Recent Advances in
SURGERY

EDITED BY
R. C. G. RUSSELL

NUMBER THIRTEEN

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Preface

By the time a book reaches its thirteenth edition, the reader could question the relevance of the subject matter or the applicability of the idea. Relevance is well catered for by commissioning new chapters for each edition, and applicability of the idea of the Recent Advances concept remains as important today as ever. The success of this venture rests with the editor's choice of titles, and if the reader finds the chapters irrelevant and lacking application, then the editor can only be saddened, for these chapters portray much of the excitement of surgery today. General surgery, as outlined in the early editions of this series, no longer exists but it is important for the surgeon who deals with a wide spectrum of disease to be aware of what the specialist has to offer. Do you still operate on a renal or ureteric stone? Are resections for acute diverticulitis still being undertaken on your service? Or are you still struggling to remove those difficult stones at the lower end of the bile duct; if so, this book may guide you differently or at least stimulate you to think of your current practice.

Surgery today is about questioning current concepts, about audit and application of lessons learnt to daily practice. Without audit the surgeon cannot assess his performance, and every surgeon should. Mr Gunn describes his own experience in the last chapter of this book, emphasising the lessons learnt in a different context in Professor Fielding's review of the Large Bowel Cancer Project, where surgical failure was not inapparent. That surgical technique is important is emphasised in the chapter on intestinal fistulae where Professor Irving describes fistulae as a constant reminder of the fallability of surgical technique. New techniques have always been of interest to surgeons, and currently the use of the laser in surgery engenders hope, recently fulfilled in laser angioplasty and the use of the laser to disintegrate stones in the ureter. As new techniques such as lithotripsy and angioplasty limit the role of surgery in one sphere, so in another surgical expertise expands—as in the wider applicability of liver surgery and as in plastic surgery, where the use of free flaps and tissue expanders have revolutionised the role of skin surgery. However, new techniques must be carefully assessed, and this is admirably undertaken in the context of stroke surgery by Professor Lumley.

Malignant disease remains an unconquered challenge but the surgeon has perhaps given up his role too easily in the management of this disease and pays too little attention to technical aspects and adjuvant therapy. If every Patey mastectomy was perfectly performed with a breast reconstruction using the techniques described in Mr Jackson's chapter, the late effects of radiation to the breast would not be observed, and the results of breast cancer improved. If the care outlined in the chapter on the management of genitourinary malignancies was applied to all such cancers, and the technical errors noted in the Large Bowel Cancer Project eliminated, then there might be a real improvement in prognosis. Have we yet achieved the ideal combination between radiotherapy and surgery? Too little thought has been given to this area; the chapter from the Massachusetts General Hospital is there to provoke thought on the subject.

Finally, the Cinderella of modern surgery is placed first amongst the chapters in Recent Advances, for surgeons seem prepared to allow trauma to be a forgotten part of modern surgery. Surely, if the guidelines outlined by Professor Rowlands were followed, young useful lives would be saved.

In compiling this volume, I have been helped by many people, all of whom I wish to thank, particularly the staff of Churchill Livingstone.

London, 1988 R.C.G.R.

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1. Management of major trauma

B.J. Rowlands

INTRODUCTION

Trauma is the most common cause of death between the ages of 15 and 45 years and its incidence has been increasing during the last decade. Approximately 18 000 people die annually in the United Kingdom due to injuries sustained as a result of civilian violence, industrial accidents and road traffic accidents. About 20% of these deaths are preventable and the realisation that the present system of emergency care is inadequate to cope with this epidemic has stimulated discussion of methods of delivering optimal trauma care which will reduce mortality and long term disability. Surgeons and emergency room physicians are usually called upon to render initial care to these trauma victims, and the speed and accuracy with which life-threatening complications of trauma are dealt with has an important impact on the quality and duration of survival. This chapter will discuss the organisation of prehospital care and transportation, the resuscitation and investigation in the accident and emergency department and the appropriate management of injuries to major systems. Because it is impossible to cover such a large topic in detail, the principles of management will be stressed so that surgeons with limited experience of the care of the critically ill or injured will be able to render therapy that sustains life and organ function. They will be able also to identify situations in which more experienced advice and help is urgently required.

ORGANISATION

Trauma care in Britain is not well organised presently, but a report prepared by the Royal College of Surgeons of England has documented the inadequacies of the system and suggests methods for improvement. The intent of any system of trauma care must be to fulfil the 'three Rs'—to get the *right* patient to the *right* hospital at the *right* time (Trunkey 1982). This means developing a system that ensures that some hospitals are capable of receiving, resuscitating, investigating and treating any trauma victim irrespective of the extent and severity of the injuries. These hospitals would be staffed around the clock by medical and support personnel with specific training in the management of the severely injured and have ready access to neurosurgical, cardiothoracic, anaesthetic, radiological and vascular expertise. The provision of modern facilities and trained personnel in centres of excellence—regional trauma centres—should lead to an improvement in the quality of care given to the seriously injured and a reduction in the cost—monetary, socioeconomic and disability—of such injuries. These 'full service' hospitals would be complimented by a network of supporting hospitals which were not able to give such a comprehensive service but which could triage the injured to appropriate medical facilities commensurate with the level of injury. This model has been developed successfully in the USA based on the 1976 guidelines of the American College of Surgeons Committee on Trauma (ACS Committee on Trauma). Hospitals receiving trauma victims are categorised into level I, II or III according to the level of care they provide. Level I facilities not only have a commitment to provide specialised trauma care but also educate physicians and paraprofessionals in trauma care, undertake trauma research, and treat a certain number of severely injured patients each year (Trunkey 1982).

Trauma patients fall into three categories from the point of view of their triage: (1) those with injuries that are rapidly fatal; (2) stable patients; (3) those with injuries that are life threatening and require urgent medical attention (Lewis 1984). The rapidly fatal conditions include massive head injury, major vessel injury producing exsanguination, upper cervical cord injury, asphyxia and major disaster such as bomb blast or air crash, causing massive tissue distruction. These injuries are amenable to no treatment and death is inevitable within minutes. Although less than 5% of trauma patients have injuries of this severity, they account for over half of the trauma deaths. Eighty per cent of patients are stable following injury, which often produces only trivial soft tissue wounds and minor fractures. These injuries need little expertise in their management and delay in treatment will not jeopardise outcome or recovery. It is, therefore, the potentially salvageable, unstable victims and those with injuries that become life threatening if not treated who are likely to benefit most from expert prehospital treatment and rapid transportation to a hospital that provides the necessary facilities and expertise. Intuitively such a system of providing 'centres of trauma excellence' should produce beneficial effects in mortality and morbidity, but critical appraisal of the results of such an organisation of trauma care needs prospective study.

The system is expensive to implement and the critical questions that need to be addressed and answered have recently been debated in an effort to provide a framework for future planning in the USA (Eastman et al 1987). Although trauma is less of a problem in Britain and Europe today, the lessons to be learnt from the American system need to be implemented in our own plans for the future. This model is best applied to urban and suburban areas where the populace are numerous and the highest incidence of major injury occurs, whereas rural areas have fewer people and the problems of transportation over long distances make ready access to trauma experts and facilities more difficult. In major metropolitan areas it is acceptable to bypass hospitals to deliver the injured to optimal care, whereas in the country the nearest available facility should be used for immediate resuscitation and evaluation.

PREHOSPITAL CARE AND TRANSPORTATION

The initial assessment of the injured patient should take place at the scene of the injury by the ambulance crew, paramedics or physician. The amount of immediate care and assessment will depend on the equipment available and the training of the personnel responsible for transportation. In Britain, ambulance crews are trained in basic resuscitation techniques and airway management but less than 5% of their calls involve on-scene management of the seriously injured. In the USA, Germany and some other European countries the level of training and experience is often higher and some systems are capable of transporting a physician to the scene by ground or helicopter quickly. The priorities at the scene are to establish adequate ventilation and oxygenation, which may be impaired due to airway, chest wall, lung and central nervous system injury, to evaluate the circulation by measuring heart rate, pulse character and blood pressure and to control haemorrhage. In addition, efforts should be made to establish the mechanism of injury, an overview of the full extent of the injuries and to splint major fractures—prior to transportation. Communication is vital at this point between the ambulance crew and other agencies, such as the police and fire brigade, and the receiving hospital so that they can be warned of the estimated time of arrival of a seriously injured patient, the extent of the injuries and the level and type of expertise that might be required on admission.

Following motor vehicle accidents, delay may be experienced in recovery of the injured due to difficulties in a ground ambulance reaching and leaving the scene of the accident. This has led to the development of several helicopter rescue systems which are particularly useful in busy urban areas where traffic problems may slow delivery to hospital by ground and in rural and isolated areas where air evacuations may be the only way to reach adequate resuscitation and treatment facilities in reasonable time.

Some of these factors will govern the amount and type of treatment given at the scene. If the patient is breathing spontaneously, the airway should be maintained by proper positioning of the patient for transportation and if necessary the use of an oropharyngeal airway. If breathing is inadequate or absent, the airway should be cleared of secretions, vomitus or foreign bodies (e.g. false teeth) and ventilation maintained by mask, oropharyngeal tube or endotracheal intubation. Once the airway is maintained and safeguarded attention may be turned to stopping obvious external haemorrhage, which is usually from wounds of the extremities or head and neck. External digital pressure, pressure dressings and inflatable extremity splints may staunch the flow of blood and occasionally tourniquets may be useful to control bleeding during extraction from a vehicle. Pneumatic trousers applied to the lower limbs may also be useful in pelvic and lower limb bleeding and may have the added benefits of maintaining venous return and hence circulation to the rest of the body. If the circulation is impaired, as indicated by rapid pulse, poor peripheral circulation and low blood pressure, an intravenous infusion may be started in the field via extremity veins of uninjured limbs using large size (no. 14 or 16) intravenous catheters. Crystalloid infusion may then be started and continued during transportation to replace some of the blood volume lost from the circulation. During initial assessment, patients who have sustained flexion, extension or rotational injuries to the spine should always be suspected of having spinal cord injury and should be safeguarded against further damage during recovery and transportation by the use of back boards and cervical collars. Brief neurological assessment at the scene of the accident should include a record of level of consciousness, pupillary reaction, signs of raised intracranial pressure and amount and type of limb movements. Obvious deformity of the limbs should be splinted, sucking chest wounds and open abdominal wounds covered and the airway checked again prior to transportation. It is important to remember that only a limited amount can be achieved in the field and delay in arrival at the hospital may be critical to survival.

Experience in two World Wars and the Korean and Vietnam conflicts clearly shows a direct relationship between mortality and the interval between injury and treatment (Trunkey 1982). Therefore, delay in transportation should only occur if there is significant advantage to be gained in three important areas: (1) establishing an adequate airway, (2) stopping external haermorrhage, or (3) supporting the circulation. Lewis (1984) has argued strongly that in urban areas valuable time may be wasted in the field by attempting to insert intravenous lines under less than optimal conditions when the patient is continuing to bleed internally and the amount of restoration of circulating volume achieved prior to admission to hospital is marginal. This has led to the 'scoop and run' philosophy when the accident occurs within easy reach of a medical facility. However, if transportation is required over a greater distance, the patient should be safeguarded against significant deterioration or further injury during the journey by attention to the details of airway management, circulatory support, fracture splintage and cervical spine immobilisation (Cleveland & Eid 1984). Rapid transportation should be to the nearest medical facility that can provide a level of support to manage the patient's injuries most appropriately.

Trauma scoring systems

In prehospital management, initial assessment on arrival at the accident and emergency department, and in subsequent management of trauma and assessment of results, trauma scoring systems have an important place. They readily identify the patient who has fatal injuries, those at greatest risk of dying or developing complications and those who are most likely to make an uneventful and full recovery (Champion et al 1983). They are important when a number of casualties occur at one accident or arrive simultaneously at a hospital and priorities in management have to be decided by medical and nursing personnel. In central nervous system injury the Glasgow Coma Scale gives a rapid assessment of the level of consciousness and motor and verbal response (Table 1.1) (Teasdale & Jennett 1974). Often head injury occurs

Table 1.1 Glasgow Coma Scale

Eye-opening response	Spontaneous	4
	To voice	3
	To pain	2
	None	1
Best verbal response	Oriented	5
	Confused	4
	Inappropriate words	3
	Incomprehensible sounds	2
	None	1
Best motor response	Obeys command	6
	Localises pain	5
	Withdraws (pain)	4
	Flexion (pain)	3
	Extension (pain)	2
	None	1
Total		3–15

in association with other injuries, and the Glasgow Coma Scale is combined with assessment of the systolic blood pressure and respiratory rate to generate the Revised Trauma Score (Table 1.2). The Revised Trauma Score has been devised from analysis of data from over 30 000 patients in the American College of Surgeons Trauma Committee Major Outcome Trauma Study in which the overall mortality rate was 10%.

Table 1.2 Revised trauma score

Glasgow Coma Scale	Systolic b.p.	Respiratory rate	Coded value	Sum of coded values	Probability of survival
13–15	>89	10–29	4	12	0.995
9–12	76–89	>29	3	11	0.969
6–8	50–75	6–9	2	10	0.879
4–5	1–49	1–5	1	9	0.766
3	0	0	0	8	0.667
				7	0.636
				6	0.630
				5	0.455
				4	0.333
				3	0.333
				2	0.286
				1	0.250
				0	0.037

The Revised Trauma Score is thought to be a more sensitive grading system for estimating the severity of injury than the Trauma Score, which also assessed capillary refilling and respiratory expansion. It also gives more weighting to severe head injury as a determinant of outcome and the probability of survival has been computed from the sum of the coded values in the Revised Trauma Score (Table 1.2). These simple observations of pulse, blood pressure and Glasgow Coma Scale together with assessment of the mechanism of injury, environmental factors and anatomical features of injury give a rapid assessment of those patients most in need of treatment and expert management and provide important guidelines for triage (Table 1.3). A Revised

Table 1.3 Factors suggesting serious injury in multisystem trauma

- Revised Trauma Score of less than 12
- Glasgow Coma Scale of less than 13
- Rapid deceleration injury
- High velocity penetrating injury
- Falls from 4.5 m or more
- Hostile environment—extremes of heat or cold
- Motor vehicle accidents involving prolonged extraction, passenger space invaded by 30 cm or more, ejection, death of another occupant, rollover, backward displacement of front axle, or pedestrian hit at 35 km/h (or 20 mph) or more
- Massive blunt soft tissue injury
- Combination of blunt and penetrating injury e.g. bomb blast
- Cave-in injury or burial
- Penetrating trauma to head, neck, torso or groin to midthigh
- Major amputation above the wrist or ankle
- Major burns (greater than 20%) associated with trauma
- Complete or partial limb paralysis

Trauma Score of less than 12 or a Glasgow Coma Scale of less than 13 indicates that the patient should be taken to a trauma centre and that an experienced doctor should be on hand to assess the injuries and initiate resuscitation, investigation and treatment. At the Royal Victoria Hospital, Belfast, junior staff are instructed that this is not a 'guideline', but an 'unbreakable rule' and that senior staff should be called immediately. In addition, all potentially lethal injuries involving rapid deceleration and high energy dissipation, falls from greater than 4.5 m (15 feet), excessive heat or cold, serious motor vehicle accidents, bomb injuries and high velocity gunshot wounds should be seen by senior staff on arrival. Injuries that cause paralysis, penetration of head, neck, chest, abdomen, groin and midthigh, major amputations and major burns associated with other injuries should also be assessed by experienced physicians. These guidelines should ensure that management priorities are appropriately identified as soon after arrival in hospital as possible.

The Injury Severity Score is a method of assessing injuries that relies on full anatomical details of extent of injury and is therefore unsuitable for use at the scene of an accident or on arrival at hospital (Baker et al 1974). The data will be available only after treatment of all injuries has been carried out, but it is a useful research tool for evaluating the quality of trauma care. The American Association of Automotive Medicine has recently updated its Abbreviated Injury Scale (AIS-85) and lists over 400 injuries in six areas of the body (AIS-85 booklet available from AAAM, 40 Second Avenue, Arlington Heights, Illinois 60005). The injuries in the six areas—head and neck, face, chest, abdomen and pelvic contents, bony pelvis and limbs, and body surface—are scored from 1 to 6 indicating trivial to severe. The Injury Severity Score is obtained by adding together the square of the three highest scores from separate areas. It correlates well with survival, although doubts have been raised as to whether the ISS is equally applicable to blunt and penetrating trauma (Beverland & Rutherford 1984). Individual cases may be characterised by both an anatomical score (ISS) and physiological score (RTS) to evaluate the effectiveness of trauma management by auditing those cases who would be expected to survive but do not and those patients who live despite injuries which are not usually associated with high probability of survival. This sort of data will be important to collect prospectively if any rationalisation of trauma care is proposed in the future.

ASSESSMENT IN THE HOSPITAL

On arrival, resuscitation and physical examination should proceed simultaneously. The initial assessment should be done as quickly as possible as the vital signs are checked. The trauma receiving area should be well lit, warm and equipped with everything necessary for adequate ventilatory support, monitoring, venous access and resuscitation fluid (Yates 1984). As the patient's clothes are removed, and taking great care with movement if injury to the cervical or thoracic spine is suspected, the patient should be rolled from side to side to inspect the back to note any obvious injuries such as penetrating entrance and exit wounds or massive haematoma or bruising. The initial examination should be completed in approximately 1 minute noting the depth and speed of respiration, the position of the trachea, strength and rate of carotid pulsation, presence of neck vein distension and air entry to both sides of the chest. Bubbling sounds in the throat and sucking chest wounds are immediately obvious. The chest should be examined for paradoxical movement or crepitus, suggesting a flail segment and broken ribs. Abdominal distention and tenderness may be noted on abdominal examination, the stability of the pelvis is noted, and the genitalia and anus are inspected for signs of bleeding. The upper and lower limbs are quickly examined for peripheral pulses, gross deformity and swelling. During this initial examination, the patient's level of consciousness will have been noted, along with any spontaneous movements or reaction to the pain and discomfort of examination. Any major soft tissue injuries, swelling, lacerations or actively bleeding external wounds will also be noted.

If, at the time of examination, respiratory difficulties are noted then immediate attention must be given to establishing and maintaining an adequate airway as oxygenation of the tissues is of primary importance to survival. In particular, the head-injured patient with depressed level of consciousness should not be allowed to become hypoxic. The mouth and pharynx are inspected for the presence of blood, saliva and vomitus and, in the conscious patient, fluid obstructions are sucked out with the head placed to one side provided there is no contraindication to neck movement. In the unconscious patient, the airway is cleared with a finger. Clearing the airway should be completed quickly, and teeth and solid debris removed from the oral cavity and pharynx. Vigorous stimulation of the pharynx should be avoided as many patients will have full stomachs and further vomiting with the hazard of aspiration may occur. Oxygen should be given by mask with the airway held open by pulling forward the jaw and respiratory exchange noted. If respiration is still inadequate, an oropharyngeal airway may improve gas exchange via a face mask and bag but this should be regarded as only a temporary measure as such an airway is difficult to maintain and is usually not well tolerated by the frightened semiconscious patient. If active airway management is required nasotracheal or endotracheal intubation is carried out, excessive movement of the cervical spine being avoided where spinal injury is suspected. Emergency tracheostomy is rarely required and is difficult to perform quickly and effectively in the emergency room. In the case of severe maxillofacial trauma or major upper airway injury, cricothyroidotomy is the procedure of choice (Toye & Weinstein 1986). In the patient who is not breathing spontaneously, ventilation should always be controlled and intubation is less hazardous after a short period of oxygenation with bag and mask. Once the airway has been established and the patient is breathing spontaneously or ventilation controlled, the arterial blood gases should be checked as part of the initial screening process.

The next priority after airway management is to assess and support the circulation based on initial vital signs—blood pressure, pulse and peripheral circulation. If there are obvious signs of shock, large intravenous lines should be placed in the veins of the upper or lower limbs, avoiding the use of injured limbs and infusing isotonic normal saline initially. Some patients compensate very well for hypovolaemia and the full extent of depletion of the circulating volume may not be immediately obvious. If percutaneous cannulation is not possible owing to collapse of the limb veins, cutdown on to the saphenous vein or antecubital fossa may be performed or direct femoral vein puncture attempted. Access to the central veins via subclavian or internal jugular cannulation is difficult in the hypovolaemic patient and should be attempted only after all else has failed and by somebody experienced in the techniques. If a central line is placed it will provide useful information to the amount of blood loss and the response to infusion of fluids. Two or three litres of isotonic crystalloid solution should be infused rapidly and then as resuscitation continues colloid in the form of blood, plasma, albumin, dextrans and gelatin solutions should be used.

When the airway has been secured, intravenous lines have been placed and infusion of resuscitation fluid has been started, the patient's condition should be re-assessed and in particular vital signs checked. By this time, the patient should be connected to a cardiac monitor to follow heart rate and electrocardiogram, rectal temperature recorded and external haemorrhage controlled by digital pressure or dressings. Blood should be taken at the time of placement of intravenous cannulae for haematocrit, haemoglobin, blood cross-match, electrolytes and urea and toxicology screening. A urinary catheter should be placed to monitor urinary output—a good sign of adequacy of resuscitation—provided there is no contraindication such as blood at the urethral meatus or a suspected pelvic fracture, which may indicate urethral injury. In these circumstances catheterisation should proceed only if a urethrogram reveals no urethral disruption. Urine should be inspected for gross or microscopic haematuria in injuries to the abdomen and pelvis.

If the patient is responding to the resuscitation, and circulation and vital signs, oxygenation and ventilation are all improving, a more thorough examination of injuries should now be carried out. Chest X-ray should be performed and checked for the position of the endotracheal tube, full expansion of both lungs, presence of haemothorax or pneumothorax, position of the diaphragms and evidence of widening of the mediastinum. If shock continues then attention must be focused on those conditions which are rapidly fatal if not treated immediately. A high index of suspicion of tension pneumothorax, cardiac tamponade, cardiogenic shock and continuing hypovolaemia due to intrathoracic or intra-abdominal haemorrhage is useful in making the diagnosis. Continuing respiratory difficulty with engorgement of the neck veins should alert the physician to tension pneumothorax or cardiac tamponade. The former may be diagnosed by decreased air entry on the affected side and mediastinal shift with tracheal deviation away from the affected side and is relieved immediately by insertion of a needle into the pleural cavity of the affected side. Once the tension is removed, a 34FG chest tube should be placed via the fourth intercostal space in the midaxillary line and attached to an underwater seal to remove air and blood from the pleural cavity as the lung expands. Chest X-ray is not necessary for diagnosis, but should be obtained after chest tube placement to confirm the position of the tube and lung re-expansion. A chest tube should also be used to drain a significant haemothorax. Cardiac tamponade is usually a sequelae of penetrating trauma to the thorax and causes rapid pulse, ECG abnormalities, raised neck veins and cardiovascular pressure, and low blood pressure. Confirmation by needle aspiration of the blood from the pericardium via the subxiphoid approach will provide temporary improvement in vital signs but the patient should be prepared immediately for definitive repair. Cardiogenic shock may also occur owing to myocardial contusion from blunt trauma and myocardial infarction from hypovolaemic shock and coronary artery air embolism associated with penetrating chest trauma and positive pressure ventilation. These conditions should be treated with pharmacological support for the failing heart and avoidance of fluid overload.

If hypovolaemia fails to respond to initial resuscitation, continuing blood loss or a failure to appreciate the full extent of pre-admission fluid loss should be suspected. Unrevealed haemorrhage may occur into the pleural cavity owing to lung and chest wall injury, into the mediastinum owing to heart or great vessel injury, into the peritoneal cavity owing to splenic, liver or mesenteric injury and into the pelvis owing to fracture and retroperitoneal tissues in major blunt and penetrating abdominal trauma. Chest X-ray and repeat physical examination of the chest may reveal widening of the mediastinum or haemothorax. Abdominal distention, bruising of the flanks, anterior abdominal wall and perineal area and absent bowel sounds may lend weight to a suspected diagnosis of unrevealed intra-abdominal, retroperitoneal or pelvic haemorrhage. Resuscitation should continue to replace measured and estimated losses. Blood loss from lacerations of the scalp, head and neck is often underestimated, fractures of major long bones in each leg may cause losses of 2–3 litres and displaced pelvic fractures may continue to bleed until some form of reduction to close the pelvic ring is achieved. Continued haemodynamic instability in the face of adequate resuscitation should precipitate urgent surgical exploration. Patients with head injury who exhibit continuing hypovolaemia should always be suspected of having additional injuries causing haemorrhage as it is unusual for head injury alone to cause significant hypotension. Spinal cord injury may cause loss of sympathetic vascular tone and generalised vasodilatation leading to hypotension, but loss of nerve function below the lesion will be manifest by lax anal tone and loss of tendon reflexes. Continued haemodynamic instability should lead to early preparation for surgical exploration while resuscitation continues. Profound continuing hypotension may lead to cardiac arrest. External cardiac massage and full cardiopulmonary resuscitation should begin immediately, but emergency room left anterior thoracotomy to facilitate internal cardiac massage may be necessary as it is difficult to maintain effective circulation in severe hypovolaemia by external compression. Cross-clamping of the thoracic descending aorta may aid resuscitation prior to rapid surgical intervention to stop the continuing haemorrhage.

Response to resuscitation and stabilisation of vital signs should afford the opportunity for further examination of injuries and investigation. Wounds may be inspected in greater detail and each system carefully examined to document the full extent of injuries. In penetrating trauma, the exact anatomical site of entrance and exit wounds should be noted. In blunt trauma, soft tissue injuries should be assessed as serious damage usually indicates a greater likelihood of damage to viscera. When the full extent of the injuries, including neurological examination, has been assessed a logical approach to further investigation and management may be formulated. There is a temptation to treat the most obvious injuries. To avoid mismanagement of injuries involving several systems, one physician should assume responsibility for deciding treatment priorities. He or she should ensure that avoidable tragedies do not occur. Exsanguination from a ruptured spleen while fractures are reduced and immobilised or from a transected aorta during exploratory laparotomy are well-documented 'mistakes' in the trauma literature.

Greater use should be made of diagnostic investigations in the assessment of the stable patient so that the surgical approach to specific injuries may be planned. Full radiological assessment of suspected fractures should be completed in the accident and emergency department. Cervical spine X-rays should be performed in all significant head injuries. The value of chest X-rays has been mentioned already but abdominal films give little information. The most useful diagnostic procedure for suspected intra-abdominal visceral injury is diagnostic peritoneal lavage. A peritoneal dialysis catheter is introduced under direct vision into the peritoneal cavity through a midline subumbilical incision after evacuation of the bladder. One litre of warm normal saline is infused into the peritoneal cavity and then allowed to 'equilibrate' for several minutes. The fluid is then allowed to run back into an infusion bag and a 50 ml sample is sent for analysis of red blood cell count, white blood cell count and amylase. A strongly positive result is a red blood cell count of greater 100 000/mm^3, and