Massive pulmonary embolism;
the place for embolectomy

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SUMMARY
Untreated massive pulmonary embolism is associated with a high mortality. Pulmonary embolectomy has been largely superceded by thrombolytic therapy, but there are cases in which pulmonary embolectomy remains the treatment of choice. We present three case reports and discuss the merits of the various treatments available for massive pulmonary embolism. The primary treatment of massive pulmonary embolism should be thrombolytic therapy, but for patients who are at risk of haemorrhage following surgery, who are in cardiogenic shock despite medical treatment, or fail to improve following cardiac arrest, then pulmonary embolectomy remains the treatment of choice.

INTRODUCTION
The role of pulmonary embolectomy in the treatment of massive pulmonary embolus has been in doubt since the introduction of thrombolytic therapy. Indeed a recent review article failed to mention pulmonary embolectomy as a treatment option, relying on anticoagulation or thrombolytic therapy for the treatment of all pulmonary emboli. However, thrombolytic therapy is not always appropriate, and an alternative treatment is desirable for patients who fail to respond to medical treatment. We report three patients in whom thrombolytic therapy was inappropriate and discuss the option of embolectomy.

PATIENTS
1. A 64-year-old man with acute urinary retention underwent open prostatectomy under spinal anaesthesia in another hospital. Postoperative haemorrhage resulted in clot retention necessitating re-exploration two days later, again under spinal anaesthesia. Within twelve hours he became acutely dyspnoeic and hypoxic with tachycardia. An initial differential diagnosis of either adult respiratory distress syndrome or massive pulmonary embolism was made. He was urgently transferred to the respiratory intensive care unit at The Royal Victoria Hospital for further treatment. On admission he gave no history of chest pain, but was centrally cyanosed with a respiratory rate of 28 per minute. He had bilateral varicose veins with thrombophlebitis of the left long saphenous vein from the lower leg to the groin. The pO₂ in arterial blood was 58 mmHg (7.6 kPa), pCO₂ was 31 mmHg (4.1 kPa) and pH 7.3. Electrocardiograph showed no
specific abnormality. Chest X-ray showed oligaemia of the left lung consistent with pulmonary embolism (Fig 1). Pulmonary angiography confirmed a large pulmonary embolus obstructing nearly all flow in the left pulmonary artery (Fig 2). In view of the recent history of surgery with bleeding complications, thrombolytic therapy was felt to be contra-indicated, and pulmonary embolectomy was performed using cardio-pulmonary bypass. A 10cm clot was removed from the left pulmonary artery. He made an uneventful recovery and was discharged back to the referring hospital on the 7th postoperative day, taking oral anticoagulants. He remained well at outpatient follow-up two months later.

Fig 1. Patient 1: Plain chest radiograph showing oligaemia of the left lung.

Fig 2. Patient 1: Pulmonary angiogram showing large embolus in the left main pulmonary artery.

2. A 68-year-old man was admitted with a history of vomiting and diarrhoea. Investigation revealed a tumour in the ascending colon. Nine days after admission he underwent right hemicolectomy for an obstructing well differentiated adenocarcinoma of the ascending colon (Duke's stage C). He received subcutaneous heparin 500 units twice daily before and after operation. At 48 hours he became dyspnoeic and cyanosed. Electrocardiograph and chest X-ray were interpreted as normal and he was considered to have developed septic complications of his large bowel surgery. He was started on a dopamine infusion because of poor peripheral perfusion and a blood pressure of 80/60mmHg. His condition continued to deteriorate and a cardiac surgical opinion was sought 11 hours after the initial episode. At this time he was cyanosed with a markedly raised venous pressure and a low cardiac output. Heart rate was 120 per min with a gallop rhythm. Respiratory rate was 28 per minute. Repeat chest X-ray showed oligaemia of the right lung and of the upper zone of the left lung. The pO2 in arterial blood was 57mmHg (7.5kPa), pCO2 26mmHg (3.4kPa) and pH 7.37. A diagnosis of pulmonary embolism was made, and confirmed by pulmonary angiography. Both lungs were severely affected, with sparing only of the lingular segments of the left upper lobe (Fig 3). His condition was continuing to deteriorate despite

Fig 3. Patient 2: Pulmonary angiogram showing bilateral multiple pulmonary emboli with sparing of the artery to the lingular segment of the left upper lobe.

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inotropic support. At operation, fifteen hours after the initial event, cardio-
pulmonary bypass facilitated removal of a large amount of clot from both
pulmonary arteries. He made an uneventful recovery, remained on oral anti-
coagulants for three months, and remained well four months postoperatively.

3. A 64-year-old woman was admitted to the Mater Infirmary Hospital with a
two-year history of bright red rectal bleeding associated with diarrhoea, lethargy
and weight loss. She was found to have a carcinoma of the ano-rectal junction.
Abdomino-perineal resection was performed nine days after admission,
secondary closure of the perineal wound was performed after three days. Five
days later, her condition deteriorated suddenly. She complained of nausea, and
was found to have a tachycardia with hypotension and a raised jugular venous
pressure. Electrocardiograph showed no acute changes but a diagnosis of
pulmonary embolism was made on clinical grounds. She was transferred to the
intensive care unit and treated by heparin anticoagulation and oxygen by face
mask. Arterial blood showed a pO2 of 48 mmHg (6·3 kPa), pCO2 of 26 mmHg
(3·4 kPa), pH of 7·2 and "base excess" of −11·2. Ninety minutes following the
initial episode she became more hypotensive and suffered a cardiorespiratory
arrest. The regional cardiothoracic unit was being consulted by telephone, and a
decision was made to attempt embolectomy. Cardiopulmonary resuscitation was
continued during her transfer to theatre whilst the operating surgeon travelled
between the two hospitals. Pulmonary embolectomy was performed during a two-
minute period of inflow occlusion after thirty minutes of attempted resuscitation.
A large clot was removed from the right main pulmonary artery, and satisfactory
cardiac output was restored with the aid of inotropic support. During this episode
she suffered a major cerebral insult and required tracheostomy and ventilation for
twenty-four days. The electroencephalogram at ten days was grossly abnormal
and the report suggested a poor prognosis for cerebral recovery. However,
she regained consciousness and returned to the ward twenty-six days after
embolectomy. Normal cerebration and speech slowly returned. She was
discharged home 110 days following embolectomy, with a residual right
hemiparesis, but able to walk with the aid of a frame. Her hemiplegia has
continued to improve.

DISCUSSION
Pulmonary embolism remains a significant cause of hospital morbidity and
mortality, especially following major surgery. Untreated massive pulmonary
embolism with significant hypotension is associated with a greater than 50% mortality rate, and 70% of the fatalities occur within two hours.² Treatment
should therefore be started as soon as the condition is diagnosed. The major
problem in making the diagnosis is that the symptoms are often non-specific³
and patients who survive the initial embolus may be diagnosed as having a wide
variety of disease. The most accurate diagnostic test is pulmonary angiography,
but as it has its own morbidity and mortality in the severely compromised patient,
it is generally only used to confirm a diagnosis made on the basis of clinical
examination, chest radiography, electrocardiography and blood gas measure-
ment. The lung perfusion scan is a useful test to exclude pulmonary embolism,
but the false positive rate may be over 50% in patients suspected of having
pulmonary emboli. Early pulmonary angiography is more than 90% accurate.³

The operation of pulmonary embolectomy for massive pulmonary embolism was
first described by Trendelenberg in 1908,⁴ performed via a left thoracotomy.

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However, he never succeeded in saving a life despite more than 12 attempts and it was left to one of his assistants, Kirschner, to perform the first successful embolectomy in 1924. The technique of inflow occlusion, clamping both the inferior and superior venae cavae prior to opening the pulmonary artery, removing the clot, and then placing a side clamp on the pulmonary artery so that the vena caval clamps were removed in under two and a half minutes, was described by Ivor Lewis in 1960. In the same year, Allison described the technique of embolectomy under hypothermia. In 1961 the first embolectomy using cardiopulmonary bypass was performed by Sharp.

The scope for treatment of pulmonary embolism was greatly improved by the development of thrombolytic therapy after the 1960s. Miller, Hall and Paneth from the Brompton Hospital reported a comparison between embolectomy using cardiopulmonary bypass, thrombolytic therapy, and anticoagulation with heparin, in massive pulmonary embolism. Their conclusion was that in most patients there was no advantage of embolectomy over thrombolytic therapy, but both were better than treatment with heparin alone. However, they recommended embolectomy in patients who were within 48 hours of surgery, because of the risk of haemorrhage with thrombolytic therapy. They also recommended surgery for those who were shocked, and showed no sign of improvement, or continued to deteriorate after one hour of medical treatment.

Many of the above patients were selected, already having survived transfer from a referring hospital where the facilities for cardiopulmonary bypass were not available. Clarke and Abrams in Birmingham have offered an embolectomy service, travelling to the hospital where the patient was in extremis, taking with them the few extra instruments required in a sterile pack and operating under inflow occlusion, rather than forcing the patient to undergo a hazardous journey to a hospital with bypass facilities. They have reported a commendable success rate over a twenty-five year period. All but one of their patients had a systolic blood pressure < 100mmHg. Three patients had embolectomy on cardiopulmonary bypass and survived. Fifty-five had embolectomy under normothermic inflow occlusion: of 36 who had not undergone a period of circulatory arrest, 35 survived the operation, 7 died during the postoperative period, and 4 deaths were not related to pulmonary embolism. In the 19 patients who had a period of cardiac arrest the mortality was 16, two not being related to the operation or pulmonary embolus. To minimise the time between the embolus occurring and surgery and because the facility was often not available, they did not usually perform angiography, and this led to a further six patients being operated on in the absence of embolism. They claim that any surgeon with thoracic training should be able to perform this operation and in an emergency when alternative treatment is inappropriate or is failing, it should be considered.

Mattox et al reported an impressive series of 40 embolectomies on 39 patients in extremis over a twenty year period, of whom 17 (43%) survived to leave hospital. Two of the deaths were in patients who had tumour emboli and three more were in patients who had cor pulmonale from previous emboli. Twenty-three patients had angiography performed prior to embolectomy, twenty-two of these were on partial bypass during angiography, which had been instituted under local anaesthetic via femoral arterial and venous cannulation.

Greenfield from Richmond has reported the use of a suction catheter for the transvenous removal of emboli at the time of angiography, but it may be unsuitable in the severely compromised patient. The use of femoro-femoral
partial bypass to support patients undergoing pulmonary angiography may make this technique more widely applicable in the future, but its role is not yet fully established.

Following embolectomy or thrombolysis, anticoagulation with heparin, continued until oral therapy is established, is recommended for at least three months to decrease the risk of recurrent emboli.1

Interruption of the inferior vena cava should probably only be considered in cases of recurrent embolism. Although Mattox reported routinely performing ligation of the inferior vena cava at the time of embolectomy, both Clarke (two patients) and Miller (no patients in the surgical group, one patient in the streptokinase group and two patients in the heparin group) reported low incidence of recurrent emboli. Clarke reported using this technique initially, but abandoned it because the decreased venous return produced a profound fall of cardiac output in several patients and also three patients complained of long term oedema of both legs.

Two of the three patients we report here were unsuitable for treatment with thrombolytic therapy because of recent surgery, and anticoagulation alone was not considered likely to offer satisfactory haemodynamic improvement. The third patient's collapse made thrombolytic therapy inappropriate. Although the first of the three patients might have survived without embolectomy, the second patient was close to death by the time of his operation, and the third patient was not responding to cardiopulmonary resuscitation prior to embolectomy.

Although pulmonary embolectomy has been largely superceded by thrombolytic therapy, and the new thrombolitics undergoing investigation may prove clinically more effective and safer, there remain three indications for surgery in massive pulmonary embolism. These are in the patient with a history of recent surgery, in the patient who is not responding to or deteriorating with thrombolytic therapy, and in the patient who is profoundly shocked needing cardiopulmonary resuscitation. The absence of facilities for cardiopulmonary bypass does not preclude surgery. In the future the availability of easily portable cardiopulmonary bypass equipment may help further to reduce the mortality of this condition.

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