPA, of which only 2 CTPAs were positive. Another third (34%) of patients in the 'unlikely PE' subgroup did not have D-dimer levels checked. In the small proportion of patients (9.4%) where PE was likely (Wells Score >4), 40% had a positive CTPA (*Figure 7*).

Outcome of CTPA

More than a fifth (21.7%) of CTPA scans were positive for PE. A number of patients had more

than one embolus. The vast majority were segmental (52.2%) while a sub-segmental PE was present in 21.7%. In 30.4% a main artery was involved while in 47.8% it was the interlobar artery which contained thrombus. Bilateral PE was present in 8.7%.

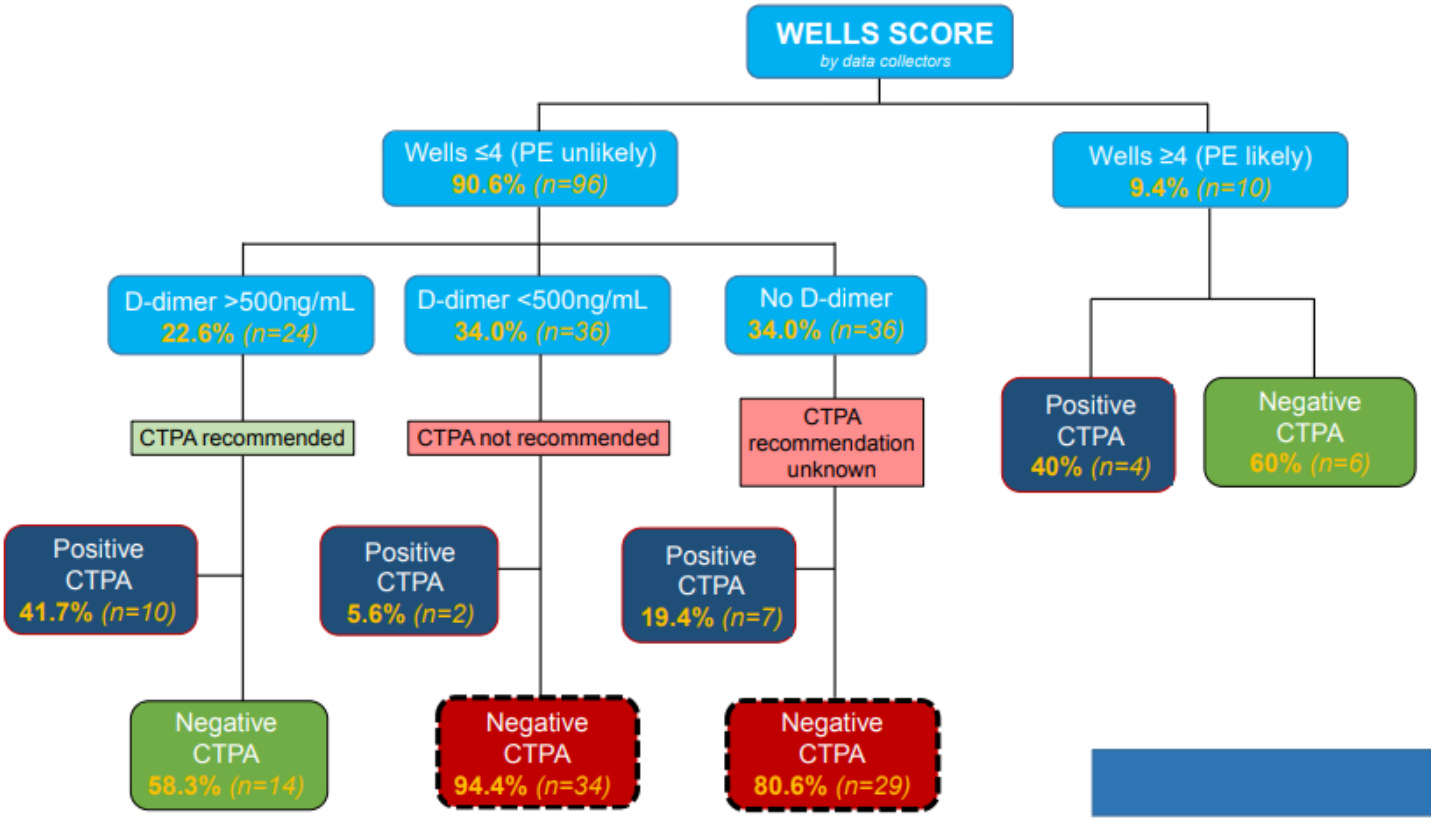
32.1% of the patient population were unnecessarily exposed to ionizing radiation from a CTPA which was not indicated according to the ESC guidelines, while another 27.4% were possibly unnecessarily exposed, as the D-dimer was not checked.

One patient suffered contrast-induced anaphylaxis as a major complication from CTPA. A deterioration in eGFR was noted in 5 patients (4.7%). All-cause mortality was 10.4% during the study period.

Table 1 Distribution of Wells score (as calculated by the investigators)

Wells Score	Percentage of subjects
0	34
1	10.4
1.5	20.8
2.5	7.5
3	13.2
3.5	0.9
4	3.8
4.5	1.9
5.5	2.8
6	0.9
6.5	0.9
7	0.9

Figure 7 Summary of results: risk for PE, based upon the Modified Wells Score, and subsequent investigation with CTPA and/or D-dimer



Discussion

PE can present in a number of ways, the most commonly reported symptoms in this audit being acute shortness of breath, and pleuritic chest pain. These two symptoms were the main documented reasons for ordering a CTPA in patients making up the subject population. Other conditions may present similarly to PE, and thus a high index of clinical suspicion is necessary. History-taking should be geared towards specific factors that increase thrombotic tendency, thus precipitating PE. These risk factors are incorporated into the Wells Score, a validated scoring system used to grade the probability of PE. These include symptoms of DVT, prior history of DVT and PE, recent immobilisation and presence of malignancy. Haemoptysis and tachycardia are also features that are associated with PE. If no alternative diagnosis better explains symptoms, this adds to the Wells Score and increases the probability of PE. Although the Wells and Geneva scores which are clearly delineated in the ESC Guidelines on Acute Pulmonary Embolism are referred to locally as a guide to stratify risk for PE and thus refer patients for CTPA accordingly, there was no established local guideline at time of data collection.

A scoring system (Wells or Geneva) was only calculated in 10.4% of study patients prior to ordering a CTPA. When the Wells Score was calculated retrospectively, PE was ruled out in at least one third, yet these still underwent CTPA, placing a not insignificant burden on radiology time and costs, whilst also exposing patients to unnecessary risks. These include ionizing radiation, contrast nephropathy and anaphylaxis. 1 patient sustained contrast-induced anaphylaxis following scanning while 5 patients (4.7%) experienced a deterioration in their eGFR. 10.4% of patients passed away during the study period however further mortality data was not looked into.

Arterial blood gas analysis is a recommended investigation in patients presenting with symptoms suggestive of pulmonary pathology. These were only taken in a minority (39.6%) of the study population. A sizeable proportion (43.5%) of patients with a positive CTPA did not have ABGs taken. Type 1 Respiratory Failure was present in 76.9% of patients with PE in whom ABGs were taken. These findings are very relevant as ABG analysis is a convenient bedside test which allows a rapid reflection of the physiological status of a patient and is valuable in prioritising an acutely unwell patient.

A D-Dimer assay is recommended in those patients in whom PE is unlikely, thus a Modified Wells Score of ≤4. It is a highly sensitive but non-specific test for PE. D-dimer was only checked in 62.5% of those in whom it was indicated, and ruled out PE in 34% of those with a low Wells Score (≤4). In only 2 patients was a positive CTPA (non-guideline request) associated with a negative D-dimer.

A limitation to the study was the relatively short period of recruitment. However, in this short period, it already became clear that guidelines were not being adhered to, with unnecessary risks to the patient and uncalled for costs to the hospital system. Furthermore, the Modified Wells Score was calculated retrospectively by the investigators, as PTP testing was only done in a minority of patients, and its absence would have precluded further evaluation. This may have been inaccurate by either under- or over-estimating the Wells score, since it was obtained from the patient's case notes rather than from first-hand history-taking and physical examination. Lastly D-

dimer values were taken at face value rather than adjusting for age[5]. Thus, the number of CTPAs correctly requested may have been even lower.

Conclusions

A basis for requesting a CTPA needs to be established, utilising the well-validated Wells Score[1], and D-dimer where indicated. A suspicion of PE should trigger a request for an arterial blood gas (ABG). CTPA is not without morbidity, and therefore should only be requested according to evidence-base. In the light of this audit's overwhelming evidence that CTPAs are often requested without adherence to guidelines, there is currently liaison with the IT department to render a Well score compulsory, as well as a D-dimer level if indicated, when digitally requesting a CTPA. The authors, together with major stake holders, agree that employment of such measures when ordering CTPAs should decrease unnecessary requests, hence diminishing risks to patients, such as contrast-induced nephropathy, anaphylaxis and radiation exposure, as well as limiting health-care costs.

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