

## Active implementation of a consensus strategy improves diagnosis and management in suspected pulmonary embolism

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### Summary

Our consensus-based strategy in the diagnostic management of patients with pulmonary embolism involves a perfusion lung scan, a ventilation lung scan, compression ultrasonography and pulmonary angiography, in sequence. We compared the diagnostic approach in patients with clinically suspected pulmonary embolism before the active implementation of this strategy (retrospective analysis of 618 patients, April 1992–March 1995) and after (prospective study of 250 patients, April 1995–March 1996), with another assessment 1 year later. The measured outcomes were: (i) final diagnosis of pulmonary embolism either directly by pulmonary angiography, indirectly by compression ultrasonography of the leg veins, or with a high

probability from a ventilation/perfusion lung scan; (ii) prescription of anticoagulant therapy. Before strategy implementation, pulmonary embolism was adequately confirmed or excluded in 11% of patients with an abnormal perfusion lung scan; in 55% the diagnosis remained uncertain, but the patient received anticoagulants. After implementation, these figures were 58.5% and 13%, respectively. A modest further improvement was observed 1 year later. Active implementation of a consensus-based strategy in the diagnosis of pulmonary embolism increases definite diagnoses, and reduces the numbers treated with anticoagulants. It induces a rapid change in the diagnostic behaviour of physicians.

### Introduction

The diagnosis of pulmonary embolism in patients presenting with chest complaints can be complex. Because of the fear of complications if untreated, in particular when diagnostic tests are inconclusive, anticoagulant therapy is often started and continued.<sup>1,2</sup> However, treatment with anticoagulants is

not without side-effects, most notably bleeding.<sup>3</sup> Thus, both the confirmation and exclusion of the diagnosis of pulmonary embolism is important. Traditional diagnostic tests, such as blood gas analysis, EKG and chest X-ray, can at best give circumstantial evidence of the presence of pulmonary

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embolism, or may point to another explanation for the symptoms.<sup>4-6</sup> Specific tests for the diagnosis of venous thromboembolism are perfusion-ventilation lung scintigraphy, ultrasonography of the leg veins and pulmonary angiography, the current gold standard.<sup>7-11</sup>

However, there remains confusion among clinicians about the order in which these tests should be performed, as well as about the correct interpretation of the test results.<sup>2,10,12</sup> Therefore, an expert panel in 1993 in the Netherlands proposed a consensus diagnostic algorithm based on an analysis of the literature, for patients with clinically suspected pulmonary embolism.<sup>13,14</sup> This algorithm is very similar to other published strategies.<sup>10,15</sup> Briefly, a perfusion lung scan is performed first, since a normal result excludes clinically relevant pulmonary embolism and anticoagulant therapy can be safely withheld. In case of at least one segmental defect, a ventilation lung scan is obtained. If the ventilation lung scan is normal, pulmonary embolism is highly likely and anticoagulant therapy is instituted or continued. If perfusion/ventilation lung scan shows matched defects, or when there are subsegmental defects, the scan is considered non-diagnostic.

In these patients, ultrasonography of the legs is performed; if a deep-vein thrombosis is demonstrated, further diagnostic evaluation is considered redundant. Finally, pulmonary angiography is performed if no deep-vein thrombosis can be demonstrated.

Initially, this consensus-based strategy was propagated in our teaching hospital at clinical conferences and journal club meetings. Two years later, the consensus algorithm was actively implemented over a period of one year in a prospective study. In the present analysis we compare the diagnostic approach in patients with clinically suspected pulmonary embolism in the period before and after the active implementation of this consensus based strategy. Finally, we assessed the impact of this implementation 1 year after the completion of the prospective study.

## Methods

### Retrospective cohort

The study cohort was identified through the records of the department of nuclear medicine, where all consecutive patients who underwent a perfusion lung scan for clinically suspected pulmonary embolism were registered. We collected data for the year before publication of the consensus (April 1992–March 1993) and the two years following this publication (April 1993–March 1995). The following data were collected from the patients charts: age,

gender, results of perfusion lung scan, ventilation lung scan, ultrasonography of the leg veins, as well as pulmonary angiography, and whether anticoagulant treatment with initial heparin and longterm coumarin was prescribed.

### Prospective study

All consecutive patients admitted to our hospital between April 1995 and March 1996 for suspected pulmonary embolism were entered in the study. The perfusion lung scans were ordered by the attending physician. In the case of an abnormal perfusion scan, the patient was seen by one of us (SGH) who assisted in the further diagnostic process in accordance with the consensus. The diagnostic strategy was completed within 72 h after obtaining the perfusion scan. The study protocol was approved by the hospital ethics committee and informed consent was obtained from all participants.

### Perfusion and ventilation lung scanning

The perfusion lung scan was performed after the intravenous administration of 75 MBq <sup>99m</sup>Tc-technetium-labelled macro-aggregates of albumin. Six views were obtained (anterior, posterior, left/right lateral and left/right posterior oblique) with at least 400 000 counts per view. The ventilation lung scan was performed with <sup>81m</sup>Krypton similarly to the perfusion scan. The perfusion lung scans were interpreted using an anatomical lung segment chart, as either normal, or showing subsegmental or segmental defects.<sup>16</sup> A segmental perfusion defect combined with a locally normal ventilation lung scan was considered as high probability for pulmonary embolism. All other results were classified as non-diagnostic.

### Compression ultrasonography

Compression ultrasonography of the lower-limb veins was done using a 5.0 or 7.5 MHz linear array transducer. The deep veins were scanned at the groin and at the popliteal fossa. A diagnosis of deep venous thrombosis was made if the vein could not be compressed completely as described previously.<sup>17</sup>

### Pulmonary angiography

Pulmonary angiography was done using a 7 F Church or 7 F Grollman catheter introduced by the Seldinger method into the femoral vein and positioned into the truncal artery. A non-ionic, low-osmolar contrast material with a volume of 20–48 ml was injected over 1–2 s. To visualize the arterial capillary and venous system, 4–6 images/s were made over 15–20 s. Usually the truncal artery, right and left pulmonary artery are selectively catheterized and

combined with anterior and oblique projections sufficient to confirm or reject the diagnosis of pulmonary embolism, using criteria described earlier.<sup>10,11</sup>

## Classification

For the periods of observation, before and after implementation as well as for the later follow-up, the outcome of diagnostic tests and subsequent treatment were classified in those with an abnormal perfusion scan as: pulmonary embolism adequately confirmed; pulmonary embolism adequately excluded; pulmonary embolism diagnosis uncertain, but treated with anticoagulants; and pulmonary embolism diagnosis uncertain, but not treated with anticoagulants. The category 'pulmonary embolism confirmed' included patients with a high probability lung scan, an abnormal ultrasonography test result or a pulmonary angiogram showing emboli. Patients with a normal pulmonary angiogram were classified as 'pulmonary embolism adequately excluded'. Patients in whom the diagnostic tests performed were inconclusive were subdivided into those treated or not treated with anticoagulants.

## Results

### Patient characteristics

Table 1 details the patient characteristics during the two study periods. During the years before the active implementation of the consensus-based diagnostic strategy (from April 1992 to March 1995), the proportion of patients with abnormal perfusion scans and their age and gender distribution were comparable. The characteristics of the patients included in the prospective phase of the study were similar to those in the previous phase.

### Before implementation

We combined the data for the years before implementation, since the patient characteristics, the various techniques available and the application of these tests were similar. In addition, the distribution of the test outcomes and the subsequent therapeutic management were fully comparable during the period April 1992–March 1995. A total of 618 patients underwent a perfusion lung scan, because of clinically suspected pulmonary embolism, of which 395 scans (64%) were abnormal, i.e. they showed subsegmental or segmental perfusion defects (Table 2). A diagnosis of pulmonary embolism was adequately confirmed in 31 patients (8%). Anticoagulant therapy was prescribed in all 31 of these patients, and also 216 of the other patients (55%) in whom the dia-

gnosis of pulmonary embolism was not definitively proven. In only 13 patients (3%) was pulmonary embolism adequately excluded. A total of 135 patients (34%) in whom a final diagnosis of pulmonary embolism remained uncertain, were not treated with anticoagulants.

### After implementation

In the period April 1995–March 1996 when the consensus-based strategy was actively implemented, 250 patients underwent a perfusion lung scan because of clinically suspected pulmonary embolism; 154 scans (62%) were abnormal (Table 2). There was a considerable increase in the proportion of patients in whom the diagnostic process resulted in the adequate confirmation or exclusion of the diagnosis of pulmonary embolism. In the period before implementation, this was only 11% of the patients with an abnormal perfusion scan, which increased to 58.5% in the prospective phase. At the same time, the number of patients who were treated with anticoagulant therapy although the diagnosis of pulmonary embolism was uncertain, decreased from 55% to 13%. The diagnosis of venous thromboembolism was demonstrated by a high-probability perfusion-ventilation scan in 21 patients, an abnormal ultrasound of the deep lower-limb veins in 10 patients, and by an abnormal pulmonary angiogram in 10 patients. In another 49 patients, pulmonary embolism was excluded by a normal angiogram. No clinically relevant complications of pulmonary angiography were observed.

The proportion of patients with an uncertain diagnosis of pulmonary embolism, but in whom anticoagulant therapy was withheld, was comparable before and after implementation. During the prospective phase, we were able to analyse the outcome of the 44 untreated patients. In about 75%, another diagnosis could adequately explain the patient symptomatology, e.g. pneumonia, myocardial ischaemia, bronchial carcinoma.

For the analysis one year after the prospective study, a total of 98 consecutive patients with suspected pulmonary embolism seen during the first 6 months of 1997, were available. A perfusion scan was abnormal in 52 patients (53%). The proportion of patients in whom pulmonary embolism was adequately confirmed remained similar (21%), while the percentage of patients in whom pulmonary embolism was adequately excluded rose to 52%, mainly due to a more frequent use of pulmonary angiography.

## Discussion

This study demonstrates that the active implementation of a consensus-based strategy in the diagnostic

**Table 1** Characteristics of patients with clinically suspected pulmonary embolism seen before and after the implementation of a consensus-based diagnostic strategy

| Characteristics                     | Before                |                       |                       | After                 |
|-------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
|                                     | April 1992/March 1993 | April 1993/March 1994 | April 1994/March 1995 | April 1995/March 1996 |
| Total number of Hospital admissions | 10 207                | 10 476                | 10 551                | 10 265                |
| Perfusion lung scans performed*     | 169 (1.7%)            | 223 (2.1%)            | 226 (2.1%)            | 250 (2.4%)            |
| Perfusion lung scans abnormal       | 107 (63%)             | 155 (70%)             | 133 (59%)             | 154 (62%)             |
| Mean age (years) (SD)               | 58.5 (19)             | 62.0 (18)             | 57.1 (19)             | 56.6 (19)             |
| Males                               | 46%                   | 42%                   | 43%                   | 42%                   |
| <i>Department of admission</i>      |                       |                       |                       |                       |
| Internal Medicine                   | 94 (56%)              | 108 (49%)             | 125 (55%)             | 137 (54%)             |
| Pulmonary Medicine                  | 48 (28%)              | 68 (30%)              | 61 (30%)              | 64 (26%)              |
| Cardiology                          | 20 (12%)              | 27 (12%)              | 27 (12%)              | 34 (14%)              |
| Surgery/Gynaecology                 | 7 (4%)                | 20 (9%)               | 13 (6%)               | 15 (6%)               |

\* For clinically suspected pulmonary embolism.

**Table 2** Outcome of diagnostic tests and subsequent treatment in patients with clinically suspected pulmonary embolism before and after the implementation of a consensus-based diagnostic strategy

|  | Before<br>April 1992–March 1995 | After<br>April 1995–March 1996 |
|--|---------------------------------|--------------------------------|
| Perfusion lung scan performed*   | 618                             | 250                            |
| Normal perfusion scan  | 223 (36%)                       | 96 (38%)                       |
| Abnormal perfusion scan  | 395 (64%)                       | 154 (62%)                      |
| Pulmonary embolism adequately confirmed  | 31 (8%)                         | 41 (26.5%)                     |
| Pulmonary embolism adequately excluded   | 13 (3%)                         | 49 (32%)                       |
| Pulmonary embolism diagnosis uncertain,<br>but treated with anticoagulants     | 216 (55%)                       | 20 (13%)                       |
| Pulmonary embolism diagnosis uncertain,<br>but not treated with anticoagulants | 135 (34%)                       | 44 (28.5%)                     |

\*For clinically suspected pulmonary embolism.

approach of patients suspected of pulmonary embolism results in a substantial increase in the number of patients in whom there is certainty about the absence or presence of pulmonary embolism. We observed a five-fold increase in the number of patients in whom pulmonary embolism was adequately confirmed or excluded, i.e. from 11% to 58.5%. Concomitantly, the proportion of patients with an abnormal perfusion scan in whom the diagnosis remained uncertain, but the proportion who were treated with anticoagulants dropped substantially. One year after completion of the prospective study, some further improvements in the adequate confirmation or exclusion of pulmonary embolism were observed, indicating a hospital-wide acceptance of the consensus strategy.

Furthermore, this study illustrates that the active implementation of a diagnostic strategy can change the behaviour of physicians. In the initial period of observation, 1992–1995, the diagnostic process was often not completed, and treatment decisions were mainly based on clinical grounds, an observation which has also been made by other investigators.<sup>1,2,10</sup> It should be realized that during this period the consensus strategy for pulmonary embolism was published and discussed in our hospital. Nevertheless only 11% of patients with an abnormal perfusion scan had the diagnosis of pulmonary embolism excluded or confirmed. The successful implementation of the consensus is most likely due to the advantages it offered the attending physician. These include the following. First, the entire diagnostic process was completed within 72 h (and in most cases <48 h) after the clinical suspicion of embolism was raised. Therefore, decisions to stop or continue anticoagulant treatment could be made at a much earlier stage than before. Second, the systematic use of pulmonary angiography revealed that the degree of clinical suspicion is often misleading, i.e. there were many cases with a high clinical suspicion of

pulmonary embolism that turned out not to have that diagnosis, and vice versa. Finally, as has been documented by others, pulmonary angiography is a safe diagnostic tool, which was not fully appreciated before the active implementation.<sup>7,10,11</sup>

There are various approaches for the implementation of a novel strategy. We have chosen a prospective study with a supervising physician. This is of course labour-intensive, but offers the advantage that the consensus approach quickly results in reliable data which in turn support the change in diagnostic behaviour. Mere publication and introduction of a consensus strategy is apparently not enough to improve diagnostic decision-making by physicians.<sup>18,19</sup> It remains to be seen whether our strategy will be similarly successful in other institutions.

It could be argued that the improvement in the diagnostic performance observed during the prospective phase is more impressive because the diagnostic approach before implementation was far from optimal. This may in part be true, although other studies have documented similar results.<sup>2,12</sup>

In conclusion, the active implementation of a consensus strategy, including ultrasonography of the leg and pulmonary angiography, improves the diagnostic approach in patients with suspected pulmonary embolism. Such an approach is associated with an increased use of angiography, and results in a substantial increase in the proportion of patients in whom treatment with anticoagulants is appropriately instituted or withheld.

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