MEDICAL GUIDANCE NOTE

Title:	**THE MEDICAL MANAGEMENT OF THE ENTRAPPED PATIENT WITH CRUSH SYNDROME**
Last revised:	**February 2012**

1. INTRODUCTION

1. The following clinical guideline has been developed by the INSARAG Medical Working Group (MWG) which consists of medical professionals actively involved in the urban search and rescue discipline. The MWG is comprised of representatives from 15 countries and organisations drawn from the three INSARAG regional groups.

2. This clinical guideline outlines a recommended approach to crush syndrome in the austere environment of collapse structure response. As such it is to be considered as a consensus statement by members of the MWG based on current medical literature and experience; it is not intended to be a prescriptive medical protocol. In addition it must be understood that these guidelines have been developed for application in an environment which may be complicated by factors such as:
   a. Hazards to rescuers and patients e.g., secondary collapse; hazardous material;
   b. Limited access to entrapped patient;
   c. Limitations of medical and rescue equipment within the confined space;
   d. Prolonged extrication and evacuation of patient;
   e. Delayed access to definitive care.

2. DEFINITION

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1. Crush Injury: Entrapment of parts of the body due to a compressive force that results in physical injury and or ischaemic injury to the muscle of the affected area, most commonly discussed in the context of collapsed structure incidents. If significant muscle mass is involved, it can lead to *crush syndrome* following release of the compressive force.

2. Crush Syndrome: A potentially life-threatening, systemic condition that can occur after release of a compressive force that has been applied to a muscle mass. The factors that lead to the development crush syndrome include:

   a. Degree of compressive force;
   b. Amount of muscle mass involved;
   c. Duration of compression.

3. The compressive force can be from one's own body weight in a static position or from an external source.

4. The onset of crush syndrome occurs following reperfusion of injured muscle when the compressive force is released. This may result in acute and or delayed-onset clinical sequelae.

5. The three primary acute pathophysiological concerns are:

- Hypovolaemia which may result in shock;
- Electrolyte imbalances including hyperkalaemia which may result in acute cardiac dysrhythmias;
- Metabolic acidosis which may result in shock.

6. Delayed-onset pathophysiological concerns include:

- Renal failure;
- Adult Respiratory Distress Syndrome (ARDS);
- Coagulopathy;

- Severe sepsis.

7. Delayed medical care and or inappropriate rescue management e.g., uncontrolled rapid removal of the compressive force before initiation of medical care e.g.; fluid administration, may result in rapid clinical deterioration and death of the patient.

3. CLINICAL PRESENTATION

1. All patients entrapped within a structural collapse environment should be considered to have some element of crush syndrome until proven otherwise. Rescuers and medical personnel should maintain a high index of suspicion of the potential for crush syndrome taking into account the following:

   - There may be no obvious physical signs of crush injury and the patient's vital signs may initially be normal;
   - Physical signs, when present, may include:
     - Mottled or blistered skin;
     - Oedema;

Photographs courtesy of Japan International Cooperation Agency (JICA)

- Reddish-brown urine;
- Absent or diminished pulses in affected limbs;
- General signs of shock;

Photographs courtesy of Japan International Cooperation Agency (JICA)

- Symptoms:
  - Dysaesthesia (e.g.; paraesthesia; hypoaesthesia; hyperaesthesia);
  - Anaesthesia;
  - Pain:
    - Presence and level of pain may not reflect the level of severity of injury;
    - May be exacerbated on movement/release;
- Paralysis or paresis of the affected limbs.

2. Note: Crush syndrome may be incorrectly diagnosed as a spinal cord injury. This is an important differential diagnosis to make as the treatment regimes differ significantly. If in any doubt, treat as for crush syndrome whilst protecting the spine until spinal injury can be excluded.

3. Hyperkalaemia should be anticipated in crush injury. It should be identified and managed as early as possible. See Section 4.2.2 below.

4. MANAGEMENT STRATEGY

1. For the general approach to patient treatment in the confined space environment see *01 MWG_Provision of Medical Care in an Austere Environment Specifically in a Confined Space_ISG Approved Feb 2011*. If relevant, see also *05 MWG_Amputations and Dismemberment_ISG Approved Feb 2011*.

4.1. General Management

- It is imperative that the rescue team recognise the dangers of not treating the patient prior to release of the compressive force;
- The method and timing of the removal of the compressive force should be closely coordinated between the rescue technicians and the medical personnel.
- Removal of the compressive force should not be delayed as the severity of crush syndrome and compartment syndrome is proportional to the duration the area is crushed for;
- The method and route out of the rubble pile should be prepared prior to the removal of the compressive force;
- The required extrication equipment should be immediately available;
- Method of transport should be established early;
- Receiving healthcare facility should be identified as soon as possible.

4.1.2 Medical Management

- Entrapped patients may appear stable whilst the compressive force is in place;

- Anticipate what medical equipment and medicines may be required to treat the patient and ensure that these are immediately available prior to removal of the compressive force.

4.1.2.1 Fluid Management in Crush Syndrome

Important Considerations:

1. Currently there is no strong scientific evidence to support any single definitive fluid regime for the collapsed structure environment.
2. However, fluid administration remains the cornerstone of therapy for the medical management of crush syndrome and establishing adequate intravenous access and providing fluid is therefore of critical importance.
3. In the USAR environment, fluid loading of the patient is recommended as one of the most important actions **prior** to release of any compressive force.
4. The USAR environment usually precludes an ability to definitively monitor haemodynamic, electrolyte and metabolic status of the patient.
5. Special consideration should be given to the administration of lower rates and doses of fluid administration which may apply to:
    a. Those with lower muscle mass:
        i. Paediatrics;
        ii. Elderly;
        iii. Chronically malnourished;
    b. Patient with known co-morbid conditions e.g.; heart failure.

Fluid Administration

1. Fluid administration routes:
    a. Consider the following methods of venous access:
        i. Peripheral;
        ii. Intraosseous (IO);

   iii. Venous cutdown;
   iv. Central (least desirable, consider the risks associated with central venous access within a confined space);

b. If intravenous (IV) access is not possible, consider alternative routes of fluid administration recognising their limited effectiveness (poor absorption) and potential side effects e.g., regurgitation:
   i. Orogastric;
   ii. Nasogastric;
   iii. Rectal;
   iv. Subcutaneous (avoid administration in crushed area);

2. Intravenous Fluid type:
   a. Preferably use warm, isotonic, potassium free solutions.

3. Fluid volume:
   a. Fluid administration is not simply aimed at replacing what is lost. There are multiple reasons for fluid administration during various stages of the extrication:
      i. Volume replacement as required to achieve haemodynamic stability;
      ii. Fluid loading to compensate for the sequestration of intravascular fluid into the interstitial space;
      iii. To maintain adequate renal perfusion and prevention of renal damage. This may require the use of volumes of fluids that may exceed volumes usually administered to a trauma patient.
      iv. To address maintenance fluid requirements.
   b. Volume:
      i. There is no strong scientific evidence to support any particular dose of administration. However, the literature supports the use of high volume fluids during extrication.
      ii. Many authors recommend 1 to 1.5 litres per hour for the adult patient until hydration status can be verified.
      iii. This may be augmented by intravenous fluid boluses.

iv. The principles of damage control resuscitation (e.g.; permissive hypotension) may not necessarily apply.

4. Other General recommendations:
   a. Insulate fluids in cold environments;
   b. Use pressure infuser devices in conjunction with rate control devices to aid with fluid administration. The confined space environment often precludes being able to place the intravenous fluid container above the level of the patients heart thereby preventing fluid flow or resulting in blood back flow up the administration set. Do not delay fluid administration waiting for equipment as manually squeezing the bag is an effective interim measure;
   c. Ensure IV sites are adequately secured;
   d. Use IV extension tubing to facilitate easier administration of fluid and medication;
   e. Use two sites of intravenous access, if possible;
   f. Adhere to sterile procedures as far as possible;
   g. Monitoring haemodynamic status using urinary output can be difficult to assess in the USAR environment, however:
      i. Encourage patient to urinate into a container if possible if they feel the need;
      ii. Make note of times patient urinates;
      iii. Observe the colour and estimate the volume, if possible;
      iv. It is not generally advisable to attempt bladder catheterization within a confined space. As an alternative consider the use of a condom catheter in a male patient.
      v. Be aware of the patient with a full bladder who is no longer producing urine i.e. a single collection of urine is not always a reliable confirmation of ongoing renal function.

4.1.2.2 Medications

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Important Considerations:

1. As crush syndrome is associated with acute renal failure, medications with known nephrotoxic effects must be avoided if at all possible e.g.; non-steroidal anti-inflammatory drugs (NSAIDs).
2. Patients presenting with possible acute renal failure may accumulate excessive doses of an administered drug due to inability of urinary excretion leading to toxicity.

Recommendations

1. The medical literature and USAR experience support the early administration of the following medications:
    a. Sodium Bicarbonate 8.4% (e.g.; 50 ml IV in an average adult patient) prior to removal of the compressive force. Although there is no strong scientific evidence to support additional bolus doses, this may be considered in a prolonged extrication. Subsequent slow intravenous infusion may assist with alkaline diuresis which is thought to aid renal protection.
    b. Analgesia: Appropriate and adequate analgesia is not only important for patient comfort, it may assist with patient extrication. Selection of analgesic may be influenced by the scope of practice, duration of action, renal elimination, effect on the haemodynamic profile and need for airway support.
    c. Antibiotics: preferably broad spectrum (including anaerobes) intravenous or intramuscular in non-damaged tissue; avoid nephrotoxic antibiotics.
    d. Medications for the treatment of hyperkalaemia may include:
        i. Sodium Bicarbonate 8.4%;
        ii. Calcium 10% (in the presence of ECG changes indicative of hyperkalaemia);

iii. Beta-2 agonist;
iv. Intravenous dextrose and insulin;
v. Polystyrene sulfonate or resonium calcium (when practical and if prolonged transfer to tertiary care is expected).

Notes:

- Mannitol 20%: May be considered once ongoing urinary production and output has been verified. Note: Mannitol is contraindicated in anuric states.
- Although the use of allopurinol has been described in patients with non-crush syndrome rhabdomyolysis, its use in crush syndrome is not described.
- Acetazolamide has also been recommended for treatment, however its use in the confined space environment is restricted due to the inability to measure blood chemistry.
- Furosemide has unfavorable heamodynamic side effects. Furthermore, it causes acidification of the urine which counteracts attempts to alkalinize the urine through the administration of sodium bicarbonate. Therefore it use in this environment is strongly discouraged.
- Suxamethonium chloride is contra-indicated due to its exacerbation of hyperkalaemia.

4.1.2.3 Tourniquets

1. There is currently no scientific evidence to support the use of tourniquets in the prevention of crush syndrome following release of the compressive force.
2. The use of tourniquets should be reserved for otherwise uncontrollable life-threatening haemorrhage. Tourniquets used in this environment should be appropriately designed for arterial occlusion.

4.2 Post-release of the compressive force

1. During and immediately following removal of the compressive force, reassess the patient's clinical condition as it may rapidly deteriorate.
2. Coordinate the extrication and evacuation with the rescue team as per pre-planned strategy.
3. Continuously monitor the ECG for signs of acute hyperkalaemia as soon as practical.
4. Continuously monitor the patient's hemodynamic status.

4.3 Compartment Syndrome

Following the release of the compressive force, patients may develop a compartment syndrome. Current evidence in the medical literature discourages the use of fasciotomies in the field environment due to the high rates of sepsis and bleeding complications, which may be life-threatening. The literature supports the use of mannitol as a non-surgical approach to reducing intracompartmental pressures.

5. REFERENCES

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