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CASE REPORT

High-pressure injection injury of the hand: peculiar MRI features and treatment implications

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Abstract

High-pressure injection injuries of the hand are rare, but potentially devastating injuries. The amount of tissue damage is dependent on the magnitude of the pressure generated by the device and the composition of the injected material. The standard of care is emergent surgical debridement of the injected material and devitalized tissue. Although, preoperative advanced imaging is not routinely pursued, MRI may be helpful in determining the anatomic distribution of the foreign material, and associated soft tissue or osseous injury. We present a case of a 28-year-old male with complications related to a high-pressure grease injection injury to his non-dominant hand. The MRI demonstrated peculiar imaging features of retained grease deposits and played an important role in surgical planning.

Keywords High pressure · Grease · MRI · Foreign body · Hand

Introduction

Nearly a third of the 11 million emergency department room visits for traumatic wounds and lacerations involve the fingers, hands, or wrists [1]. High-pressure injection injuries make up an extremely small minority of these visits, but patients often present with devastating injuries that lead to significant morbidity and loss of function for the patient. Clinical judgment and surgeon experience remain important variables in the initial evaluation of these patients. Prompt diagnosis and emergent surgical intervention can decrease amputation rates [2]. High-pressure injection injuries occur when equipment capable of achieving pressures sufficient to breach the human skin injects its contents into the human body, most commonly into the hand. Treatment usually consists of broad-spectrum antibiotics, tetanus prophylaxis, and in most cases, surgical wide debridement [2–4]. Although management algorithms on the role of different imaging modalities in a suspected foreign body have been proposed [5], there are currently no consensus guidelines. Plain radiographs are often obtained for initial evaluation. These are helpful in cases of air or radiodense materials to assess the extent of spread and deep tissue injury. However, many of the foreign materials injected are radiographically occult and the volume and extent of soft tissue involvement is variable and often underestimated. Cross-sectional imaging is not routinely obtained [6]. However, preoperative MRI or CT can serve as a useful adjunct to assess the extent of soft tissue involvement, presence and distribution of foreign bodies, and coexisting ligamentous, tendon, vascular, or bony injuries. Additionally, ultrasound is useful particularly in the detection of non-radiopaque foreign bodies and can provide guidance for removal of foreign objects if they are not readily found at surgery [7].

We present a case of retained foreign material in the hand following a high-pressure machine grease injection injury with peculiar imaging features.

Case report

The patient is a 28-year-old, right-hand-dominant gentleman who works as a heavy machine operator. He presented to an outside facility with an injection injury to his left hand. He stated that he was working with machine grease, when a grease hose became disconnected and injected into his hand.

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He stated the machine grease was not heated or warm, he was unsure of the PSI, and felt that it was only grease material that was injected and no additional foreign bodies. He denied any prior injuries or surgeries to that hand, coexisting medical comorbidities, and reported a ten pack-year smoking history. He initially presented to a local community emergency department, prior to being transferred to our center. On presentation to our facility, the patient endorsed decreased sensation to the little and ring fingers, thought in part secondary to a topical lidocaine mixture placed on the wound at the outside facility. Physical exam demonstrated an entrance and exit wound on the mid volar palm in line with the long finger and dorsum of the ring finger (Fig. 1). He had tenderness to palpation of all his digits. His vascular status and range of motion were intact. No pre-operative imaging was obtained. The patient proceeded to the operating room for irrigation and debridement. A large amount of grease was noted about the ring finger dorsally and volarly, including around a significant portion of the ring finger flexor digitorum superficialis and profundus tendons, deep interossei, and lumbrical muscles. This was irrigated and debrided with 6 l of normal saline. Guyon's canal and carpal tunnel releases were performed, given the patient's sensory symptoms. Postoperatively, the patient was placed in a splint for 3 weeks, underwent hand therapy, and was followed intermittently with no significant complaints.

Eleven weeks following the irrigation and debridement, the patient presented acutely to the hand clinic with atraumatic pain and inability to flex the small and ring fingers of the left hand. Physical exam noted a swollen left hand and he was found to be significantly tender to palpation over the distal palmar crease on the ulnar hand and about the incision. Any attempt at flexion of the small or ring finger resulted in severe pain in the left hand. His sensation and vascular status remained intact. MRI of the left hand was obtained to rule out infection given the new onset of hand swelling. The examination demonstrated two ovoid areas of fat-signaling foreign material within the palmar aspect of the hand, compatible with retained machine grease. The larger deposit was located in the deep palmar space between the ring and small finger flexor tendon units (Fig. 2), while the smaller deposit was located in the palmar soft tissues overlying the flexor tendon unit of the index finger (Fig. 3). Soft tissue inflammatory changes were present about both of these deposits and more diffusely about the 3rd–5th flexor tendons, with an abscess associated with the larger deposit. The patient returned to the operating room and the two retained grease deposits with associated abscess were irrigated and debrided. Microbiological cultures were sent and returned negative for any organisms. The wounds were left to heal by secondary intention and the patient returned to work 6 weeks following the repeat irrigation and debridement. He continued range of motion and scar massage therapies and denied any functional or neurovascular deficits at his 2-month follow-up appointment.

Discussion

High-pressure injection injuries make up an extremely small minority of emergency department visits for traumatic wounds and lacerations involving the hand and wrist, however, these patients often present with devastating injuries that lead to poor outcomes. High-pressure guns can produce pressures exceeding 2500 bar (35,500 psi), with most grease guns producing pressures of 350–700 bar. Spray guns used to apply paints, hydraulic fluids, and solvents operate in the range of 200–500 bar, with diesel fuel injectors operating in the 200–500 bar range, and water guns in the 400–550 bar range [8].

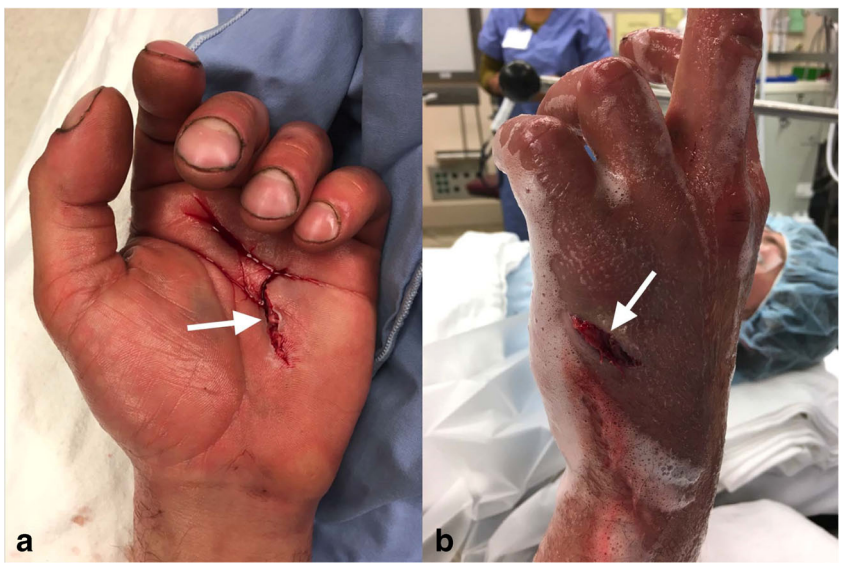

Fig. 1 A 28-year-old male with a high-pressure grease injection injury in his left hand. Clinical photographs at the time of initial presentation prior to the initial surgical debridement show large palmar entrance (**a**) and dorsal exit (**b**) wounds (*white arrows*)

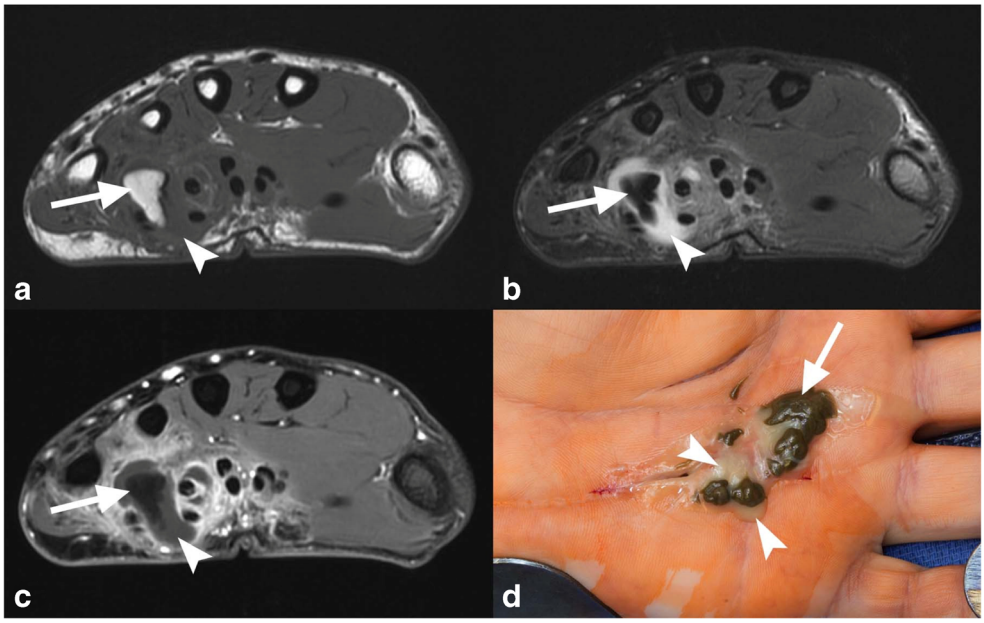

Fig. 2 MRI obtained 11 weeks after initial surgical debridement to rule out infection. Axial T1-weighted (**a**) fat-suppressed T2-weighted (**b**) and fat-suppressed T1-weighted + contrast (**c**) images demonstrate retained machine grease interposed between the flexor tendon units of the ring and small fingers (*white arrow*). The material has the signal intensity of subcutaneous fat on all sequences. A loculated abscess surrounds the foreign body (*white arrowhead*). Intraoperative photo (**d**) demonstrates the debrided machine grease (*white arrow*) and surrounding purulent material (*white arrowheads*)

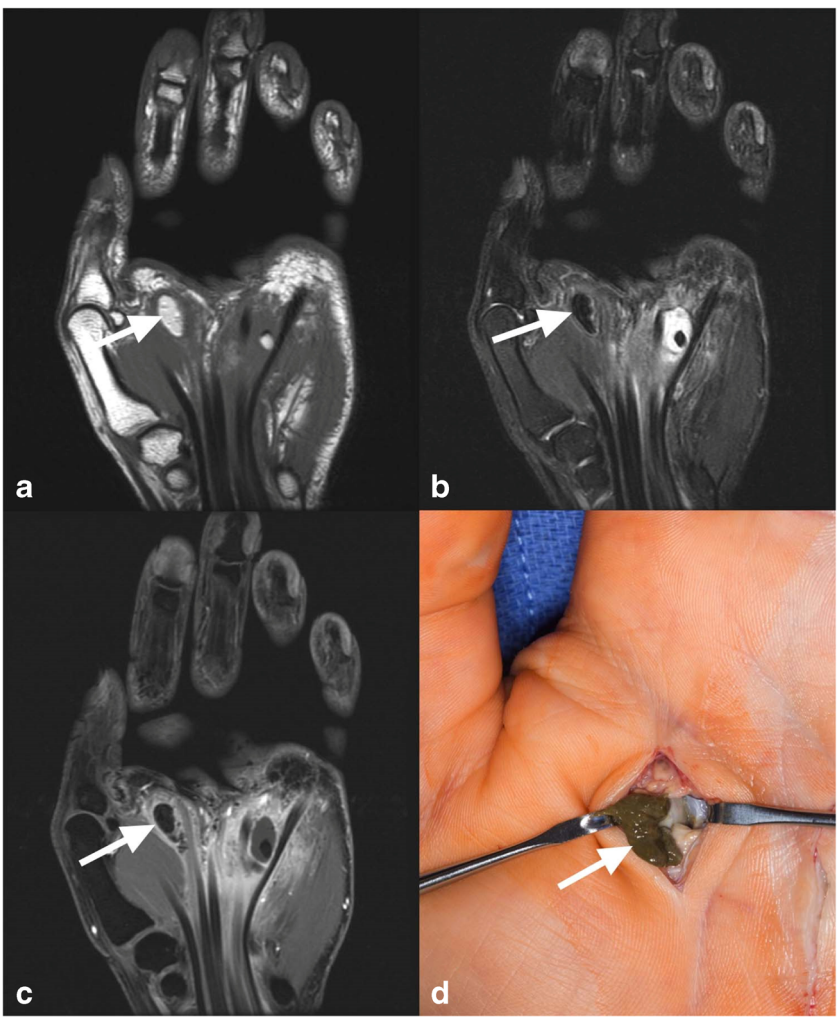

Fig. 3 MRI obtained 11 weeks after initial surgical debridement to rule out infection. Coronal T1-weighted (**a**) fat-suppressed T2-weighted (**b**) and fat-suppressed T1-weighted + contrast (**c**) images demonstrate an additional smaller collection of retained machine grease overlying the flexor tendon unit of the index finger (*white arrow*). The material again has the signal intensity of subcutaneous fat on all sequences. Intraoperative photo (**d**) demonstrates the debrided machine grease (*white arrow*) with a smaller amount of surrounding inflammatory change

High-pressure injection injuries result from both mechanical and chemical effects of the injected material. The injected material transfers significant kinetic energies to the involved tissues, while simultaneously resulting in mechanical compression of vessels and nerves leading to further tissue damage. Chemical noxious effects from the injected material frequently results in vasospasm, small vessel occlusion, and a secondary inflammatory effect. The type of material injected is an important variable, with organic solvents (paint, paint thinner, gasoline, jet fuel, and oil) resulting in worse outcomes, compared with water and air injuries. Hydraulic fluid and grease tend to elicit less of an inflammatory response compared with the other organic solvents [2]. Hogan et al. [2] looked at 435 patients with injection injuries distal to the elbow and found that the overwhelming majority of these patients were male (99%) with a mean age of 34.7 years. The non-dominant index or middle finger was most commonly injured (78%), with an overall amputation rate of 30%.

In patients presenting with high-pressure injection injuries, an accurate history is important. The pressure of the injection gun, exact material injected, distance from the gun to the extremity, and an estimate of volume injected are all important details with prognostic implications. Neurovascular status, tendon involvement, and the presence of crepitus are important to evaluate on initial physical examination. Physical exam can also detect the presence or absence of entrance and exit wounds. The entrance wound is often a small puncture wound, with the injected material often able to be expressed. However, the small size of the entry site might lead to inexperienced practitioners underestimating the true extent of the injury, resulting in delayed or inappropriate treatment.

While plain radiographs are often obtained for initial evaluation, cross-sectional imaging (CT or MRI) and ultrasound are typically reserved for rare instances if other studies have failed to detect a suspected foreign object or to evaluate complications of retained foreign bodies. Missed foreign bodies may remain asymptomatic for prolonged periods of time or lead to a wide range of complications including pain, abscess, chronic discharging wound, bone and joint destructive lesions, granulomas, impairment of tendon mobility, migration, delayed tendon ruptures, neurologic deficits, and vascular events [7]. Additionally, the failure to treat or diagnose retained foreign bodies in the hand is among the top ten claims for most malpractice carriers, resulting in the fifth highest amount of indemnity awards to patients [8].

In our case, a postoperative MRI was obtained to evaluate for complications and, in particular, to rule out infection given his new hand swelling. The MRI confirmed the clinical suspicion for abscess formation associated with retained grease deposits. Of note, the grease material demonstrated high signal intensity on the T1-weighted sequences, uniformly suppressed on the fat-saturation T2-weighted and post-contrast sequences matching the imaging appearance of subcutaneous fat. Typically, the T1-weighted hyperintense lesion differential includes fat, blood products such as extracellular methemoglobin, proteinaceous fluid, mineralization (i.e., manganese, copper), slow venous flow, and gadolinium contrast [9]. Machine or lubricating grease is typically composed of three components: oil, thickener, and additives. Collectively, the chemical composition of grease results in a very peculiar MRI appearance, with discrete fat-signaling lobules. We propose that in cases of high-pressure grease injection injuries, pre-operative MRI may be beneficial to evaluate the amount and extent of the retained foreign material to help guide surgical debridement and prevent complications. While targeted ultrasound may be helpful [10], MRI can give a more comprehensive picture of the anatomic involvement and to characterize any associated osseous injuries.

In conclusion, high-pressure injection injuries of the hand are rare, but potentially devastating injuries that lead to significant morbidity and loss of function for the patient [11]. The standard of care is emergent surgical debridement of the injected material and devitalized tissue. Although preoperative advanced imaging is not routinely pursued, MRI may be helpful in determining the anatomic distribution of the foreign material, and associated soft tissue or osseous injury.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval All procedures in studies involving human participants were in accordance with ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was waived.

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