

## Diagnostic approach to pulmonary embolism in a rural emergency department

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**Introduction:** Pulmonary embolism (PE) is a serious condition with mortality estimates of up to 10%. We sought to investigate the diagnosis of PE, time to access imaging and diagnostic utility of each modality in a rural emergency department (ED).

**Methods:** We completed a retrospective chart review to determine the investigations performed and treatments initiated in the management of suspected PE in a rural hospital.

**Results:** A total of 47 charts from a 5-year period were reviewed. Of these, 83.0% indicated a D-dimer test was ordered, and 31.9% and 40.4% indicated either ventilation-perfusion (V/Q) or computed tomography (CT) were ordered during the ED visit. Computed tomography diagnosed 11 of the 12 instances of confirmed PE. Mean time to patients undergoing V/Q or CT was 1.58 and 1.59 days, respectively. Low-molecular-weight heparin was started in 83.0% of patients.

**Conclusion:** In this ED there may be overreliance on the D-dimer test, irrespective of Wells score. Access to V/Q and CT were similar to that of an urban centre. Empiric anticoagulation was started in most patients.

**Introduction :** L'embolie pulmonaire (EP) est un problème grave dont le taux estimatif de mortalité peut atteindre 10 %. Nous avons cherché à étudier le diagnostic d'EP, le temps d'attente pour avoir accès aux services d'imagerie et l'utilité diagnostique de chaque mode dans un service d'urgence rural.

**Méthodes :** Nous avons effectué une étude rétrospective des dossiers pour déterminer les examens effectués et les traitements administrés dans la prise en charge d'une embolie pulmonaire soupçonnée dans un hôpital rural.

**Résultats :** Nous avons analysé au total 47 dossiers qui s'étaient sur une période de 5 ans. Sur ce total, 83,0 % des dossiers indiquaient qu'on avait prescrit un dosage des D-dimères et 31,9 % et 40,4 %, respectivement, indiquaient qu'on avait prescrit soit une ventilation-perfusion (V/Q), soit une tomographie (TDM) au cours de la visite à l'urgence. La tomographie a permis de diagnostiquer 11 des 12 cas d'embolie pulmonaire confirmée. Les patients qui ont subi une V/Q ou une TDM ont attendu en moyenne 1,58 et 1,59 jour, respectivement. On a amorcé l'administration d'héparine de faible poids moléculaire dans 83,0 % des cas.

**Conclusion :** Au service d'urgence en cause, on compte peut-être excessivement sur le dosage des D-dimères, sans égard au score de Wells. L'accès à la V/Q et à la TDM était semblable à celui qu'offrait un centre urbain. On a amorcé l'administration d'une anticoagulation empirique à la plupart des patients.

### INTRODUCTION

Pulmonary embolism (PE) is a serious condition with mortality estimates of up to 10%.<sup>1</sup> The diagnosis of PE can be difficult because of the nonspecific signs and symptoms, which include cough, dyspnea, tachypnea, hemoptysis and pleuritic

chest pain. Evidence-based algorithms can help clinicians diagnose PE.<sup>2,3</sup>

A literature review found 2 Canadian reviews of diagnosis and treatment of PE, only 1 of which was focused on rural patients.<sup>4,5</sup> A key component to the diagnosis of PE in low-risk patients was the use of the D-dimer test. As of 2005,

most rural hospitals had this test available locally. A meta-analysis in 2010 validated these Canadian recommendations for the use of the D-dimer test in low-risk patients.<sup>6</sup>

Given the relation between deep vein thrombosis and PE, ultrasonography can also be used to help make the diagnosis in patients with leg symptoms.<sup>7</sup> Almost 100% of rural hospitals in Ontario report having ultrasonography available.<sup>8</sup>

More advanced imaging techniques such as ventilation–perfusion (V/Q) or computed tomography (CT) may be required to diagnose PE in patients with moderate to high pretest probability. These imaging methods are not readily available in most rural centres.

A study by Aujesky and colleagues in 2008 reported there was reduced short-term mortality in patients with PE who received treatment in high-case volume (urban) hospitals.<sup>9</sup> This has raised the issue of whether the management of PE should be regionalized.<sup>10</sup> Although there is evidence for regionalization of trauma and perinatology care,<sup>11</sup> we could find no research that assessed regionalization in the context of PE. However, it has been shown that excellent care can be provided in a rural setting to patients with acute myocardial infarctions, painful lower limb injuries and pneumonia.<sup>12–14</sup>

The purpose of this study was to investigate the diagnostic approach for PE, time to access imaging and diagnostic utility of each modality in a rural emergency department (ED).

## METHODS

The South Huron Hospital is a 19-bed community hospital serving a rural population of about 20 000. The ED is open 24 hours and sees about 10 000 patients per year. The study was performed as a retrospective chart review. Permission to conduct the study was granted by the Medical Advisory Committee of the South Huron Hospital Association.

Through the health records department, a search was completed for all ED charts from Apr. 1, 2004, to Mar. 31, 2009, that had been given a diagnostic code pertaining to PE, including “suspected PE,” “query PE,” “rule out PE” and cases in which PE was high on the differential diagnosis.

Each patient’s chart was manually reviewed to extract data that included demographic data, investigations performed (D-dimer, chest radiography, V/Q, CT, Doppler ultrasonography of the legs), time to obtain these investigations and what, if any, anticoagulation therapy was started in the ED.

Because South Huron Hospital is a small hospital

in a rural area, it has no onsite nuclear medicine or CT availability. All patients requiring V/Q were transferred to London, Ont. (45 km away), although Stratford, Ont. (50 km away) also offers V/Q. For CT, patients can be transferred to London, Stratford or Strathroy, Ont. (55 km away). The hospital in Strathroy obtained a CT scanner in March 2007, partway through the period of data collection, and imaging services remained unchanged in London and Stratford throughout the study period.

Two studies that outlined methods for improving retrospective chart review research were consulted with respect to study design.<sup>15,16</sup> We adhered to 6 of the 8 suggestions by Gilbert and colleagues<sup>15</sup> and 9 of the 12 by Worster and colleagues,<sup>16</sup> including the creation of specific inclusion criteria and data abstraction forms, as well as holding periodic meetings between the data abstractor and the study supervisor to ensure consistency. Because there was a single data abstractor who was involved with the study design, we were unable to blind the abstractor to the hypothesis being tested or to test for interrater agreement (i.e., checking to see to what extent 2 or more data abstractors would obtain the same results). Given the use of pre-determined data abstraction forms, we do not believe that the use of a single data abstractor had a negative impact on the data from the study.

Statistical analysis of the data, including descriptive statistics, Student *t* test and  $\chi^2$  analysis, was performed using Microsoft Excel and MedCalc statistical software.

## RESULTS

Our initial search yielded 54 charts. The list was then manually reviewed, with 8 charts removed because of pre-existing knowledge of PE on admission to the ED or inappropriate coding of PE in the chart. During the chart review process, 1 last case (just before the end of the study period) of PE was diagnosed in the ED, which brought the total number of charts reviewed to 47.

Of the 47 charts reviewed, 27 involved female patients (57%). The mean age of patients was 62.7 (interquartile range 24.5) years. Chest radiography was ordered in 87.2% of charts, D-dimer in 83.0%, CT in 40.4%, V/Q in 31.9% and bilateral leg Doppler ultrasonography in 25.5%. In 14.9% of charts, both V/Q and CT were ordered in the course of the workup. In each of these cases, CT was ordered subsequent to V/Q as a definitive investigation. In several cases, CT was ordered after the ED workup (often while the patient was staying in hospital) and was

discovered by the data abstractor during investigation of follow-up care received by the patients.

The mean time to patients undergoing either V/Q or CT was 1.58 and 1.59 days, respectively, which was not a statistically significant difference ( $t_{27} = 0.0049$ ,  $p = 0.50$ ).

Twelve of the 47 charts (25.5%) included diagnoses of PE that were confirmed by imaging. Of these, 11 were diagnosed using CT and 1 using V/Q. D-dimer was ordered in 8 of the 12 positive charts.

Low-molecular-weight heparin was started in the ED in 83.0% of charts, including 10 of the 12 charts that included diagnoses of PE.

We compared PE-positive and PE-negative charts. With respect to both patient age and time to obtain imaging there was no significant difference between the 2 groups ( $t_{38} = 0.279$ ,  $p = 0.39$ , and  $t_{24} = 0.074$ ,  $p = 0.47$ , respectively). We used  $\chi^2$  tests for the comparison of 2 proportions to evaluate any difference in investigations ordered between the PE-positive and PE-negative groups. Of all investigations, only D-dimer proved to have a statistically significant difference, with the PE-negative group having more D-dimer tests ordered ( $\chi^2 [1, n = 35] = 4.35$ ,  $p = 0.040$ ). The significance levels for the remaining comparisons as well as a summary of the comparative data between confirmed PE-positive and PE-negative charts are shown in Table 1.

## DISCUSSION

A literature review did not reveal any previous studies examining the diagnosis of PE and time required to access imaging modalities from a rural ED. Furthermore, this review did not find any studies that compared time to obtain imaging in academic and rural centres. However, there has been a debate in the literature about possible regionalization of treatment for PE.<sup>9,10</sup>

A discussion with the nuclear medicine department at London Health Sciences Centre revealed

only that instances of suspected PE are triaged as urgent, with V/Q performed either the same day or the following day (Dr. Jonathan Romsa, Chief/Chair Nuclear Medicine, The University of Western Ontario, London, Ont.: personal communication, 2011). Our study suggests that in this rural ED the time of about 1.6 days for patients to undergo either V/Q or CT was comparable. There is evidence to suggest that the use of imaging and procedural techniques varies by geographic location and between urban and rural settings. A Norwegian study showed that all radiographic imaging techniques (including CT and magnetic resonance imaging) were used more frequently per capita in the more populated as opposed to rural regions of the country.<sup>17</sup> Similar evidence has been collected in Ontario, showing that patients who live closer to a tertiary hospital are more likely to undergo angiography after myocardial infarction.<sup>18</sup>

Previous research evaluating the efficacy of both V/Q and CT in the diagnosis of PE has been less than conclusive. Several studies have suggested that V/Q is an effective modality that combines low exposure to radiation with a high level of sensitivity.<sup>19,20</sup> Other studies support the use of CT, citing higher levels of both sensitivity and specificity, as well as pointing out that in many cases CT is ordered subsequent to V/Q when an indeterminate scan result is obtained.<sup>21-23</sup> Although our results suggest that in this ED physicians prefer the use of CT in diagnosing PE, it is unknown whether this reflects a perceived ease of access from this site or some other underlying preference.

Of the 47 charts examined, 39 (83.0%) had a D-dimer ordered during the ED workup. Two previous studies that examined use of D-dimer by emergency physicians both concluded that D-dimer is not being used according to established guidelines.<sup>24,25</sup> The issues identified in these studies were the overuse of D-dimer in high-probability cases of suspected PE<sup>22</sup> and failure to use D-dimer to appropriately determine the need

**Table 1. Comparison of charts positive for pulmonary embolism and negative for pulmonary embolism,  $n = 40^*$**

| Variable     | Sample size<br>(% female) | Age, mean<br>(IQR) yr | ED investigations; no. (%) |            |            |            |            | Time to obtain<br>imaging†, mean (IQR) d |
|--------------|---------------------------|-----------------------|----------------------------|------------|------------|------------|------------|------------------------------------------|
|              |                           |                       | D-dimer                    | CXR        | Leg US     | V/Q        | CT         |                                          |
| PE positive  | $n = 12$ (41.7)           | 61.3 (23.3)           | 8 (66.7)                   | 10 (83.3)  | 3 (25.0)   | 1 (8.3)    | 8‡ (66.7)  | 0.90 (1.75)                              |
| PE negative  | $n = 28$ (75.0)           | 62.9 (25.5)           | 27 (96.4)                  | 25 (89.3)  | 4 (14.3)   | 11 (39.3)  | 9 (32.1)   | 0.88 (1.00)                              |
| Significance |                           | $p = 0.39$            | $p = 0.04$                 | $p > 0.99$ | $p = 0.70$ | $p = 0.30$ | $p = 0.09$ | $p = 0.47$                               |

CT = computed tomography; CXR = chest radiograph; ED = emergency department; IQR = interquartile range; Leg US = bilateral venous ultrasonography of the legs; PE = pulmonary embolism; V/Q = ventilation-perfusion.

\*Of the 47 charts reviewed, 40 had documented PE positive or PE negative in the chart, and 7 had no documentation as to whether PE had been confirmed.

†Refers to V/Q or CT.

‡Refers to imaging that was ordered during the initial emergency department visit for suspected PE; does not include imaging as part of follow-up investigations.

for further testing.<sup>25</sup> Efforts were made to retrospectively calculate a Wells score for the patients reviewed in our study to evaluate adherence to clinical practice guidelines. Upon review, only one of the charts contained documentation of all the pertinent positive and negative signs and symptoms required for the Wells score. For this reason, it was not possible to accurately calculate use of the Wells score and D-dimer test retrospectively. The lack of documented pretest probability combined with these previous experiences suggests that, in our ED, D-dimer is being overused in the workup of suspected PE. One method to reduce this possible overuse of investigations would be to implement a protocol whereby Wells scores would be calculated before further imaging was ordered.

Our study has a number of limitations. The study was limited to one rural ED, raising questions about the generalizability of the data. The small number of patients included in the review limits the study's power. As a retrospective chart review there is the possibility of data being recorded incorrectly on charts as well as errors in transcription into the electronic records system. As was previously mentioned, the inability to calculate a Wells score, and therefore evaluate adherence to clinical practice guidelines, is a further limitation to the study.

## CONCLUSION

Our results conclude that, in one rural ED, patients with suspected PE were subjected to equally short delays in undergoing either V/Q or CT and that CT was used more often in the diagnosis of PE than V/Q. There may be overreliance on D-dimer testing in this rural centre, compared with quoted averages, irrespective of Wells score. Doppler ultrasonography of the legs was not used any more frequently than CT or V/Q in aiding the diagnosis. Anticoagulation was started in most patients empirically. Further research needs to be done at multiple centres in both rural and urban settings to characterize the diagnosis, treatment and outcome for patients with PE. Then, an informed decision about the regionalization of treatment for PE could be addressed.

**Competing interests:** None declared.

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