Emergency diagnosis of pulmonary embolism

Acute massive pulmonary embolism is an emergency requiring immediate treatment. The right heart functional reserve is the major determinant of acute survival. Because most of the deaths resulting from the initial haemodynamic insult occur either immediately or within a few hours, the relief of pulmonary vascular obstruction must be as fast as possible. This can be achieved by thrombolytic treatment, perhaps combined with mechanical fragmentation of the clot through catheter techniques, or by embolectomy. All these measures have inherent risks and must therefore be applied only in patients with unequivocal evidence that the acute haemodynamic failure is caused by massive pulmonary embolism. Morbidity and mortality of patients receiving thrombolysis or embolectomy with an incorrect diagnosis will be very high. In order to initiate aggressive treatment without delay, the challenge is to diagnose this disorder promptly. The problems are magnified by the fact that patients with massive pulmonary embolism are often too ill to transport to locations where diagnostic tests can be carried out.

Acute massive pulmonary embolism should be suspected in hypotensive, cyanotic, and dyspnoeic patients when there is evidence of (or predisposing factors for) venous thrombosis, clinical evidence of acute right heart failure (high jugular venous pressure, an S3 gallop at lower sternum, tachycardia, and tachypnoea), and ECG signs of inferior vena cava compression. The differential diagnosis includes all conditions that can lead to acute circulatory collapse, particularly if they are also likely to cause acute dyspnoea. The most important are left heart failure, cardiac tamponade, ventricular septal rupture, myocardial infarction, aortic dissection, tension pneumothorax, and severe asthma. The absence of pulmonary rales is the warning that the haemodynamic problems do not result from left ventricular impairment, but a pattern similar to acute massive pulmonary embolism can result from right ventricular infarction.

Problems with pulmonary angiography and scintigraphy

Selective pulmonary angiography is the gold standard for the diagnosis of pulmonary embolism. Unfortunately, it is invasive, time consuming, and not always readily available. Perfusion lung scintigraphy is an indirect method of diagnosis since it does not detect the embolus itself but only its consequence—the perfusion abnormality. The diagnosis of acute massive pulmonary embolism is very unlikely in patients with normal or near normal scans. High probability scans usually indicate acute pulmonary embolism, particularly if the scan defects are multiple and extensive, but fewer than half of those patients with pulmonary embolism have a high probability scan. Scans that fall between these extremes of the spectrum are non-diagnostic, and further testing is necessary. The rather long time needed for the investigation makes scintigraphy problematic in haemodynamically unstable patients in shock or after cardiopulmonary resuscitation. Ascending aortic dissection may compress the right pulmonary artery and mimic unilateral massive pulmonary embolism on scintigraphy. Patients with a low cardiac output or on catecholamines may have important local disturbances of lung perfusion in the absence of pulmonary embolism. Thus, before sending a compromised patient to a nuclear laboratory, remember that the result may be inconclusive in over half of the cases.

Computed tomography

Computed tomography (CT) has emerged as a valuable method for diagnosing pulmonary embolism and, because of its widespread availability, it is becoming the first choice of many institutions. Although CT still requires the patient to be transported to and placed onto the CT scanner, it is faster, less complex, and less operator dependent than conventional pulmonary angiography, and has about the same frequency of technically insufficient examinations (2–5%). The chest can be scanned during a single breath hold. There is better interobserver agreement in the interpretation of examinations with CT than for scintigraphy. Another advantage of CT over scintigraphy is that by imaging the lung parenchyma and great vessels, an alternative diagnosis (for example, pulmonary mass, pneumonia, severe emphysema, pleural effusion) can be made if pulmonary embolism is absent. CT can also detect right ventricular dilatation, thus indicating severe, potentially fatal pulmonary embolism.

Criteria for a positive CT scan result are similar to those for angiography and include a partial filling defect (defined as intraluminal areas of low attenuation surrounded by a contrast medium), a complete filling defect, and the “railway track sign” (masses seen floating freely in the lumen, allowing the flow of blood between the vessel wall and the embolus). The procedure has over 95% specificity and sensitivity in diagnosing massive pulmonary embolism in the main and lobar pulmonary arteries.

Transthoracic echocardiography

Transthoracic echocardiography (TTE) is a widely and readily available rapid non-invasive diagnostic tool. Although it rarely enables direct visualisation of the pulmonary embolus, it may reveal a floating thrombus trapped in transit in the right atrium or ventricle (such thrombi carry a high risk of early re-embolisation and are associated with an adverse outcome). In the presence of right heart thrombi on echocardiography, angiography is not necessary and, indeed, is contraindicated because of the risk of thrombus dislodgement.

The right ventricle that is not chronically pressure overloaded responds to massive pulmonary embolism by dilating and becoming hypokinetic, with a corresponding decrease in left heart dimensions. Characteristically there will be interventricular septum flattening or bulging towards the left ventricle in diastole. The inferior vena cava is dilated and does not collapse during inspiration. In patients with normal blood pressure on presentation, this right ventricular dysfunction provides indirect evidence of severe pulmonary artery obstruction and impending haemodynamic failure. Unfortunately, the finding of right ventricular dysfunction is non-specific and certain conditions commonly confused with pulmonary embolism.
artery; this di- 
nary artery is a relatively blind spot for TOE as the left 
imaged in more than one plane. The proximal left pulmo-
alters the blood flow by Doppler imaging, and can be 
blood and vascular wall, protrudes into the arterial lumen,
when it has distinct borders and di-
However, because the right ventricle may show no dysfunction even in patients 
with massive pulmonary embolism, TTE is an ancillary 
rather than a principal test for the diagnosis of acute 
pulmonary embolism. TTE may be technically unsatisfac-
tory in obese subjects or those with lung hyperinflation, as 
well as in immobile, mechanically ventilated patients.

Transoesophageal echocardiography

With transoesophageal echocardiography (TOE) it is pos-
sible to visualise emboli in the central pulmonary arteries. Enhanced visualisation of the proximal pulmonary arteries is the main advantage of TOE over TTE: pulmonary embolism detection compared to TTE. False positives by TOE are uncommon, but the sensitivity varies widely and is 
dependent on the selection of patients and the expertise 
and thoroughness of the echocardiographer. In order 
to minimise false positive diagnoses of pulmonary 
embolism, unequivocal thrombus should be reported only 
when it has distinct borders and different echodensity than 
blood and vascular wall, protrudes into the arterial lumen, 
alters the blood flow by Doppler imaging, and can be 
imaged in more than one plane. The proximal left pulmo-
nary artery is a relatively blind spot for TOE as the left 
main bronchus runs between the oesophagus and the 
artery: this difficulty may be overcome by the use of multi-
plane probes. The specificity of TOE in diagnosing central 
pulmonary embolism seems comparable to CT; TOE offers 
a distinct advantage because it can be performed 
promptly in the emergency room or intensive care unit 
without the need to interrupt treatment and transfer the 
patient to the radiology department.

In this issue of Heart, Pruszczyszyk and colleagues report 
their favourable experience with TOE in suspected 
haemodynamically significant pulmonary embolism. The 
authors investigated the use of TOE to search for 
pulmonary arterial thrombi in 113 consecutive patients 
with clinical suspicion of pulmonary embolism and other-
wise unexplained signs of right ventricular overload on 
TTE. Fifty one of the 113 patients were examined within 
14 days after the onset of symptoms, while the remaining 
62 subjects with a longer history were suspected to have 
chronic pulmonary embolism. Forty two out of 51 patients 
suspected of acute pulmonary embolism had confirmed 
emboli (by scintigraphy, CT, angiography, or at necropsy). 
Emboli were identified in 32 (76%) of these patients by 
TOE; there were no false positive findings.

The authors do not inform us whether their institutes 
serve as general acute referral hospitals and, of particular 
concern, whether all patients with haemodynamic compro-
mise and suspicion of pulmonary embolism were investi-
gated. Were this not the case, the validity indices of TOE in 
visualising pulmonary embolism could not be calculated. 
The authors also do not state whether there was patient 
overlap in this and their two previous studies on the same 
topic. None of the patients presented as an emergency 
with haemodynamic instability at the time of TOE; in the 
majority of them, it was possible to perform other investiga-
tions for confirming or excluding pulmonary embolism (all 
patients could be investigated by ventilation-perfusion scin-
tigraphy). With respect to the emergency diagnosis of 
massive pulmonary embolism, the most valuable (but unfor-
unately not tested) potential of echocardiography is the 
possibility to perform the investigation quickly in unstable 
patients at the bedside in the intensive care unit. In the study 
by Pruszczyszyk and colleagues, only patients referred to 
the echocardiographic laboratory were investigated; probably 
those most in need of prompt diagnosis—that is, patients 
who needed intensive haemodynamic monitoring and 
support—were not transferred to the echo lab.

Despite the above shortcomings, some generalisations 
from the study of Pruszczyszyk and colleagues seem possible. 
TOE is feasible, rapid, well tolerated and, in the absence 
of oesophageal disease, probably safe in haemodynamically 
stable patients with right ventricular strain. The finding of 
intraluminal masses as defined by the authors is, in the 
context of a clinical presentation suggestive of acute 
pulmonary embolism, probably specific for the condition.

What is the best approach to diagnosing pulmonary 
embolism?

How should we use TTE and TOE in the emergency man-
agement of patients with suspected acute massive pulmo-

Editorial

nary embolism? All of the above mentioned studies suffer 
somewhat from methodologic imperfections, such as small 
numbers, patient selection bias, and inadequate standards 
in confirming pulmonary embolism. However, we cannot 
suspend patient care while we await the results of “perfect” 
studies. TTE should be used as a rapid initial test in 
patients with suspected massive pulmonary embolism or 
unexplained hypotension, especially for patients who are 
too ill to move out of the intensive care unit. Right heart 
thrombi or diagnoses other than pulmonary embolism may 
be apparent on TTE. The finding of right ventricular dys-
function would support (but not confirm) a diagnosis of 
chronic pulmonary embolism. Like TOE, CT has near perfect specificity for 
haemodynamically significant pulmonary embolism un-
likely. When evidence of significant and otherwise 
unexplainable right heart strain without clots is present on 
TTE, TOE should rapidly follow at the bedside. The find-
ing of unequivocal thrombus in the pulmonary arteries by 
TOE has a very high specificity for pulmonary embolism, 
and warrants treatment without further testing if the diag-
nosis fits clinically. If TOE is unavailable, negative for pul-
monary embolism or inconclusive, spiral CT or pulmonary 
angiography should follow, depending on which is available 
with least delay. Both procedures, however, may be 
constrained by logistic problems, including patient trans-
portation. Like TOE, CT has near perfect specificity for 
the diagnosis of central massive pulmonary embolism. 
Sometimes angiography may be the most readily available 
investigation, especially in centres specialised in catheter 
treatment of acute coronary syndromes; besides providing 
definitive proof of pulmonary embolism and accurate 
assessment of the haemodynamic situation, catheterisation 
also enables rapid fragmentation of central emboli.

There will never be any trials of appropriate size or design 
which compare all of the described investigations in the 
emergency diagnosis of life threatening pulmonary embolism. 
There will also be no single algorithm for the approach to 
acute massive pulmonary embolism in the near future. The 
diagnostic approach will be influenced by the ready 
availability of and experience with a certain technology. 
Although proof of pulmonary embolism is a requirement for
thrombolytic or surgical treatment, in the imperfect real world there are occasional circumstances when massive pulmonary embolism is highly likely and intuitively obvious in a moribund patient, and where it may be appropriate to consider significant unexplained right ventricular dysfunction as an indication for immediate treatment without definitive proof of pulmonary embolism.

MARTIN RIEDEL

Deutsches Herzcentrum, Technische Universität München, München, Germany
m.riedel@dhm.mhn.de


IMAGES IN CARDIOLOGY

Isolation of the left subclavian artery in a patient with Williams-Beuren syndrome

A 7 year old child with a genetic diagnosis of Williams-Beuren syndrome (microdeletion 7q11.23) had a ventricular septal defect, supravalvar and peripheral pulmonary artery stenosis, supravalvar aortic stenosis, and isolation of the left subclavian artery from the right aortic arch, originating from a patent ductus arteriosus.

Cardiac catheterisation in infancy revealed systemic pressure in the central portion of the pulmonary arteries, and angiography showed systolic blood flow from the pulmonary to the left subclavian artery. At 7 years of age, peripheral pulmonary artery stenosis had decreased and mean pressure in the central PA was subsystemic. The left subclavian artery was now supplied by a retrograde perfused left vertebral artery with retrograde flow into the pulmonary arteries during diastole (pulmonary artery and subclavian artery steal) (a, aberrant left subclavian artery; s, stenoses of left and right superior lobe arteries).

Right aortic arch with isolation of the left subclavian artery is the least common type of right arch. The embryologic development of this malformation can be explained by regression of the left aortic arch between the left common carotid and the left subclavian artery, as well as between the left subclavian artery and the descending aorta, with persistence of a small bridge of the left arch connecting the left ductus and the left subclavian artery.

The diagnosis of this anomaly is of clinical importance because it can cause vertebrobasilar or left upper extremity ischaemia which is amenable to surgical treatment.

We believe this is the first report of a right aortic arch with isolation of the left subclavian artery in a patient with Williams-Beuren syndrome.

JAIME F VAZQUEZ-JIMENEZ
EBERHARD G MUEHLER
DIETER KOCH
Emergency diagnosis of pulmonary embolism

MARTIN RIEDEL

*Heart* 2001 85: 607-609
doi: 10.1136/heart.85.6.607

Updated information and services can be found at:
http://heart.bmj.com/content/85/6/607

These include:

**References**
This article cites 16 articles, 5 of which you can access for free at:
http://heart.bmj.com/content/85/6/607#BIBL

**Email alerting service**
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

**Topic Collections**
Articles on similar topics can be found in the following collections
- Venous thromboembolism (495)
- Drugs: cardiovascular system (8842)
- Clinical diagnostic tests (4779)
- Epidemiology (3758)
- Hypertension (3006)
- Acute coronary syndromes (2742)
- Interventional cardiology (2933)
- Tachyarrhythmias (208)

**Notes**

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/