CLINICAL VIGNETTE

Coming to Grips with High Pressure Hand Injuries

Miguel Lemus, M.D., and Derrick Darnsteadt, M.D.

Case Presentation

A 21-year-old right hand dominant male presented to the Emergency Department with a left third digit injury (Figure 1). The injury occurred 6 days prior from a high pressure paint gun injection. He had been seen at a clinic after the injury and was started on amoxicillin and had his tetanus vaccination updated. He presented to the Emergency Department due to worsening pain and swelling. He was unaware of the paint gun pressure or the quantity of paint injected.

He had no systemic symptoms. On exam, his left 3rd digit pad was tense with tenderness to palpation to the distal interphalangeal joint (DIP). There was a small puncture wound at the tip with dry paint. There was no flexor tendon tenderness to palpation. There was some erythema and warmth. Strength was intact at the DIP, proximal interphalangeal, and metacarpophalangeal joints. Sensation was intact to light touch on dorsal and volar aspects of the digit. Capillary refill was normal. A hand x-ray showed a radiopaque density projecting over the palmar aspect of the middle finger at the level of the DIP joint. There was a small foci of air at the same location. No fracture was seen (Figure 2).

Hand surgery was consulted and a cruciate incision and drainage was performed in the Emergency Department. Approximately 1-2 cc of semi-hardened paint was removed. The wound was packed. He was discharged with betadine soaks and amoxicillin/clavulanic acid. He was closely followed by hand surgery and had a repeat paint debulking procedure 3 days later with continued instructions for daily soaks and wick changes. At 14 days after the injury, the incision had closed and the swelling had improved. The finger had a normal posture with nearly full, painless, active flexion and extension but some residual stiffness. Sensation at the fingertip remained intact. He was discharged with hand therapy and regained full motion with no stiffness at 2 months.

Discussion

The hand is considered the most mechanically complex orthopedic structure in the body. This complexity mirrors the functional demands of the hand. Disability resulting from hand injuries can be life changing.[1]

High-pressure injection injuries (HPI) are soft tissue traumas caused by accidental injection of substances by industrial equipment under pressure sufficient to breach the human skin. Although these types of injuries are rare and frequently underestimated, they can be devastating and are potentially life and limb-threatening.[2-6] HPI are considered surgical emergencies. The first reported cases were described by Hesse (1925) and Rees (1937) who reported the injection of diesel fuel.[7]

HPI usually involves young men and are mostly occupation-related.[2,6,8,9] The majority of injuries affect the index finger on the non-dominant hand with the palm and middle finger being the next most frequently injured areas.[6,7,10] The prevailing cause is industrial equipment. Grease guns, spray guns, and diesel engine injectors account for the majority of these injuries.[8] HPI are typically attributed to lack of training, inappropriate use, fatigue, and equipment failure.[2,9] The most frequently injected substances are paints, paint solvents, grease, and fuel oil. Additional cases have involved the injection of hydraulic fluid, plastic, wax, water, air, molten metal, dry cleaning solutions, and semifluid cement.[2,6-8,11]

In order to breach the human skin, the injection pressure must be at least 100 pounds per square inch (psi). High-pressure equipment can reach pressures of 2,000 to 12,000 psi.[2] The extreme pressures that are forced through the skin can diffuse through fascial planes, tendon sheaths, and neurovascular bundles. The resulting injury can be related to both the mechanical and chemical insult. The substance may cause edema, while the direct high-speed mechanical trauma may cause ischemia. Factors contributing to ischemia include vessel thrombosis from volatilization of the injected material, temporary vascular spasm, venous outflow obstruction, and arterial compression related to compartment effect from the injected substance.[7] The direct toxic effect as well as the systemic effects of the substance must also be considered.

When a patient seeks early treatment, the true extent of injury is often underestimated. The puncture wound may appear small and harmless.[2,12] There may be some tenderness and fusiform swelling of the tissue related to the volume of the injected substance.[8] Within hours, vascular compromise and tissue necrosis may develop at the injection site and systemic symptoms may develop as the substance is absorbed. The clinician should note neurovascular status and evidence of any developing compartment syndrome. Radiologic studies may be useful to assess the extent of the injury.

The severity of injury as well as prognosis depend on the type and amount of injected material, temperature of the substance,

time of injury, anatomic site, development of secondary infection as well as the pressure with which the material was injected.[2,4,7,8,10] The chemical composition of the substance is paramount as this determines the degree of tissue inflammatory response and subsequent development of fibrosis. High viscosity substances (i.e., grease) have less dispersion in contrast to low viscosity substances (i.e., paint, paint thinners) that disperse easily along tissue planes. In addition, organic substances dissolve in lipids and cause marked destruction of tissue.[7,8] Amputation rates resulting from HPI are reported to be between 16% and 48%.[2] The highest rate of amputations are reported in injections of organic solvents such as paint and paint thinners into digits.[10,13]

Prompt and correct diagnosis is crucial in order to involve a hand specialist in a timely manner. In cases of uncertainty, consultation with a hand specialist can also assist in an accurate diagnosis. Almost all of these injuries require surgical decompression, debridement, and irrigation.[6,11,13] Better functional outcome as well as a lower risk of amputation are reported if wide surgical debridement occurs within 6 hours of injury.[2,10,12-14] The patient should be operated under general or regional anesthesia and digital nerve blocks should be avoided.[2,7,10] Multiple procedures are often necessary and late reconstruction may be required to restore maximum function.[2,7,14] Clean water and air injuries can usually be managed with observation and serial examinations.[10]

Medical management includes tetanus prophylaxis, antibiotics and analgesics. Although sometimes used in severe injuries, the role of steroids is not well defined.[2,7,10,13] The affected region should be elevated while awaiting surgical intervention. Ice should be avoided as this can worsen vasoconstriction.

High-pressure injection injuries are surgical emergencies that demand prompt recognition and treatment to avoid mutilating and function-limiting outcomes.[6,7,12] Virtually all patients suffer some impairment of hand function and the injury has significant repercussions for future mobility. This information should be shared with the patient at the outset.[2,3] With early aggressive management and rehabilitation, successful outcomes can be obtained.[6,7,12] Given the seemingly harmless initial appearance, the extent of these injuries can be easily underestimated. Medical professionals should be aware of the potential severity of this injury so that crucial, and often time-sensitive care is not delayed.

Figures

Figure 1.

Figure 2.

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