

CRUSH INJURY

by Kenneth Capek RRT, CHT, MPA



I'm not in the construction business but I understand that building a parking garage these days requires placing very heavy cement slabs together to form each level. I know this because I treated a patient a few weeks ago who unfortunately got the tip of his left index finger snagged between two of those slabs. When it came out it wasn't a pretty sight. A plastic surgeon worked to try and save the tip of his finger by performing what is called a fasciotomy. A fasciotomy is performed by cutting into the fascia (thin connective tissue covering muscle or organs) in order to relieve ensuing swelling and internal pressure.

Crush injuries are most common to areas like finger and toes. I believe that ever since they invented doors, people have been smashing their fingers in them. This typically results in severe pain but may also present as numbness, deformity, exposed bone, and bleeding. When blood is found under the nail it is called subungual hematoma and it may need to be drained to relieve pressure or even removal of the nail is necessary. In worse scenarios the finger may have lacerations, avulsions (part of the skin or tissue is torn off) or full amputations. Separated tissue may be reattached to the finger and skin grafting (transfer skin from one area to injury site) is another an option. Sometimes if the tissue is too small or damaged or separated for too long, it may not be salvageable. Crush injuries along with; compartment syndromes, burns, frostbite, failing skin flaps and

re-attachments which can be found under the heading of acute traumatic peripheral ischemias (ATPI's). ATPI's may vary in origin and characteristics but all share three main factors; ischemia, edema and gradient of injury, which all lead to the main villain of the story; tissue hypoxia. Ischemia is the primary cause of tissue hypoxia and can occur by direct injury to blood vessels (laceration) or decreased blood flow (excessive bleeding) or vascular collapse from external pressure on the vessel itself as found with compartment syndrome. Compartment syndrome is a serious condition that is defined by perfusion pressure falling below tissue pressure in a closed anatomic space, typically caused by long bone fractures. These pressures can actually be measured (CPP or capillary perfusion pressure) and if greater than 30 mm Hg will require intervention. If untreated it will lead to tissue necrosis.

The bottom line with these injuries is that insufficient blood flow can lead to insufficient oxygen for tissues and their metabolic needs. Unfortunately, it's during the healing process that these needs are greatest. Edema is another problem. Intracellular fluid leakage to extracellular spaces also adds to hypoxia. When edema is severe, healing and control of infections is challenged. Edema will actually increase the distance for diffusion to take place between capillary and cell thus impeding oxygenation. It can also collapse capillaries due to external pressure on the vessel wall. Once interstitial fluid pressure exceeds capillary pressure in a closed space, capillaries will collapse along with microcirculation. The gradient of injury is the relationship of having minimally tissues along with areas that are unsalvageable and the difficulty of these areas having different treatments. Lastly, infection is always a concern because without adequate circulation, bacteria will flourish. In addition, without blood flow, antibiotics can't reach the site where they are needed and the ability of leukocytes (which require oxygen) to battle the infection is diminished. Ultimately when tissues get insufficient oxygen, they become non-functional and die. If this occurs necrotic tissue must be drained and/ or removed.

Hyperbaric oxygen therapy (HBOT) is used as an adjunct for the treatment of these injuries primarily for super oxygenation. HBOT saturates the blood plasma with enough oxygen for cell metabolism to continue without red blood cells. This is especially important when red blood cell availability is diminished due to reduced blood flow. Plasma may also travel where red blood cells cannot due to size of the vessels restricted by external pressures. HBOT can produce up to a 20% reduction in blood flow due to its vasoconstriction effect thus reducing edema. The increased oxygenation of the blood offsets this reduction in flow. Reduction in edema can on the other hand increase flow. HBOT can also help fight off infections in the area of the injury by fortifying the neutrophils ability to fight bacteria. HBOT can directly inhibit the growth of anaerobic bacteria such as clostridia and others.

HBOT is typically administered using different protocols based upon treatment objective; general promotion of healing or for the threat of tissue viability due to acute, profound ischemia.

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When promoting healing we administer HBOT treatments 1 to 2 times daily at a pressure of 2 ATA (atmospheres absolute) for 1 to 1 1/2 hours per treatment. Microcirculation problems should resolve within 4 to 6 days with neovascularization in 10 to 14 days. For preserving tissue with profound ischemia, the protocol is to treat every 4 to 6 hours for 24 to 48 hours or using more intense scheduling of therapy until resolved. When fighting ischemia in order to save tissues, the frequency of therapy is dramatically increased, but the importance of immediate treatment following injury is critical for determination of outcome. Studies have shown that tissue necrosis can develop after just 6 hours of ischemia!

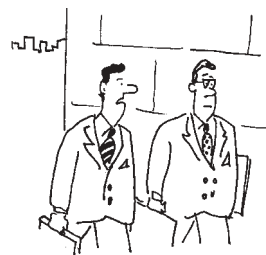
Unfortunately there are a few problems when it comes to effectively treating these injuries with HBOT. Many physicians are not aware of the benefits of using HBOT for these cases and/or may not realize the urgency required for treatment to be successful. Access is another problem since many hospitals simply do not provide this therapy and patient transfers can take an excessive amount of time. Lastly, even if a hospital has this service it is unlikely they provide around the clock on-call services. So don't get hurt on a weekend. Better yet don't get hurt at all. Prevention of crush injuries is important in all areas of life whether it be in work, sports, house and car repairs and even kitchen activities. Always use safe practices and be aware of your environment and potential dangers. Ten is a good number for digits.

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In the next installment on this topic, we'll take a closer look at the respiratory drug market itself. I'll break it down so we can see that portion that includes aerosol solutions, inhaler, nebulizers and unique delivery systems. We'll also examine the new drug pipeline for respiratory drugs, and specifically for inhalable agents that we might have to administer in the future. If I may end with a little teaser: we are in for some interesting and intriguing surprises in this business as we dust off the crystal ball and look at the new drug pipeline. Inhalation drugs are no longer used solely for targeting the respiratory system. On the horizon are a number of new drugs that target the brain and central nervous system, although they are first delivered to epithelium in either the nose or lung. This respiratory drug biz never ceases to amaze.

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**"The job candidate was underqualified.
I was just too overqualified to recognize it."**