OPEN Case Report

High-Pressure Refrigerant Gas Injection Injury to the Hand

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ABSTRACT

High-pressure injection injuries, although rare, are commonly discussed orthopaedic surgical emergencies. In many cases, high-pressure injection injuries can have detrimental effects on the patient. However, there are rare instances where surgical intervention may be more harmful than helpful. Here, we present a case report of a patient who sustained a high-pressure chemical refrigerant injection injury into the palm of his hand working on an air conditioning refrigeration unit. He was treated nonsurgically with excellent outcomes. The aim of this case report was to bring awareness to the potential nonsurgical management of high-pressure injection injuries in select circumstances.

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High-pressure injection injuries to the hand are relatively uncommon injuries, accounting for approximately one of every 600 hand injuries seen in an emergency department (ED).[1] Trauma centers see approximately one to four high-pressure injuries per year,[2] with the most common location being the nondominant index finger.[3] A recent single institution retrospective analysis by Nichols et al[4] over 10 years demonstrated an average of 2.1 cases per year,[4] thus emphasizing the rarity of these injuries. High-pressure injection injuries are surgical emergencies. There is a known correlation with high-pressure injection injuries and subsequent need for amputation, with rates as high as 30%.[5] Amputation risk was lower if wide surgical débridement was urgently completed. In scrutiny of the literature, the most common injected materials are automotive grease, diesel oil, and paint.[6] Amsdell et al demonstrated injection with small amounts of air, gas, or veterinary vaccines could be managed by observation if there was no concern for compartment syndrome.[7] There is documented increased risk of infection with paint injection injuries, but overall pressure washer injuries are most common.[8] However, there is a sparsity of information specifically relating to refrigerant injection injuries into the palm of the hand. We were only able to identify one case report discussing four separate patients with an injection of Freon into a finger while working on athletic shoes.[9] To our knowledge, a high-pressure injection injury to the hand while working on an air conditioner has not been documented. Described below is a case report of a patient who injected a refrigerant known as R410A into the palm of his hand. Informed consent was sought and granted by the patient before the development of this report.

Case Presentation

A right-hand–dominant 39-year-old man with no medical history initially presented to an outside hospital after sustaining a high-pressure injection injury to the left hand at around 3:30 pm. While working as an air conditioning unit repairman, the patient was repairing a refrigeration system when a small valve came loose, causing a high-pressure injection of gas into his left volar mid-palm. He reported immediate severe pain and dorsal hand swelling. He initially presented for evaluation at an outside hospital, where radiograph and CT imaging reports indicated gas within the left hand, forearm, and tracking proximal to the left elbow. The patient arrived at our institution as a transfer at approximately 6:00AM the following morning, approximately 15 hours after the injury. We did not have a clear reason as to why there was a delay in transfer to our institution from the tertiary center. At the time of orthopaedic evaluation, the patient denied any pain, numbness, or tingling to his left hand or upper extremity. A punctate wound with superficial eschar was observed in the volar mid-palm without any bleeding, ecchymosis, or dorsal wound. The left hand was mildly swollen in comparison with the contralateral side without any noted crepitus. He had full painless range of motion of his left fingers, wrist, and elbow with full pronation/supination; had full strength in his extensor pollicis longus, flexor pollicis longus, and interosseous muscles; and was fully sensate in median, radial, and ulnar nerve distributions. The hand was well perfused with brisk capillary refill. Repeat posteroanterior and lateral radiographs were obtained (Figure 1) which demonstrated decreased subcutaneous gas within the extremity compared with the report from outside hospital radiographs.

The injected chemical was R410A, which is a type of hydrofluorocarbon refrigerant gas commonly used in air conditioning and heating systems. The chemical was injected into our patient in a gaseous form because R410 is a gas at ambient temperatures. When in contact with skin, this gas can cause a defatting action on soft tissue. As a liquid, R410A can cause frostbite, although this was not of concern in our specific case. After identification of the product involved in the injection injury, we discussed with poison control and reviewed the safety datasheet for R410A.[10] Given the patient was asymptomatic at the time of transfer from the outlying facility, we had low concern for defatting injury to the hand. A CT scan obtained at the outlying facility had indicated gas tracking into the forearm. Given the gaseous nature of the injection injury, this was a logical finding. Repeat CT was deferred because the patient was clinically asymptomatic on arrival at our institution.

Given the patient's stable condition and benign examination after presenting to our institution nearly 15 hours after the initial injury, we elected for nonsurgical management and continued observation in the ED. An irrigation and débridement procedure was considered; however, given the gaseous state of the injected material, making a large incision would likely fail to yield any identifiable chemical requiring irrigation. Therefore, the patient was placed in our clinical decision unit, while serial hand, forearm, and arm compartment checks were done every 2 hours until the 24-hour mark from his initial injury was reached. We deferred splinting for ease of serial examinations, while the patient remained in the ED. He did receive a dose of cefazolin. His tetanus was up to date and therefore was not provided. He remained pain-free with full hand range of motion and his compartments remained soft and compressible while being distally neurovascularly intact. Given this reassuring examination, he was discharged from the ED and given strict return precautions.

Owing to distance involved, the patient deferred follow-up because he was symptom-free. We contacted the patient 6 months postinjury for a telehealth visit to assess his hand. During the telehealth visit, the patient denied any residual symptoms, including hand numbness or tingling, any evidence of scarring, or pain. He denied any effect on his day-to-day life or ability to perform work activities. He responded "no difficulty" or "not at all" to all questions on the QuickDash questionnaire. It can be ascertained that the correct decision was made to treat this patient nonsurgically, despite a high-pressure chemical injection injury to the hand.

Discussion

High-pressure injection injuries can be devastating injuries that typically warrant emergent evaluation and potential surgical intervention. Instinctively for the orthopaedic surgeon, when the term "high-pressure injection injury" is used in the emergency setting, the decision for irrigation and débridement is quickly made, and patients are subsequently brought to the operating

Figure 1

Repeat injury radiographs of the left hand. **A,** Posteroanterior view demonstrating residual gas presence in the palm of the hand both ulnarly and radially along the carpal bones, sparse gas proximally along the radius and ulna, and mild soft tissue swelling appreciated. **B,** Lateral view demonstrating a gaseous shadow along the volar distal radius and along the dorsum of the carpal bones, as well as mild soft tissue swelling.

room for what will likely be large incisions for wound irrigation and removal of chemical materials. Given the nature of the injury, this is an acceptable treatment in many cases including injection with grease, oil, or paint. Literature supports prognosis being correlated with time to débridement, material injected, extent, and location of soft tissue injury, as well as the magnitude of the pressure.[11] However, given the outcome of the present case, it may be a reasonable option to pursue treatment in the form of careful observation and follow-up rather than emergent surgical intervention.

We must, however, emphasize the importance of knowing which chemical material has been injected. This caveat is of the utmost importance regarding treatment strategy for high-pressure injection injuries. Rosenwasser et al demonstrated that magnitude of initial wounding force, chemical properties, presence of secondary infection, and timing of débridement all dictate functional outcomes of the hand.[12] It is well known that organic solvents can have detrimental effects on soft tissue. High-pressure injection of turpentine leads to nearly an 80% amputation risk, whereas grease injections confer a 20% risk.[1] Air and water on the other hand have a much better prognosis.[11] Goetting et al[9] described four cases of Freon injection injuries, each involving isolated injury to the index finger with a common presentation of edema, limitation of motion, and crepitus, with subcutaneous gas revealed on imaging. Nonsurgical management was pursued for each patient, which included splinting, tetanus immunization, and antibiotics. Like our case, rapid improvements were seen in patients with conservative treatment. Snarski et al[13] also described a nonsurgical high-pressure injury to the hand, although this report involved a high-pressure water injection injury. In this water-only injury, good results were achieved after conservative management with antibiotics, narcotics, and elevation.[13] Another report by Pipkin et al[14] demonstrated nonsurgical management with a high-pressure air injection into the index finger, with the patient resulting in no deficits at 3 years of follow-up.[14]

Our case report aims to raise awareness of the potential for nonsurgical management of high-pressure gaseous injection injuries, depending on the chemical composition of the injected material. Furthermore, this case emphasizes the importance of knowing the exact chemical composition of the injected material. Without speaking with poison control and reviewing the safety datasheet information for the chemical R410A in our refrigerant injection injury case, our decision-making strategy may have followed a very different course and may have resulted in urgent surgical management for a patient who could have otherwise been successfully managed nonsurgically. Orthopaedic surgeons and emergency medical personnel should avoid the "knee-jerk" response of escalating a high-pressure injection injury to emergent surgical intervention until they know the chemical involved. Moreover, educating those involved in the emergent care of high-pressure injection injuries to delve deeper and ask specific questions regarding the chemical injected is essential to proper decision making and may save a patient from unnecessary surgery. Although most high-pressure injection injuries do require urgent irrigation and débridement, there are certain scenarios where nonsurgical management is appropriate. It is of the utmost importance to know the exact chemical and material injected to determine a plan of care that results in the most favorable outcome for the patient.

Summary Statement

It is important to identify which chemical is involved in a high-pressure injection injury. In this case, an injection of R-410A was successfully treated nonsurgically.

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