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Emergency Preparedness and Response

After an Earthquake: Management of Crush Injuries & Crush Syndrome

Background

Crush injury and crush syndrome may result from structural collapse during an earthquake. **Crush injury** is defined as compression of extremities or other parts of the body that causes muscle swelling and/or neurological disturbances in the affected areas of the body. Typically affected areas of the body include lower extremities, upper extremities, and trunk. **Crush syndrome** is localized crush injury with systemic manifestations. These systemic effects are caused by a traumatic rhabdomyolysis (muscle breakdown) and the release of potentially toxic muscle cell components and electrolytes into the circulatory system. Crush syndrome can cause local tissue injury, organ dysfunction, and metabolic abnormalities, including acidosis, hyperkalemia, and hypocalcemia.

Previous experience with earthquakes that caused major structural damage has demonstrated that the incidence of crush syndrome is 2-15% with approximately 50% of those with crush syndrome developing acute renal failure and over 50% needing fasciotomy. Of those with renal failure, 50% need dialysis.

Clinical Presentation

Sudden release of a crushed extremity may result in **reperfusion syndrome**—acute hypovolemia and metabolic abnormalities. This condition may cause lethal cardiac arrhythmias. Further, the sudden release of toxins from necrotic muscle into the circulatory system leads to myoglobinuria, which causes renal failure if untreated.

Hypotension

- Massive third spacing occurs, requiring considerable fluid replacement in the first 24 hours; Patients may sequester (third space) more than 12 L of fluid in the crushed area over a 48-hour period
- Third spacing may lead to secondary complications such as compartment syndrome, which is swelling within a closed anatomical space; compartment syndrome often requires fasciotomy
- Hypotension may also contribute to renal failure

Renal Failure

- Rhabdomyolysis releases myoglobin, potassium, phosphorous, and creatinine into the circulation
- Myoglobinuria may result in renal tubular necrosis if untreated
- Release of electrolytes from ischemic muscles causes metabolic abnormalities

Metabolic Abnormalities

- Calcium flows into muscle cells through leaky membranes, causing systemic hypocalcemia
- Potassium is released from ischemic muscle into systemic circulation, causing hyperkalemia
- Lactic acid is released from ischemic muscle into systemic circulation, causing metabolic acidosis
- Imbalance of potassium and calcium may cause life-threatening cardiac arrhythmias, including cardiac arrest; metabolic acidosis may exacerbate this situation

Secondary Complications

- Compartment syndrome may occur, which will further worsen vascular compromise

Initial Management: Prehospital Setting

- Administer intravenous fluids before releasing the crushed body part. (This step is especially important in cases of prolonged crush [more than 4 hours]; however, crush syndrome can occur in crush scenarios of less than 1 hour)
- If this procedure is not possible, consider short-term use of a tourniquet on the affected limb until intravenous (IV) hydration can be

initiated

Initial Management: Hospital Setting

Hypotension

- Initiate (or continue) IV hydration—up to 1.5 L/hour

Renal Failure

- Prevent renal failure with appropriate hydration, using IV fluids and mannitol to maintain diuresis of at least 300 cc/hr
- Triage to hemodialysis as needed

Metabolic Abnormalities

- *Acidosis:* Alkalinization of urine is critical; administer IV sodium bicarbonate until urine pH reaches 6.5 to prevent myoglobin and uric acid deposition in kidneys
- *Hyperkalemia/Hypocalcemia:* Consider administering the following (adult doses): calcium gluconate 10% 10cc or calcium chloride 10% 5cc IV over 2 minutes; sodium bicarbonate 1 meq/kg IV slow push; regular insulin 5-10 U and D5O 1-2 ampules IV bolus; kayexalate 25-50g with sorbitol 20% 100mL PO or PR
- *Cardiac Arrhythmias:* Monitor for cardiac arrhythmias and cardiac arrest, and treat accordingly

Secondary Complications

- Monitor casualties for compartment syndrome; monitor compartmental pressure if equipment is available; consider emergency fasciotomy for compartment syndrome
- Treat open wounds with antibiotics, tetanus toxoid, and debridement of necrotic tissue
- Apply ice to injured areas and monitor for the 5 P's: pain, pallor, parasthesias, pain with passive movement, and pulselessness
- Observe all crush casualties, even those who look well
- Delays in hydration of greater than 12 hours may increase the incidence of renal failure; delayed manifestations of renal failure can occur

Disposition

Patients with acute renal failure may require up to 60 days of dialysis treatment; unless sepsis is present, patients are likely to regain normal kidney function.

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