

Pre-hospital Care: The Trapped Patient

Maj R Mackenzie

PhD, MRCP, Dip IMC RCSEd, RAMC(V)

Maj R Sutcliffe

MA, MRCGP, Dip IMC RCSEd, RAMC(V)

254 (City of Cambridge) Field Ambulance (V), 450 Cherry Hinton Road, Cambridge, CB1 8HQ.

Introduction

Rescue of the injured has always been an inherent feature of peacetime and operational medical support (1). Despite this, doctrine and skills training in technical rescue and extrication has not been formally developed for Army Medical Services (AMS) personnel (2). This is in stark contrast to the civilian emergency services who have the capability of delivering a wide range of rescue skills (Box 1). One of the most common situations in which casualties require rescue is entrapment following a road traffic accident. Road accidents, although relatively infrequent, account for over half of all MoD injury deaths and are more common on operations (3). This article discusses the management of the trapped patient in the context of road traffic accidents. While much of the material is specific to these relatively common events, the principles apply to almost any entrapment situation.

Box 1 - The spectrum of technical rescue skills

- **Rope rescue** - Access to and transport from steep slopes, cliffs, high buildings, mine shafts, and similar areas.
- **Water rescue** - Maritime operations and rescue from flood waters and fast flowing rivers, drains or aqueducts.
- **Search and rescue** - Co-ordination of detailed searches of parks, built-up areas, inland lakes and rivers, mountainous and other areas.
- **Confined space rescue** - Rescue from confined spaces such as trenches, storage tanks, underground rooms, tunnels, sewers and other spaces with potential for collapse and/or irrespirable, toxic, flammable or explosive atmospheres.
- **Firefighting and rescue** - Techniques to fight fire and effectively hold back flame, smoke and toxic fumes to facilitate rescue.
- **Heavy rescue** - Rescue from incidents such as road traffic or industrial accidents utilising specialised heavy-duty cutting, compressing, ramming, lifting and winching tools.
- **Rescue from collapsed structures** - Management of structural instability and recognition of collapsed building hazards such as mains services (gas, electricity, water) and signs of imminent further collapse.
- **Tactical rescue** - Rescue operations in military and civilian hostile environments including civil disturbance, firearms incidents and military operations.

Entrapment in road accidents

Entrapment is a relatively common complication of road accidents. Of all road traffic accidents in Oxfordshire over a two year period, 131 of 2211 occupants (6%) were trapped in their vehicles (4). Entrapment is more likely in more serious, high energy, accidents. The London based Helicopter Emergency Medical Service attended 737 serious road accidents within the M25 orbital over two years; 90 (12%) of these involved

entrapment for an average of 44 minutes (5). In England and Wales between 1996 and 1997, the Fire Service rescued an estimated 10,000 people trapped in vehicles following road accidents. Thirty percent of these incidents involved more than one casualty (6).

Collisions with other vehicles account for the majority of road accident casualties (7) with head on, front-oblique, side impact and rollover impacts involving proportionally more seriously injured casualties than other collisions (8). In rural areas, 75% of entrapments occur after head on, front-oblique and side impacts. In built-up areas, these accident types account for 90% of entrapments (5,9). Although head on and front-oblique impacts tend to produce the highest numbers of trapped patients, side impacts tend to produce the highest severity of injury (5,8,9).

The mechanism of entrapment in head on and front-oblique impacts is rearward movement of the engine, bulkhead, gearbox, foot pedals, steering and suspension assemblies into the passenger space. This is associated with multiple lower limb fractures and entrapment of the driver's legs and feet (8-11). The head, face and cervical spine are commonly injured if the windscreen pillar intrudes into the vehicle in front-oblique impacts (8-11). The steering wheel may injure and compress the chest and abdomen. In most studies, drivers have been shown to have proportionately more severe injuries than other passengers (4,7,8).

Side impacts are associated with injuries to the viscera on that side and more frequently involve injuries of the head, chest and spine. Intrusion into the passenger space is more pronounced and injuries tend to be multiple and more severe: the average level of injury severity is almost twice that found in similar energy frontal crashes (4,7,8). There is generally little difference in injury patterns between different seating positions (8).

Rollover accidents are not particularly common but may result in complex entrapment (Fig 1) (9,10). Injuries to the head, chest



Fig 1. A rescue and extrication exercise with an overturned military ambulance.

and spine are common(4,7,8) and casualties may be suspended upside down.

Regardless of the mechanism, entrapment can be divided into three categories: relative, absolute or complicated. These categories are useful for describing the extent of entrapment and planning rescue. With relative entrapment, the forces generated on impact have deformed the vehicle or injured the occupant sufficiently to make normal entrance or exit impossible. The casualty may actually be uninjured or simply prevented from escaping by the combination of injuries and restricted space. In the Oxfordshire study, jammed doors were recorded as the cause of entrapment in 10 of the 131 cases (4).

In absolute (or 'superstructure') entrapment, the casualty is physically enclosed in the vehicle by a deformity of the superstructure. Cutting or repositioning of the superstructure is required in order to free the casualty. Complicated entrapment is absolute entrapment with the additional complications of physical impalement or partial traumatic amputation.

Managing the Scene

The UK Fire Service College has identified a number of recurrent management failings at rescue scenes (4). These include the absence of a clearly identified commander, poor liaison between rescue, medical and other personnel and sequential rather than concurrent activity (4). As a result, a systematic approach to the rescue of trapped casualties from conventional road accidents has been developed and is now taught throughout the fire services (4,5,9,12). This system involves six phases (Box 2) and proceeds in parallel with medical assessment and interventions. It relies on good command and control, unity of effort and mutual understanding of the system, the capabilities of the equipment and the needs of casualties. It also relies on heavy rescue skills and the availability of powered hydraulic rescue equipment (now standard on fire appliances in the UK)(4).

Box 2 - Systematic approach to rescue of trapped casualties

- | | |
|---------------------|------------------|
| • Scene assessment | • Space creation |
| • Hazard management | • Full access |
| • Gaining access | • Extrication |

Scene assessment (9-12)

Assessment of the scene commences before the rescue and medical teams actually arrive. Information received from those on site should influence safety measures and resource allocation. On arrival, the incident commander should walk around the incident to determine immediate hazards, numbers of casualties, the full extent of the incident, mechanisms of injury and possible rescue strategies. Walking completely around the incident is important: observations from only one perspective often do not reveal the true nature of any entrapment. While this 'sizing up' of the incident is being carried out, the driver of the response vehicle should have positioned it appropriately and one member of the team should be preparing to gain rapid access and make contact with the casualties. Appropriate positioning depends on hazards but includes protecting the scene from traffic, parking upwind and uphill of fuel leaks and directing exhaust fumes away from wreckage and confined spaces. A trained team should already be considering any other safety precautions necessary to protect the scene.

Hazard management (9-13)

Effective hazard management also commences before arrival at

the scene. The most common contributing factor in non-fatal injury amongst rescue personnel is lack of personal protective equipment (PPE). Thus it is important to have PPE (boots, gloves, overalls, helmets, eye protection etc) readily available. Fire fighters are the only members of the civilian emergency services who routinely arrive at the scene wearing PPE. The majority of fatally injured rescuers are struck by other vehicles while working at the scene. Thus controlling traffic flow is fundamental to road accident rescue. It may be extremely difficult to do this without significant manpower. In such cases, there should be a low threshold for temporarily blocking the road to protect the scene.

Apart from traffic, other main hazards at road accidents are fire, the damaged vehicles, and hazardous loads. Fire fighting equipment should always be laid out ready for use and sources of ignition identified and controlled. These include existing fires, the vehicle electrical system, smoking by bystanders, and hot exhaust pipes or catalytic converters. Fuel leaks from damaged fuel systems (e.g. tanks and injector pumps) can produce a flammable atmosphere within the vehicle. A vehicle which is on fire is a serious safety threat. Apart from the fuel systems, a number of pressurized containers found on the vehicle may overheat and explode. These include hydraulic piston units (lifting cylinders for hatchback and strut suspension units), sealed batteries and any aerosol cans or gas cylinders that may have been carried on the vehicle.

The damaged vehicle is a source of glass, sharp metal edges and hot surfaces. It is not a stable work platform and, unless stabilised, may collapse during rescue operations. Chocks, blocks, ladders, ropes and removal of air from the tyres can all be used to stabilise the wreckage. Glass can be effectively managed by winding down windows, controlled breakage or removal. Other vehicle related hazards are the electrical system and the supplemental restraint systems (airbags).

Disconnecting the battery is often regarded as one of the first steps in neutralising the electrical system. Before doing this, it is worth considering whether, where safety allows, the electrical system can be useful in effecting rescue. Interior lighting and fan heaters can be valuable in the early stages of rescue. Operation of electric windows, seats and door locks can also be achieved. The dangers of leaving the system operational are that automatic cooling fans, fuel pumps and supplementary restraint systems may be energized. Short circuits may cause sparking when superstructure elements containing cables are removed.

Airbags which have not deployed should be regarded as loaded weapons. At no time should a rescuer place themselves between the airbag and the casualty. Front seats should be reclined or pulled backwards if possible to maximise the distance between the casualty and the airbag. Airbags that have already deployed represent minimal risks.

The presence of hazardous loads should always be considered, particularly in incidents involving military or goods vehicles. A valuable pocket size ready reference guide to international hazard identification systems (including NATO weaponry and ammunition) is the Symbol Seeker (13). This allows rapid initial identification of the nature of the hazardous material and any specific precautions or risks associated with it. Finally, if a hazard cannot be controlled (e.g fire) then it may be necessary to attempt to remove the patient immediately at this stage (the 'snatch rescue').

Gaining access (9-13)

Scene assessment and hazard management should be achieved in most cases within a few minutes of arrival. Simultaneously, a member of the team should be gaining access to the casualty to determine their condition. Gaining access involves identifying a pathway that will allow medical personnel access to the casualty.



Fig 2. Rescue Tools carried on Military Ambulances
Hacksaw, pliers, flatpoint and crosspoint screwdrives, 18 inch wrecking bar (crowbar), 8 inch adjustable spanner, release knife, Keech cutting tool. Not shown are the leather gloves, portable 'DANGER' sign, 18 inch bolt cutters, guideline (7.35 metres) and tool roll.

In most cases, the accident will have provided initial access points. These may need to be made safe before they can be used (e.g glass management). If there is no access to the patient, then some form of access must be created. This access hole need not be the planned extrication hole. In attempting to gain access, all the doors should be tried first regardless of the extent of damage. If these do not open, a centre punch or glass hammer will allow access via a window.

Most initial access is accomplished by using existing access points or making openings with simple hand tools (Fig 2). Rarely, it is necessary to bodily roll or winch an overturned vehicle on to its side or wheels in order to gain access.

Space creation (9-13)

Having gained access, the creation of space is the next priority. When faced with a trapped casualty, a general rule is to create the biggest space first (6,9,10). This is best achieved by removal or folding back of the roof structure. Simple space creation techniques such as adjusting seat positions and removing rear seat or luggage compartment loads should always proceed in parallel with the major structural operations. Roofs can be removed in a number of ways - complete removal, flap back, flap forwards, flap sideways - with only a few strategic cuts. Immediate medical care (primary survey) typically takes place during the gaining access and space creation phases of the rescue. The application of multi-modality monitoring equipment at this stage will allow the medical team to stand back from the working area while full access is obtained.

Full access (9-13)

If the clinical condition of the casualty permits, wide full access is achieved by systematic dismantling of the vehicle around the casualty. Attempts to extricate the casualty without full access can result in poor patient handling, unnecessary manoeuvring and an increased risk of further injury. This is the phase in which power rescue tool systems are used to full effect.



Fig 3. Combined cutting and spreading tool (combination tool) with man portable generator, hydraulic hoses and connectors.

Forced door opening, side removal and rolling the dash away from the casualty can be realistically achieved in 10-15 minutes. Typical components of a power rescue tool system include power plant, manual backup pump, cutter, spreader, rams, hydraulic hoses and chain accessories. Portable, light-weight cutter/spreaders (combination tools) complete with power generators and hydraulic hoses are now produced by most rescue tool manufacturers for rapid response vehicles (Fig 3).

Persons trapped in vehicles can be further injured by the actions of the rescue teams. Physical protection from falling objects, glass fragments, rescue tools, hydraulic hoses and connections, bare metal edges, noise and vibrations is easily forgotten. A fire blanket can provide soft protection. Hard protection with a heavy duty plastic or wooden board is also recommended whenever cold or hot cutting is taking place. Safety goggles, helmets and hearing protection should all be available for the casualty throughout these operations.

Extrication (9-13)

Extrication is the process of physically removing the disentangled patient from the wreckage. Whether the casualty has full spinal immobilisation or not, this is an extremely difficult phase in the rescue. Displacement of fractures and haematomas, further bleeding and pain and disruption of existing lines and tubes can all occur. In many cases, analgesia and sedation may have to be increased in order to facilitate extrication. Detrimental physiological responses to these may go unnoticed during extrication.

The whole process (Box 2) can be accomplished by a fire crew with currently available rescue equipment within 30 minutes. This impressive time scale depends on close co-operation with paramedic and medical teams and can be significantly lengthened by the need to conduct medical interventions at the scene.

Immediate medical care

Medical teams need to understand the importance of systematic assessment and reassessment of the trapped patient throughout the rescue process. In addition to following the conventional ABCDE principles, the team must be aware of the specific problems likely to be faced in prolonged entrapment.

A-Airway management

Assessment and management of the airway can be particularly difficult in entrapment situations. Facial injuries, poor light, limited access, restricted space, the position of the patient and the need to maintain spinal immobilisation all present problems (11,12,14,15). Nevertheless, aggressive airway management may dramatically improve oxygenation and outcome, particularly for those with prolonged entrapment and those with head injuries. Apnoea and cyanosis in the field have been found to be powerful predictors of outcome after head injury (16,17). In terms of mortality, a retrospective study of prehospital trauma deaths reported a significant proportion of patients with post-mortem evidence of airway obstruction or soiling but otherwise survivable injuries(18). Thus the full range of basic (19) and advanced (20) airway management interventions should be available to the medical team. These interventions should be performed if there is any suspicion of airway obstruction or compromise on clinical grounds. Most basic airway management techniques can be employed if access to the face is possible. Suction, nasopharyngeal and oropharyngeal airways can be life saving while space is created around the casualty by removing bodywork or the roof (11). Once full access is achieved advanced airway management in the seriously injured casualty includes securing a tracheal tube or if this proves difficult, protecting and maintaining the airway with a Combitube, Laryngeal Mask Airway or surgical technique (11,20).

Tracheal intubation remains the gold standard but can be difficult to achieve and has a low success rate if performed by unskilled personnel. Prolonged laryngoscopy may cause harm by predisposing the casualty to unwanted physiological reflexes (causing hypertension, raised intracranial pressure and dysrhythmias), vomiting and aspiration, laryngospasm and hypoxia. The struggling, semi-conscious patient requires cautious sedation and, ideally, rapid sequence intubation. Despite the dangers, tracheal intubation is associated with improved survival (21,22) and can be facilitated by a variety of sedatives and anaesthetic agents (12,23-25). The method and drugs chosen will depend on the availability of equipment, the rescuers training and expertise and the characteristics and circumstances of the individual patient. It is important to realise that the specific airway intervention is probably less important than the ability to adequately oxygenate and ventilate critically injured casualties.

Trapped patients pose particular problems if anaesthetic agents are used to facilitate airway management or extrication. Four people are generally required to perform a safe rapid sequence intubation: one to provide manual immobilisation (with cervical collar removed), one to provide cricoid pressure, one to intubate and one to give drugs and pass equipment (suction, tracheal tube, bougie, syringe, bag-valve-mask etc) (12). The physical space required by these rescue personnel simply may not be available. In addition, many anaesthetic agents are vasodilators and have direct cardiac depressant effects (with the notable exception of ketamine). Muscle relaxants will reduce the patient's ability to tamponade haematomas and splint fractures (especially those of the vertebral column). Thus, precipitous falls in blood pressure and further deterioration may be caused by anaesthesia. This situation is more likely in the hypovolaemic patient who is trapped in the upright position. Only careful titration of agents, close monitoring of vital signs and fluid replacement can

minimise the risks of profound hypotension. Multimodality monitoring (pulse rate, non invasive blood pressure, three lead electrocardiography, pulse oximetry and capnography) is regarded as essential for pre-hospital anaesthesia. One final critical airway problem in the trapped patient is confirmation of airway device placement both immediately following insertion or intubation and throughout the disentanglement and extrication process (Box 3)(26).

Box 3 - Methods used to confirm airway device placement

Observed

- Direct visualisation*
- Observation of chest movement
- Auscultation of breath sounds
- Absence of epigastric sounds with respiration
- Presence of exhaled tidal volume
- Reservoir bag compliance
- Difficulty ventilating
- Absence of air escape*
- Tube condensation with exhalation

Measured

- Capnography (end tidal CO₂)
- Continuous pulse oximetry
- Oesophageal detector device*

* *specific to endotracheal intubation*

B - Assessment of breathing and ventilatory support

Recognition of chest injury and respiratory compromise can be difficult, particularly when access to the chest is restricted by seatbelts, clothing, the steering wheel or other wreckage. A useful but often forgotten space making technique is to slide the seat back, reduce its height or recline it. A steering column 'tilt and reach' mechanism may also be fitted which can be adjusted if it remains intact (9,10).

Clinical assessment should include inspection for pattern bruising, inadequate expansion, respiratory distress and abnormal (paradoxical) movement. The presence of crepitus and pain on palpation should, combined with assessment of the mechanism of injury, indicate the likely site of significant chest trauma. Percussion and auscultation should always be attempted. Many standard texts of pre-hospital care advocate abandonment of these aspects of clinical examination in the pre-hospital setting because it is difficult to hear percussion notes and breath sounds. Percussion notes are however best palpated and the presence of good bilateral breath sounds may significantly influence interventions at the scene regardless of other findings. It is rarely impossible to hear air entry when it is present (27). The respiratory rate is one of the most valuable indicators of respiratory or circulatory compromise. It is also the most frequently omitted vital sign from clinical records.

All trauma patients should have high inspired oxygen concentrations delivered by a system which best meets their ventilatory pattern and needs. For the spontaneously breathing patient, a non-rebreathing mask with a reservoir bag and oxygen flow rate sufficient to meet peak inspiratory demands will provide maximal oxygenation. High oxygen flow will rapidly diminish oxygen supplies and may create an additional confined

space hazard. A full 'D' size cylinder with 340 litres of oxygen will only last 34 minutes at 10 l/min flow rates. However, high flow oxygen for even a short period may sufficiently enrich the atmosphere within the wreckage to create a significant explosion hazard (particularly in the presence of spilt fuel). Effective management of this hazard involves appropriate use of oxygen, ventilation of the space and control of sources of ignition.

In addition to administration of oxygen, the most important pre-hospital interventions in patients with thoracic trauma are ventilation and decompression of a tension pneumothorax (28-30). In entrapment, spontaneous and positive pressure ventilation can be impeded by injury, the wreckage or indeed the application of an extrication device (12). Positive pressure ventilation is best achieved in prolonged entrapment with a portable ventilator and a multi-modality monitor (ideally with capnography or an apnoea alarm to indicate disconnection). This allows access for rescue personnel to dismantle the vehicle while the medical team monitor the patient from a distance. Overzealous positive pressure ventilation by either portable ventilator or bag-valve-mask apparatus may however cause harm by increasing intrathoracic pressure and reducing venous return. This may well go unnoticed in the trapped, moribund trauma patient who may have lower ventilatory requirements (as a result of lower oxygen consumption and carbon dioxide production) (31). The resulting reduction in cardiac output may be erroneously attributed to other injuries. Six to eight breaths per minute at tidal volumes of approximately 10ml/kg may be adequate to maintain oxygenation without impairing cardiac output (31).

Positive pressure ventilation also predisposes the patient to development of pneumothoraces which may, if not identified and treated, tension. All trapped and injured patients should have a tension pneumothorax deliberately excluded at initial assessment and at any sign of deterioration throughout the rescue. This is particularly the case if an oxygen / nitrous oxide mixture has been used for analgesia; the nitrous oxide will diffuse rapidly into air filled body cavities. Immediate chest decompression by needle thoracocentesis is life saving. Pneumothoraces may still reaccumulate with this technique and definitive decompression via either tube (28,29) or open (30) thoracostomy is indicated in prolonged entrapment. This has been shown to be safe in the pre-hospital environment and is associated with statistically significant improvements in oxygen saturation, blood pressure and pulse rate (28). There have been no iatrogenic injuries and, despite the lack of a sterile field, very low infection rates in these studies (28-30).

In ventilated patients, the open thoracostomy technique has several theoretical and practical advantages. Conventional chest drain insertion can take several minutes to perform and may further delay extrication. The drain itself may also become dislodged or tangled. The open thoracostomy technique involves all the initial stages of chest drain insertion but without actually inserting a drain (30). With ventilated patients, positive pressure expels air through the thoracostomy as the lungs expand and the intrapleural pressure rises. Intrapleural pressure never becomes negative as it does with spontaneous breathing and thus air is not sucked back through the thoracostomy. The open thoracostomy wound acts as a pressure relief valve and it can simply be covered with a dry dressing. Those who are concerned about inspiratory efforts in the non-paralysed patient can cover the wound with an 'Asherman Chest Seal' or similar three-sided dressing (32). The open technique is quicker than full chest drain insertion (insertion, positioning and securing the tube together with a drainage device), easier to perform and less invasive. Neither open nor closed thoracostomy is advocated in casualties with a haemothorax without respiratory compromise.

Given that thoracic decompression and drainage are the definitive interventions for most patients with thoracic injury, doctors involved in prolonged prehospital care should be experienced in these techniques.

C-Haemorrhage control and circulatory support

Lower limb injuries are particularly common in trapped road accident casualties (4,7,8). These patients may have no other injuries but can lose substantial quantities of blood if they are trapped sitting upright. A key aspect of dealing with trapped patients is identification and control of such external haemorrhage. Blood dripping from under the floor may be the only indication of active bleeding. Seat cushions and carpets can absorb significant quantities of blood; as can underlying soft soil. These areas should all be checked if direct access to the casualty cannot be achieved. Medical teams should use all methods at their disposal to identify and stop the bleeding. These include direct pressure, arterial pressure points, ligatures, tourniquets and splints. Secure intravenous access should be obtained in all cases and a deliberate assessment made of the casualty's fluid status. Intravenous access may require cut down techniques or, when both upper limbs are injured, external jugular or central access (11). The injuries and vital signs (particularly pulse rate, respiratory rate, capillary refill time and blood pressure) together with the haemodynamic response to initial fluid resuscitation will allow the rescuer to estimate likely blood loss and plan appropriate fluid replacement. In all cases, fluid replacement should be titrated to response.

There is currently considerable debate regarding both the type and quantity of fluid which should be used in resuscitation of trauma patients (33). Advocates of early aggressive fluid resuscitation (the current ATLS® approach) cite the proven benefits of blood pressure support in head injuries, and the value of fluid administration in animal studies of severe circulatory compromise (16,31). More recent experimental and clinical studies suggest however that intravenous fluids and other measures to reverse hypotension may be detrimental if provided before control of internal haemorrhage has been achieved. Proponents of the concept of 'delayed' or 'hypotensive' fluid resuscitation argue that fluid replacement is ineffective, time consuming and leads to increased bleeding, haemodilution and impaired coagulation (31,33). Although the studies supporting these concepts are interesting, they involve patients with penetrating injuries rather than blunt trauma (34).

Casualties trapped in road traffic accidents rarely have penetrating trauma. A trapped casualty with a reduced level of consciousness, left upper quadrant pain and a closed femoral shaft fracture presents a dilemma for medical teams. Aggressive fluid resuscitation may theoretically increase intra-abdominal haemorrhage from splenic injury but blood pressure support for the head injury is considered critical (16). Add to this the potentially massive blood loss and fluid sequestration from an unreduced femoral shaft fracture and the dilemma worsens (31,33) In such circumstances, attempts to maintain an adequate cerebral perfusion pressure should be balanced with the risks of continued uncontrolled bleeding if blood pressure is restored to normal.

There is currently no clear evidence from controlled trials that resuscitation with colloids reduces the risk of death compared to crystalloids or that any one colloid solution is more effective than any other (35,36). Perhaps the most appropriate fluid replacement for the trapped casualty is blood. Blood transfusion at the scene of an accident is indicated when the estimated blood loss is >20% blood volume and the expected duration of entrapment and transfer is likely to exceed the time required to organise blood (37). It may take a long time to organise blood at

the accident scene if arrangements have not been made in advance with receiving medical facilities. Key issues are accurate and unique identification of patients and samples, collection of appropriate samples (generally 10ml without anticoagulant), checking of blood products for compatibility prior to transfusions, use of a blood giving set with integral filter and recognition of adverse reactions. The most relevant adverse reactions in the pre-hospital environment are acute haemolytic transfusion reactions, allergic and anaphylactic reactions and fluid overload. In the context of a rescue, these problems may go unnoticed or be misinterpreted. Nonetheless, pre-hospital blood transfusions are performed regularly in civilian practice and may dramatically influence outcome (38).

A further aspect in the management of shock is control of pain. Pre-hospital analgesia is frequently inadequate (39). Analgesics should be titrated against response and augmented, where possible, by local anaesthetic techniques (e.g axillary brachial plexus block for upper limb injuries, femoral nerve block, digital nerve blocks and intercostal blocks) (12,40). In the trapped patient, there is often sufficient time between initial assessment and final extrication to allow regional anaesthetic techniques to take full effect. Entonox and ketamine are invaluable in the process of extrication.

D-Spinal immobilisation and assessment of neurological disability

Indications for pre-hospital spinal immobilisation have generally been based on mechanism of injury (potential for injury) rather than clinical evidence of vertebral column or spinal cord damage. Although mishandling of patients has frequently been cited as a common cause of iatrogenic spinal injury, these instances, have not been identified in the literature (41). Recent guidelines have therefore advocated an assessment of both the mechanism of injury and the clinical findings on examination (41,42).

Box 4 - Clinical criteria for spinal immobilisation

- Altered mental status or level of consciousness
- Evidence of intoxication with alcohol or drugs
- A distracting painful injury (e.g. long bone extremity fracture)
- Neurological signs related to spinal injury
- Pain or tenderness in the cervical, thoracic or lumbar spine
- Known pre-existing injury to the spine

Spinal immobilisation is now indicated for casualties who sustain an injury with a mechanism having the potential for causing spinal injury and who have at least one of the clinical criteria in box 4. Patients without a mechanism for injury or even those with a suitable mechanism but none of the clinical features in box 4 may safely have spinal immobilisation omitted (41,42). This decision may dramatically influence the speed and process of disentanglement and extrication of casualties with isolated minor injuries. Caveats are that there must be no difficulty with communication (language barriers, hearing impairment etc), the definition of a distracting injury has not been prospectively determined and pre-hospital medical personnel have been shown to be poor at judging intoxication (43).

Where spinal immobilisation is indicated, the full range of immobilisation techniques should be employed. Manual in-line immobilisation, semi-rigid cervical collars and extrication devices which immobilise the entire vertebral column are

required (e.g Kendrick® and Telford® extrication devices). In recognition of the fact that full spinal immobilisation can considerably lengthen rescue and scene times, only those casualties with no immediate threat to life should have full immobilisation prior to extrication. Those with a major risk to life as a result of their injuries can be extricated on to a long spinal extrication board. Although these boards allow more rapid extrication, they do not provide complete spinal immobilisation and commit the casualty to being log rolled later in their care. Where there is immediate risk to life, the casualty must be rescued as rapidly as possible and, in these circumstances, some risks to the vertebral column and spinal cord must be accepted.

Patients with a Glasgow Coma Score of eight or less (roughly equivalent to **P** or **U** on the Alert / Responds to Voice / Responds to Pain / Unresponsive scale) are defined as having a major head injury. In these patients, the importance of maintaining blood pressure and oxygenation has already been emphasised(16). In addition, raised intracranial pressure (ICP) is an important direct cause of death and disability. The observed development of asymmetric pupils, pupil dilatation, motor posturing or unexplained neurological deterioration during a prolonged rescue are all evidence of a rising ICP (16). Steps must be taken to attempt to reduce the rise in ICP. This can be achieved by treating airway, breathing and circulation problems and providing analgesia and sedation if it is safe to do so. If ICP appears to be increasing (as witnessed by further neurological deterioration), specific ICP lowering strategies such as hyperventilation and administration of diuretics (frusemide or mannitol) can be employed. These interventions should not be performed on head injured patients without evidence of high ICP as they may cause reduction in cerebral perfusion and exacerbate hypotension (16).

E-Exposure and extrication

As full access is obtained, the extent of injuries will become evident and the medical team can plan the most appropriate transport arrangements and 'packaging'. Where pelvic fractures are thought likely, there is currently a trend away from long spinal boards as a means of transport because of the potential pelvic disruption caused on log rolling the patient in the A&E department or reception. These patients may have been extricated with a long spinal board but can be easily transferred to a normal stretcher or trolley using an orthopaedic scoop stretcher. Military Anti Shock Trousers (MAST) suits have not been shown to be associated with improved survival when used routinely on hypotensive patients (44). However, they still have an important role in the simple splinting and stabilisation of pelvic and multiple lower limb fractures.

Many critically ill patients will be hypothermic by the time they are ready to be extricated. Warmed intravenous fluids, warm packs, portable heaters and preservation of clothing are all important in reducing unnecessary heat loss.

Extrication in many cases will be facilitated by the administration of analgesic or anaesthetic doses of ketamine. This is widely regarded as the analgesic and anaesthetic agent of choice in the management of trapped patients (45).

Conclusion

Entrapment is one of the most challenging and difficult aspects of pre-hospital care. In military practice, entrapment is seen across the spectrum of conflict. If the AMS is to provide a level of operational medical support as closely equivalent to peacetime UK standards as possible, then the development of a technical rescue capability within every AMS unit with a responsibility to respond to road accidents is essential. Rescue of trapped patients from conventional vehicles cannot be achieved within current

civilian time standards or operational time lines without the use of heavy rescue skills and equipment. This equipment is currently only available within the Defense and RAF Fire services. There have however been notable operational examples of rescue of trapped patients utilising *ad-hoc*, theatre specific arrangements with medical, engineer, Defense Fire Service and other assets. Theses demonstrate that the multidisciplinary approach utilised by the civilian emergency services can be readily applied to management of the trapped patient on operations.

This is the first part of a new add-on series of articles on pre-hospital care. Throughout the series, the current management philosophies for a range of pre-hospital problems will be discussed and related to the military environment. The series is edited by Maj R Mackenzie, Specialist Registrar in Emergency Medicine. The series was conceived and planned by Maj I Greaves and Maj R Mackenzie.

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