Changing trends in venous thromboembolism-related imaging in Western Australian teaching hospitals, 2002–2010

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Abstract

Objective: To determine trends in referral for venous thromboembolism (VTE) imaging in Western Australian teaching hospitals.

Design and setting: Retrospective audit of the WA picture archiving and communication system, PathWest Laboratory Medicine records, the hospital morbidity database at the four adult teaching hospitals in Perth, WA, and the WA death registry.

Patients: All patients referred for VTE-related imaging, and all hospital separations for pulmonary embolism (PE) during 2002–2010.

Main outcome measures: Number of referrals for computed tomography pulmonary angiography (CTPA), ventilation–perfusion lung scintigraphy, leg ultrasound and plasma D-dimer assay; hospital separations for PE and deaths from PE.

Results: Referrals for VTE-related imaging increased by 34%, while PE-related imaging increased by 65% during the study period, owing entirely to referrals for CTPA, which increased by more than 500%. The number of hospital separations for PE increased by 45% over the same period and the prevalence of PE among referred patients fell from 22.1% in 2002 to 19.5% in 2010. There was no fall in the death rate from PE in WA during the study period ($P = 0.19$). The number of D-dimer tests performed in the same hospitals increased by 42% over the study period.

Conclusions: The increased number of referrals for PE-related imaging resulted in more diagnoses but no reduction in deaths from PE in WA. Widespread D-dimer testing did not reduce referrals for imaging and is likely to have resulted in increased referrals. Increased imaging leads to overdiagnosis of clinically insignificant PE, and alternative strategies are required to reduce PE death rates.

Venous thromboembolism (VTE) is a significant cause of morbidity and mortality. The clinical features of VTE are variable; many patients remain asymptomatic, while others present with non-specific illness, for which further investigation is required, particularly when pulmonary embolism (PE) is suspected. Diagnostic management of patients with suspected VTE is often inappropriate and does not always conform to recommended guidelines.[1,2] The use of structured diagnostic algorithms and decision-support tools improves the accuracy of clinical assessment and the appropriateness of referral of patients with suspected VTE; however, these resources are seldom used by referring clinicians, in spite of evidence that adherence to guidelines significantly improves clinical outcomes.[1-3]

Several clinical probability scoring systems have been developed for use among patients with suspected VTE, of which the modified Wells score is the most widely used in Australia.[4] The use of structured scoring systems and rapid assessment of plasma D-dimer, a cross-linked fibrin degradation product, has been shown to reduce the likelihood of referral for VTE-related imaging in experimental settings.[4,5] Such structured assessment has now become standard practice in Western Australian teaching hospital emergency departments, where an online decision-support tool has been available since 2001.[1,6] There is a widespread perception among imaging specialists in public hospitals in WA that, in spite of the availability of structured assessments and decision support, the volume of referrals for VTE investigations has increased over recent years, and that many may be inappropriate.[2] We aimed to document trends in referrals for VTE-related imaging within WA teaching hospitals to see whether this perception is valid and what impact any increase in testing may have had on the incidence of deaths related to PE.

Methods

VTE-related imaging

Since 2002, all referrals for imaging in the four teaching hospitals in WA, located in metropolitan Perth, have been recorded on a single public radiology picture archiving and communication system (Agfa Healthcare Australia). We obtained the numbers of referrals for leg ultrasound, ventilation–perfusion lung scintigraphy (VQS) and computed tomography pulmonary angiography (CTPA) at the four adult teaching hospitals in Perth (Fremantle Hospital, King Edward Memorial Hospital for Women, Royal Perth Hospital and Sir Charles Gairdner Hospital) from 2002 to 2010.

D-dimer assays

We also obtained the numbers of referrals for plasma D-dimer testing from PathWest Laboratory Medicine WA, the sole pathology provider in the public sector in WA, for the same period.

Hospital separations for PE

The number of hospital separations for PE over this time at the four hospitals was obtained from the WA Hospital Morbidity Data System. PE was included if it was coded as a primary or a secondary (comorbid) diagnosis. We reasoned that few, if any, patients were treated for PE as outpatients. We did not obtain the same data for deep vein thrombosis (DVT), since this is frequently treated on an outpatient basis.

PE-related deaths

Numbers of deaths from PE were obtained from the WA Office of Births, Deaths and Marriages, which maintains records of all primary and secondary causes of death in the state. It was not possible to restrict the data to patients dying only at Perth metropolitan teaching hospitals, although these are likely to represent the majority of inhospital deaths from PE in the state. DVT is a rare cause of death, so mortality data for this condition were not obtained.

Population data

Population estimates for WA over the period were obtained from the Australian Bureau of Statistics.[7]

Statistical analysis

We used linear regression modelling to evaluate the significance of trends in the number of hospital separations for PE in the four teaching hospitals, and the raw and adjusted (for population growth) number of deaths from PE in the state. Lack of individual patient data (including age) precluded calculation of age-standardised mortality. Pearson correlation coefficient (R) values with $P < 0.05$ were regarded as significant.

Human research ethics committee approval was not sought, as this study was a clinical audit of referral patterns, for which individual patient data were not required.

Results

VTE-related imaging

Numbers of referrals for CTPA grew rapidly between 2004 and 2007, after which the rate of growth slowed significantly (Box 1, Box 2). The volume of referrals for VQS showed a corresponding decline between 2004 and 2007. In the last year studied, there was an upswing in the volume of referrals for VQS (Box 1, Box 2).

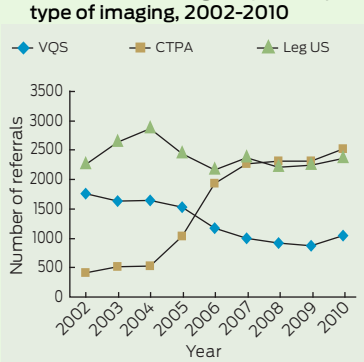
Overall, during this period, the number of referrals for CTPA increased by more than 500%, from 410 scans in 2002 to 2526 scans in 2010, while referrals for VQS declined by 40%, from 1760 scans in 2002 to 1051 scans in 2010 (Box 1). The total number of referrals for PE-related imaging during this period increased by 65%, from 2170 in 2002 to 3577 in 2010, while referrals for all VTE-related imaging increased by 34%, from 4430 in 2002 to 5934 in 2010 (Box 1). The number of leg ultrasound examinations performed each year remained relatively stable (Box 1), and the increases in all PE-related imaging and all VTE-related imaging during the study period are explained entirely by increased referrals for CTPA.

1 Number of requests for D-dimer level and referrals for leg ultrasound, VQS and CTPA at four Western Australian teaching hospitals, 2002–2010

Test	2002	2003	2004	2005	2006	2007	2008	2009	2010
D-dimer level	3635	4118	4478	5041	4811	4956	5035	4907	5174
Leg ultrasound	2260	2641	2872	2439	2168	2370	2210	2249	2357
VQS	1760	1634	1652	1532	1173	1001	916	870	1051
CTPA	410	521	534	1041	1938	2263	2309	2310	2526
Total, PE-related imaging	2170	2155	2186	2573	3111	3264	3225	3180	3577
Total, VTE-related imaging	4430	4796	5058	5012	5279	5634	5435	5429	5934

CTPA = computed tomography pulmonary angiography. VQS = ventilation–perfusion lung scintigraphy. VTE = venous thromboembolism. ◆

2 Referrals for VTE-related imaging in four WA teaching hospitals, by type of imaging, 2002-2010

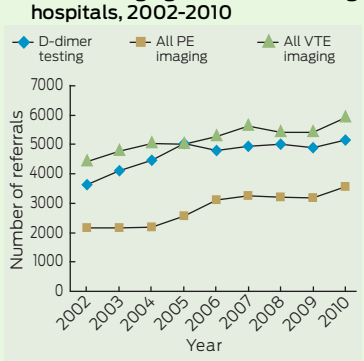


CTPA = computed tomography pulmonary angiography. US = ultrasound. VQS = ventilation–perfusion lung scintigraphy. VTE = venous thromboembolism. WA = Western Australia. ◆

D-dimer assays

The number of requests for D-dimer testing increased by 42% during the study period, from 3635 in 2002 to 5174 in 2010 (Box 1). Increased D-dimer testing was not associated with any reduction in the number of VTE-related imaging requests or PE-related imaging requests (Box 3).

3 Number of referrals for D-dimer testing and VTE-related and PE-related imaging in four WA teaching hospitals, 2002-2010



PE = pulmonary embolism. VTE = venous thromboembolism. WA = Western Australia. ◆

Hospital separations for PE and PE-related deaths

PE separations increased by 45% between 2002 and 2010, from 480 in 2002 to 698 in 2010 (Box 4, Box 5). The proportion of patients referred for PE-related imaging who subsequently had a confirmed diagnosis fell only slightly, from 22.1% in 2002 to 19.5% in 2010.

The population of WA increased by 18.9% during the study period from 1 926 111 people in 2002 to 2 290 572 in 2010 (Box 4). There was a clear increase in the number of hospital separations for PE each year ($P < 0.001$), while the number of deaths from PE in WA remained stable ($P = 0.192$ for raw death numbers [slope, 1.817; 95% CI, −1.160 to 4.793]); $P = 0.069$ for deaths adjusted for population growth [slope, −1.387; 95% CI, −2.915 to 0.142]).

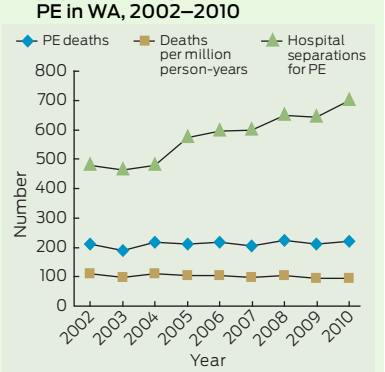
Discussion

The number of PE-related imaging requests at the four adult teaching hospitals in Perth increased by 65% over the 9-year period studied. The number of PE diagnoses in the same four hospitals over the same period increased by 45%. It has long been the case that only a minority of patients referred for PE-related imaging are subsequently shown to have this condition; over the study period, the proportion of referred patients with a positive scan declined by 2.6%. Simi-

4 Separations for pulmonary embolism (PE) at four teaching hospitals, and statewide deaths from PE, Western Australia, 2002–2010

	2002	2003	2004	2005	2006	2007	2008	2009	2010
Number of PE separations	480	463	479	572	595	598	649	641	698
Number of deaths from PE	211	188	217	210	217	205	223	210	220
Population of WA	1 926 111	1 953 070	1 982 637	2 017 088	2 059 381	2 112 967	2 176 980	2 244 436	2 290 572
Deaths per million person-years	109.54	96.26	109.45	104.11	105.37	97.02	102.43	93.56	96.05

5 Hospital separations and raw and population-adjusted deaths from PE in WA, 2002–2010



PE = pulmonary embolism. WA = Western Australia. ◆

lar declines in the prevalence of PE among patients referred for imaging have recently been observed in France[8] and the United States.[9]

Although our data do not permit conclusions to be drawn regarding cause and effect, the increase in referrals for PE-related imaging was associated with a sizeable increase in the number of requests for D-dimer evaluation. Given that the D-dimer result is used together with the Wells score in the four hospitals to determine the need for imaging among patients with suspected VTE, it is reasonable to conclude that increased D-dimer testing drove the observed overall increase in referrals for VTE-related imaging. On breakdown, this was entirely accounted for by increased referrals for PE-related imaging — even though a positive D-dimer result does not indicate the site of thrombosis — since referral for leg ultrasound remained stable.

Historically, D-dimer assay was suggested as a screening tool for VTE at a time when PE diagnosis was more difficult than it is now, and with the goal of reducing the number of patients who might be referred along complex and potentially invasive diagnostic pathways.[10] We anticipated that routine D-dimer testing would have reduced the number of patients referred for VTE-related imaging, but our data showed that imaging has increased in line with increased D-dimer testing. This may reflect a relatively indiscriminate use of D-dimer testing to "rule out" VTE; when used indiscriminately, D-dimer may actually increase referrals for VTE-related imaging due to a high number of false-positive results. Contrary to perceived wisdom among many clinicians, PE is an infrequent diagnosis among patients presenting to emergency departments with a primary complaint of chest pain,[11] while spontaneous VTE has been shown to be uncommon in non-elderly populations in Australia.[12]

Two further points are worthy of mention in relation to structured assessment before referral for VTE-related imaging. Firstly, the Wells score places significant weight on the physician's overall impression of the likelihood of VTE. While this may be appropriate in the hands of experienced clinicians or researchers, it may not be the case when the score is used by junior medical staff, who may be likely to overestimate the likelihood of VTE. Secondly, when the scoring system is used after receipt of the D-dimer result, medical staff are biased towards producing a positive score,[13] so use of the score may not result in the objective assessment hoped for. Therefore, in a setting of low clinical probability, a positive D-dimer test is likely to result in unnecessary imaging, especially in emergency departments, where D-dimer tests may be ordered for any patient with shortness of breath or chest pain before they are assessed by a doctor.[14-16]

The overall increase in PE-related imaging observed in our study was driven entirely by increased referrals for CTPA. CTPA was first introduced in WA in 1999 and referrals grew rapidly between 2004 and 2007, after which the rate of growth slowed significantly. VQS had been the standard imaging method for suspected PE until the introduction of CTPA and showed a steady corresponding decline in the volume of referrals between 2004 and 2007. During the study period, referrals for VQS declined by 40%, while referrals for CTPA increased by more than 500%. Part of the drift from VQS to CTPA may be explained by the referring clinicians' dissatisfaction with non-diagnostic VQS reports, a frequent consequence of using PIOPED (prospective investigation of pulmonary embolism diagnosis) reporting criteria,[17] which was commonplace in WA teaching hospitals at the start of the study period. On the other hand, CTPA scans have always been reported dichotomously (ie, positive or negative for PE), which may induce the impression of greater accuracy compared with VQS. There has been widespread adoption of dichotomous reporting styles in nuclear medicine departments in WA teaching hospitals since the introduction of VQ single photon emission computed tomography (SPECT) scanning in 2010, at the same time as the medical community became increasingly aware of high radiation doses from rapidly escalating referrals for CT scanning. This may explain the rise in referrals for VQS seen during 2010, although this was not accompanied by any downturn in referrals for CTPA.

The increased number of imaging referrals for CTPA in our hospitals reflects a similar growth in referrals for CT scans in the US, particularly from emergency departments.[18] We did not measure the increased radiation burden to patients as a result of this switch in referral patterns, although annual population radiation burden from diagnostic imaging is rising steeply and is now at about the level received from background radiation at sea level.[19]

The increase in referrals for PE-related imaging was associated with increased hospital separations but no decline in the statewide death rate from PE, indicating increased detection of low-risk PE. A similar phenomenon has been observed in the United Kingdom[20] and in the US.[9] Indeed, technological advances in both CTPA and VQS have permitted detection of small, clinically insignificant emboli in low-risk patients.[21] It has been suggested that many of the small clots seen in the pulmonary arteries during CTPA are physiological, with the lung capillary beds trapping and dissolving emboli by endogenous fibrinolysis, thereby protecting the systemic circulation.[22] In addition to unnecessary irradiation, the overdiagnosis of clinically insignificant PE is almost certainly associated with unnecessary complications of anticoagulant therapy,[9] although we did not assess this in our study.

Because many patients with DVT are now treated on an outpatient basis, we were unable to determine the total number of patients with a diagnosis of VTE during the study period from hospital morbidity data. Outpatient treatment of PE, however, is currently less usual, so we determined that hospital separation figures were a reliable measure of the frequency of diagnosed PE. We were unable to determine from our data whether the increase in the number of patients referred for PE-related imaging was due to an overall increase in patient attendances at the four study hospitals, a lower threshold for referral among clinicians, or both. It is reasonable to infer, however, that the decision threshold to refer for imaging has fallen, since the prevalence of confirmed PE declined over the study period among referred patients. No data were available for VTE-related imaging performed in private practice settings, including private hospitals, and so the trends observed in our study are specific to the public teaching hospitals in WA.

We have shown a significant increase in the volume of referrals for VTE-related imaging over a 9-year period in WA teaching hospitals. This increase was due entirely to increased referrals for CTPA and occurred in spite of routine D-dimer testing. There was no reduction in PE mortality in the state as a result, and the increase in hospital separations we have observed is likely to be explained by increased detection and overtreatment of clinically insignificant PE. These results call into question the wisdom of a "rule out" strategy for PE, particularly among patients presenting to hospital emergency departments with non-specific symptoms, and indicate the need to re-evaluate the way in which D-dimer testing is used to screen patients for VTE in our hospitals.

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