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Intensive Care Medicine

Movement of the Critically Ill within Hospital

C.D. Hanning[1], D.G. Gilmour[2], A.P. Hothersall[3], A.R. Aitkenhead[4], R.M. Venner[5], and I. McA. Ledingham[1]

[1] University Department of Surgery, Western Infirmary, Glasgow, [2] Department of Surgery, Royal Infirmary, Glasgow, [3] Department of Anaesthetics, Stobhill Hospital, Glasgow, [4] Nuffield Department of Anaesthetics, Radcliffe Infirmary, Oxford, [5] Department of Orthopaedics, Western Infirmary, Glasgow, UK

Abstract. Critically ill patients can be safely moved within hospital using a mobile intensive care unit (MICU). The MICU allows the critically ill to benefit from specialised investigation and treatment they might otherwise be denied. The MICU in use at the Western Infirmary, Glasgow is described and its merits outlined in the light of clinical experience gained over a twelve month period.

Key words: Transport, Mobile Intensive Care Unit, Specialised Investigation, Ultrasound, Pulmonary Angiography, Sepsis.

Introduction

Precise information about the effects of movement on patients is sparse and the term 'neglected disease' [1] remains a relevant description of present knowledge. Movement is usually assumed to be hazardous. For this reason critically ill patients are often considered to be "too ill to be moved", with the result that they may be denied the benefits of specialised investigation and treatment. When movement is unavoidable the patient is transported hurriedly in order to minimise the period 'at risk'. Inadequate preparation for the journey, a rough rapid ride and discontinuation of monitoring and treatment may combine to produce a deterioration in the patient's physical and psychological condition. The hazards are increased by the piecemeal modernisation and extension of hospital sites. Such developments not infrequently place accident and emergency departments, operating theatres and intensive therapy units at opposite corners of the hospital.

Redevelopment of the Western Infirmary, Glasgow (WIG) (Fig. 1) was commenced in 1973 and Phase I of the project, a ten-storey block, was opened in 1976. The new block contains the Accident and Emergency Department, operating theatres, acute medical, surgical and orthopaedic beds, and the ITU which is located on the third floor. The new block is linked to the Diagnostic Radiology Department and the older parts of the hospital by a 75 metre tunnel with an average slope of 1.3°; lifts at either end of the corridor provide access to all levels of both blocks. The Department of Diagnostic Ultrasound is located in the Radiology Department and access is limited by sharp turns and narrow corridors. Angiography is performed in the Cardiac Investigation Department located in the new block one floor below ITU. The distance between different areas of the hospital has previously been a deterrent to the movement of critically ill patients. For example, the return distance between the ITU and the Department of Diagnostic Ultrasound is 225 m, requires the negotiation of several sharp corners and two lifts and is a journey to which we would previously have been loth to submit a critically ill patient.

A Mobile Intensive Care Unit has been developed at the WIG to allow the transfer of critically ill patients between hospitals [2, 3]. Experience of over 130 transfers has previously shown that the critically ill can be moved without untoward effect *between* hospitals. This technique has recently been adapted for transport of patients *within* hospital and the present study summarises experience gained during a 12 month period at the WIG.

Mobile Intensive Care Unit

The MICU (Fig. 2.), which has been described in greater detail elsewhere [3], is a well-sprung trolley-bed mounted on castor wheels. A suction unit and metered supplies of oxygen and nitrous oxide are mounted on the removable bedhead. Shelves beneath the bed hold a pressure-driven ventilator (Manley Pulmovent MPP, BOC), D-C defibrillator (DCX 822, Simonsen and Weel) and battery power supplies. A twin-channel oscilloscope (Datascope 861) is pole-mounted at the foot of the bed. The electrocardiogram (ECG), body temperature and intra-arterial blood pressure or pulse wave-form are displayed continuously. Physiological data, inclination and tri-axial acceleration can be continuously recorded on cassette tapes. Monitor

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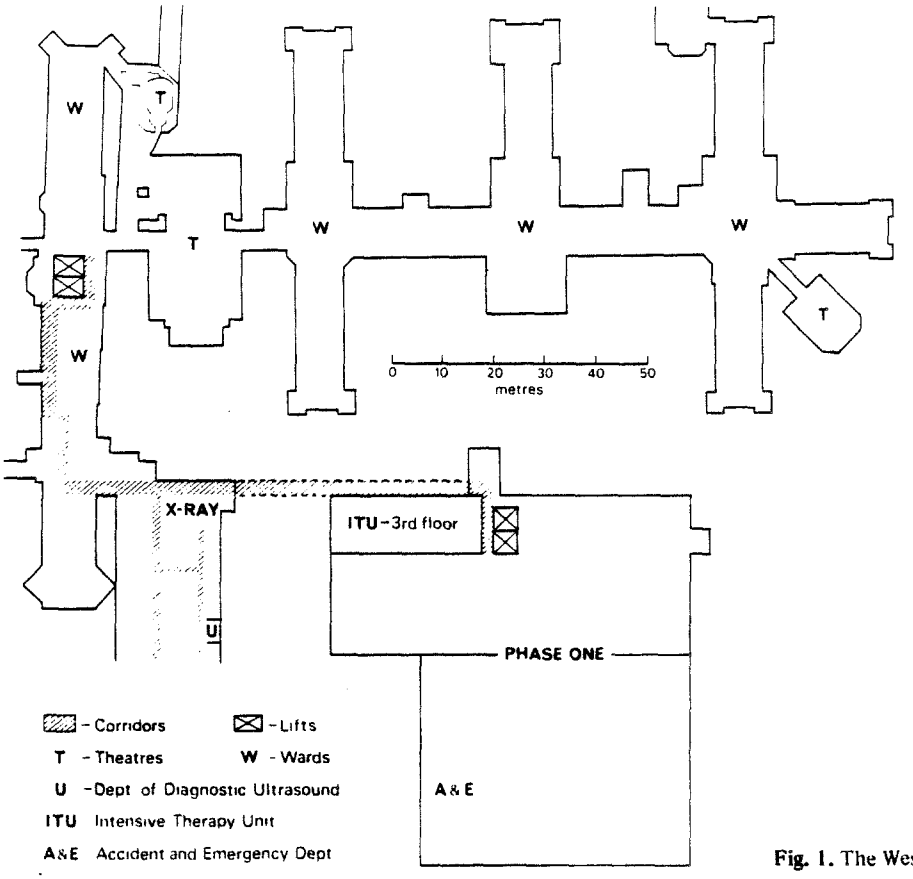

Fig. 1. The Western Infirmary Glasgow

leads and ventilation tubing are sufficiently long to permit movement of the patient to an adjoining bed without disconnection. A case containing a comprehensive range of drugs, intubation equipment, intravenous infusion apparatus and cannulas accompanies the bed. The patient is accompanied by a member of the Intensive Therapy Unit medical staff and an ITU nurse.

Cardiovascular and respiratory stability, including intermittent positive pressure ventilation (IPPV) is ensured before movement is undertaken, using the facilities of the MICU. Adequate sedation is achieved with diazepam, and analgesia with nitrous oxide and narcotic analgesics. The patient is carefully lifted onto the MICU and further assessment of cardiorespiratory stability and adequacy of analgesia and sedation carried out. The patient is monitored continuously during transport, and treatment adjusted accordingly. No attempt is made to hurry but unnecessary delays are avoided, emphasis being placed on smoothness of ride. Monitoring is maintained during investigation and until the patient is returned to his own bed.

Results

Twelve patients, of whom seven survived to leave hospital, made a total of 17 journeys on the MICU in the period February 1976 to February 1977 (Table 1). Each journey averaged 184 m (range 60-225) and involved two movements into and out of lifts. All patients were seriously ill at the time of movement and all were maintained on IPPV for at least one journey. Continuous monitoring throughout the journey allowed trends to be identified and corrected promptly resulting in overall cardiovascular stability. No patient was adversely affected by movement and there was no consistent change in pulse rate or blood pressure. Significant hypotension was noted on only one occasion and was apparently related to continuing haemorrhage rather than to movement (case 5). The most common occurrences were minor degrees of hypertension which responded to increased sedation or analgesia.

Ten ultrasound examinations were performed on seven of the 12 patients transported on the MICU (cases 1-7). Abdominal fluid collections were seen in four (cases 1,2, 5,6) of the seven patients and as a consequence, three patients (cases 1,2,6) underwent laparotomy and drainage of purulent fluid, resulting in clinical improvement. The negative findings in the remaining three patients enabled the abdomen to be eliminated as a major source of sepsis. Two patients (cases 2 and 8) underwent pulmonary angiography for suspected pulmonary thromboembolism. Pulmonary emboli were noted in one patient (case 8) and later confirmed at autopsy. The normal vascular pattern seen in the other patient (case 2) enabled early weaning from IPPV to be undertaken and obviated the need for

Table 1. Diagnoses, indications for transfer, journeys and outcome of patients moved on the MICU
IPPV Intermittent Positive Pressure Ventilation; S.V. Spontaneous Ventilation; U.S. Ultrasonography; P.A. Pulmonary Angiography; A.A. Arch Aortography

No	Age	Sex	Diagnosis	Respiration	Indication for Transfer	Journey	Findings	Subsequent Management	Outcome
1	49	M	Septic shock Respiratory failure	IPPV	Suspected abdominal sepsis US	225m 2 lifts	Subphrenic abscess		Survived
				IPPV	Suspected abdominal sepsis US	225m 2 lifts	Enlarging subphrenic abscess	Laparotomy and drainage	
2	23	F	Hepatic rupture Renal failure Respiratory failure	S.V.	Suspected abdominal sepsis US	225m 2 lifts	Subphrenic abscess	Laparotomy and drainage	Survived
				S.V.	Suspected abdominal sepsis US	225m 2 lifts	Subphrenic abscess		
				IPPV	Suspected pulmonary embolism PA	60m 2 lifts	Normal	Pulmonary embolism excluded	
3	64	F	Septic shock Respiratory failure	IPPV	Suspected abdominal sepsis US	225m 2 lifts	No abdominal fluid	Laparotomy avoided	Survived
4	61	M	Mediastinitis Renal failure Respiratory failure	IPPV	Suspected abdominal sepsis US	225m 2 lifts	No abdominal fluid	Laparotomy avoided	Died: Septicaemia
5	31	M	Ruptured duodenum Aortic contusion Respiratory failure	IPPV	Suspected aortic rupture AA	70m 2 lifts	Aortic dilatation	Thoracotomy haemostasis	
				IPPV	Suspected abdominal sepsis US	225m 2 lifts	Pelvic abscess Pleural effusion	Conservative	Survived
				S.V.	Suspected abdominal sepsis US	225m 2 lifts	Pericardial effusion		
6	60	M	Ruptured abdominal aortic aneurysm	IPPV	Suspected abdominal sepsis US	225m 2 lifts	Right retroperitoneal fluid collection	Laparotomy and drainage	Survived
7	6	M	Pancreatitis Septic shock Respiratory failure	IPPV	Suspected abdominal sepsis US	225m 2 lifts	No abdominal fluid	Laparotomy avoided	Died: Gastrointestinal haemorrhage
8	50	M	Right ventricular failure Respiratory failure	IPPV	Suspected pulmonary embolism PA	60m 2 lifts	Pulmonary emboli	Anticoagulated	Died: Pulmonary emboli
9	52	M	Diabetes mellitus Septic shock Respiratory failure	IPPV	Continued intensive therapy	175m 2 lifts	Not relevant	IPPV, antibiotics	Died: Bronchopneumonia Pancreatic carcinoma

Table 1 continued.

No	Age	Sex	Diagnosis	Respiration	Indication for Transfer	Journey	Findings	Subsequent Management	Outcome
10	58	F	Rheumatic heart disease Intra-operative haemorrhage	IPPV	Continued intensive therapy	170m 2 lifts	Not relevant	IPPV, Transfusion	Survived
11	62	M	Mediastinitis Respiratory failure	IPPV	Opening new ITU	170m 2 lifts	Not relevant	IPPV, Antibiotics	Died: Multiple organ failure
12	60	M	Bronchitis Respiratory failure	IPPV	Opening new ITU	170m 2 lifts	Not relevant	IPPV, Antibiotics	Survived

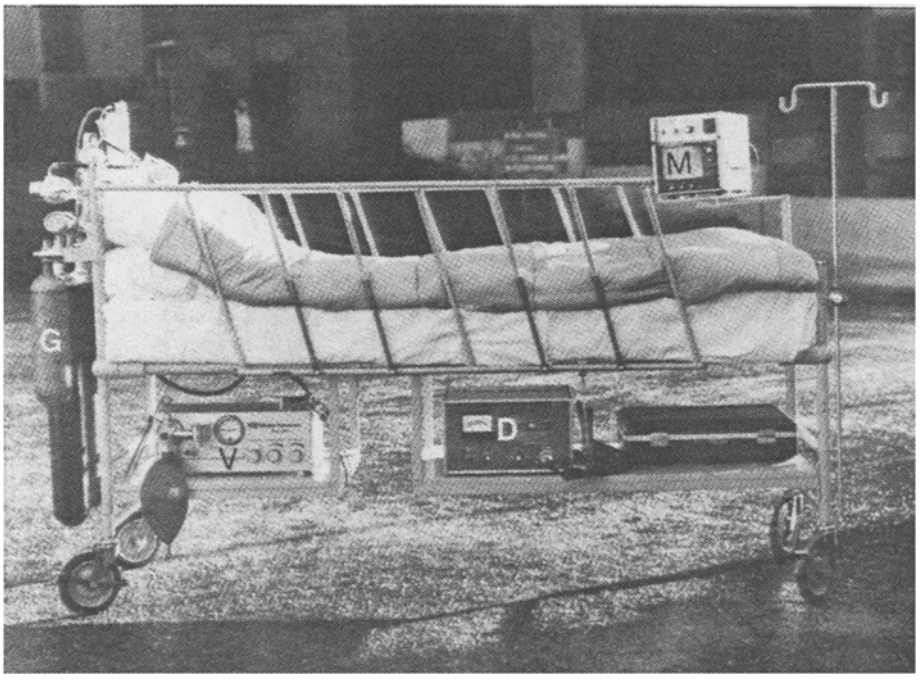

Fig. 2. The Mobile Intensive Care Unit. G = Medical gas supplies; V = Ventilator; D = Defibrillator; M = Monitor

anticoagulant therapy. One patient (case 5) underwent arch aortography for suspected traumatic aortic rupture and is described in greater detail below.

Two patients (cases 9,10) were transferred from other parts of the hospital to the ITU for further management and two patients (cases 11,12) were transferred from an old ITU when a new ITU was opened at the WIG.

The following case reports illustrate the clinical indications for use of the MICU in transporting patients for essential investigations without untoward effect.

Case No. 2

A 23 year old primigravida was admitted to another hospital with pre-eclamptic toxaemia and abdominal pain at 30 weeks gestation. Coagulation studies revealed a mild consumption coagulopathy. Shortly after delivery of a stillborn infant the patient became hypotensive and anuric. Laparotomy revealed three litres of blood in the peritoneal cavity and a 1.5 cm tear in the anterior margin of the right lobe of the liver. IPPV was maintained post-operatively. The following day, in view of an increase in blood urea to 22 mmol/l (132 mg/100ml) and potassium to 8.2 mmol/l (8.2 mEq/l), the patient was transferred on the MICU by ambulance to the WIG for intensive care and haemodialysis. IPPV was discontinued on the fourth day. A persistent pyrexia developed in association with abdominal tenderness and a right sided pleural effusion. The patient was transferred on the MICU to the Diagnostic Ultrasound Department on the ninth and 12th days; an enlarging right subphrenic fluid collection was demonstrated and drained at laparotomy on the 12th day. IPPV was maintained post-operatively and haemodialysis con-

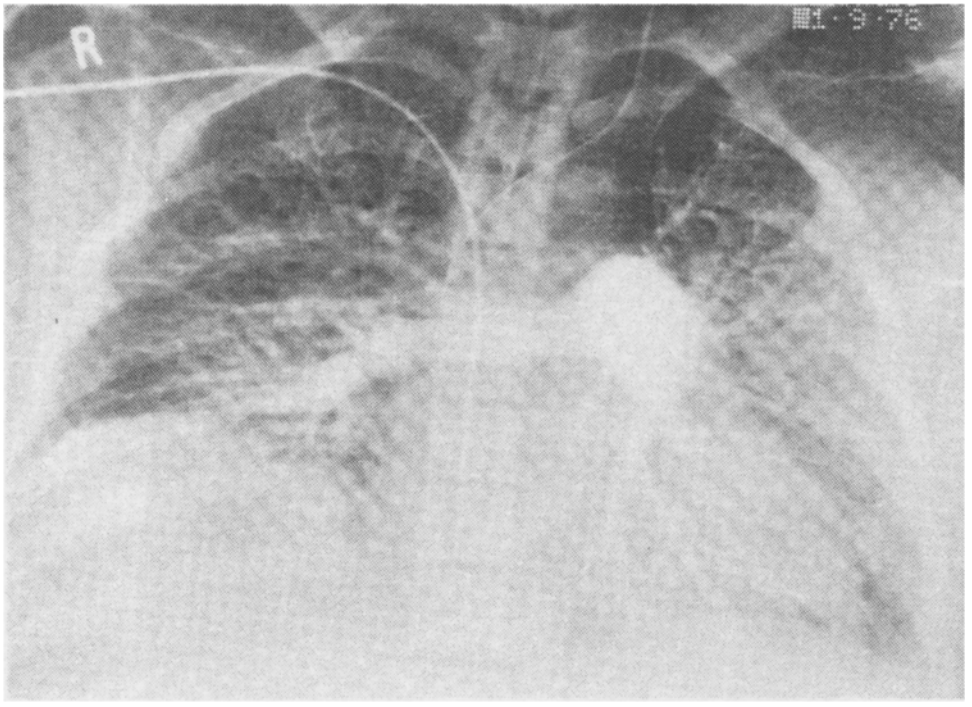

Fig. 3. Pulmonary angiogram (case 2) showing crowding of the vessels on the right but no evidence of pulmonary embolism (By courtesy of Dr. D. Vernon, Department of Respiratory Medicine, and Dr. G. McCreath, Department of Diagnostic Radiology, Western Infirmary, Glasgow)

tinued. On the 15th day the patient complained of right sided chest pain in association with an enlarging right sided heavily bloodstained pleural effusion. In order to exclude pulmonary embolism, transfer to the Cardiac Investigation Department was arranged using the MICU. Pulmonary haemodynamic measurements and angiography were within normal limits (Fig. 3). Weaning from IPPV was commenced the same day. The patient improved slowly and renal function began to recover on the 24th day; she was finally discharged six weeks after the original illness and remains well six months later.

This case will be reported in greater detail elsewhere [4].

Case No. 5

A 31 year old male was admitted after falling from a fourth floor window. He suffered a crush fracture of the first lumbar vertebra and a fractured pelvis. Ten h after admission abdominal tenderness was noted, a laparotomy performed, and a ruptured duodenum repaired. He was admitted to the ITU for monitoring and IPPV. Acute renal failure developed which was treated by haemodialysis. Forty h after admission a right haemothorax developed in association with mediastinal widening and evidence of myocardial ischaemia on ECG. He was transferred to the Radiodiagnostic Department on the MICU, maintained on IPPV and sedated with nitrous oxide and phenoperidine. Arterial blood pressure and ECG were monitored continuously and central venous pressure (CVP) measured intermittently throughout the transfer and investigation. An arch aortogram demonstrated widening of the inferior aspect of the aortic arch. The CVP increased progressively during the procedure and blood pressure and heart rate decreased. The patient was immediately transferred on the MICU to the operating theatre and emergency thoracotomy performed. The aorta was intact but bruised and several intercostal vessels were bleeding. His condition improved following haemostasis and infusion of dopamine.

Post-operatively the patient's conditon stabilised and he was maintained on IPPV and haemodialysis. He became pyrexial on the 11th post-operative day and intra-abdominal sepsis was suspected clinically. Transfer to the Diagnostic Ultrasound Department was arranged using the MICU. Ultrasound examination of the abdomen revealed a pelvic abscess, a right pleural effusion and a pericardial effusion confirmed by a Time Position Scan (Fig. 4). The patient's condition slowly improved on antibiotic therapy and IPPV was discontinued on the 21st day. He was again transferred on the MICU to the Ultrasound Department on the 23rd day. The pelvic abscess and the effusions were unchanged. He continued to improve and by the 28th day renal function had recovered. He was discharged home six weeks after his initial injury and remains well.

Discussion

Previous studies have drawn attention to the hazards of patient movement within hospital. In a study of "high risk" cardiac patients moved within hospital Taylor et al [5] found an 84% incidence of arrhythmias, 52% of which needed treatment. In a previous report from this hospital [6] concerning a group of critically ill patients for whom no special measures had been taken, one patient per

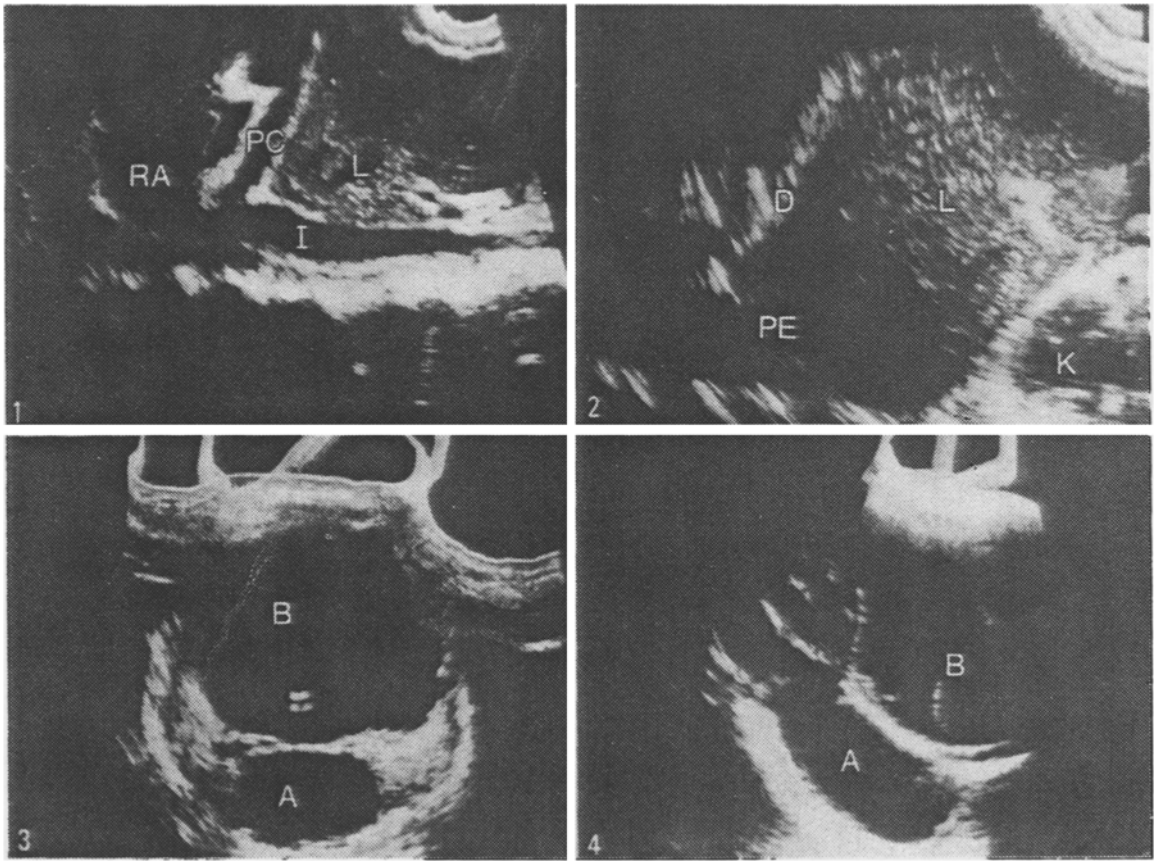

Fig. 4. Ultrasonograms (Case 5). (1) Midline, longitudinal section through the uppper abdomen showing a pericardial effusion. (2) Longitudinal section five cm to the right of the midline through the upper abdomen showing a pleural effusion. (3) Transverse section two cm above the pubis showing a pelvic abscess. (4) Midline longitudinal section through the lower abdomen showing a pelvic abscess. L = Liver: I = Inferior vena cava: PC = Pericardial effusion: RA = Right artium: D = Diaphragm: PE = Pleural effusion: K = Kidney: B = Bladder A = Pelvic abscess (By courtesy of Dr. P. Warner, Department of Diagnostic Ultrasound, Western Infirmary, Glasgow)

month suffered a major cardiorespiratory collapse or died as a result of movement. The difficulties of airway management and ventilation during movement were also described. Snook [7] found a 15% failure of ventilation with a self-filling bag and mask in ambulances during cornering and braking and a 10% failure of external cardiac massage. It is likely that the failure rate would be at least as high when the operator was walking or running at the same time. By contrast the present study demonstrates that the critically ill can be moved safely within a hospital provided certain precautions are observed. Adequate resuscitation and sedation prior to transfer are essential together with maintenance of monitoring and therapy throughout the journey. Liberal use of analgesics and sedation appears to be particularly important and appreciation of this fact has led to considerably improved cardiopulmonary stability during transport [3].

Ledingham [8] showed that active management of septic shock with early aggressive surgery, antibiotics and IPPV reduced mortality from 71% to 38%. However, the diagnosis of intra-abdominal sepsis may be difficult in a paralysed, sedated patient maintained on a ventilator. Ultrasound scanning is a safe non-invasive investigation ideally suited for use in the critically ill [9] and is a reliable and sensitive technique for detection of intra-abdominal fluid collections [9, 10] and confirmation of pleural and pericardial fluid [11]. However, most of the apparatus in common use is not portable and patients may thus be denied the benefits of this technique. The present study confirms the value and safety of ultrasonography in the detection and localisation of intra-abdominal sepsis. The minimal risks involved in moving critically ill patients on the MICU are fully justified by the improved diagnostic accuracy and selection for operative intervention.

Pulmonary angiography remains the most specific investigation in the diagnosis of pulmonary embolism [12] and has the advantage that simultaneous pulmonary haemodynamic measurements can be performed. Trujillo, Castillo and Espana [13] have described a technique for bedside pulmonary angiography but state that if possible, "patients should have the benefit of optimal study in a catheterisation laboratory". Arteriography is mandatory

in the diagnosis of traumatic rupture of the aorta [14] or other major vessels. Few, if any, centres are able to perform systemic arteriographic studies at the bedside.

Critically ill patients must be moved on occasion to permit full investigation and treatment. A Mobile Intensive Care facility permits the transfer to be carried out readily and safely. The Mobile Intensive Care Unit developed in this centre has proved robust, reliable and adequate for the safe transport of critically ill patients. Similar transport facilities are being developed elsewhere in the United Kingdom both for general and specialised hospital purpose [15, 16]. It is clear that the provision of such facilities will shortly be considered essential in all hospitals offering a comprehensive range of intensive care services.

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C.D. Hanning FFARCS
University Department of Surgery
Western Infirmary
Glasgow
UK