High-pressure injection injury of foreign material into the finger: a case report on perioperative management

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Key points

This case report presents the diagnosis, the anesthesiological and the surgical treatment of a high-pressure injection injury of foreign material into the finger, a rare condition but often characterized by an underestimation of damage at the initial presentation, resulting in treatment delay and a high risk of permanent injuries.

Abstract

High-pressure injection injuries of the fingers are a rare clinical entity but represent true surgical emergencies. They are characterized by a discrepancy between a small entry point and extensive damage to the subcutaneous tissue, leading to a frequent underestimation of the injury at initial presentation and a delay in treatment. This type of injury requires rapid intervention with surgical debridement of all injected material and ischemic and necrotic tissue, without which it leads to permanent functional deficit, extensive local destruction, and a high risk of amputation. In this case report, a farmer presented to our emergency room reporting a trauma occurred a week earlier from the burst of a grease tube on the second finger of his right hand. The extent of the injury had been initially underestimated and improperly treated.After a thorough clinical, radiographic, ultrasonographic, and anesthesiological evaluation, urgent surgical debridement was performed under plexus anesthesia. Despite the high morbidity of this injury described in the literature and the risk of a poor outcome in case of late treatment, one month after surgery, the patient showed good recovery of grip and sensory function, reporting only nocturnal neuropathic pains.

Keyword

High-pressure injection injuries, high-pressure injuries, finger surgery, mid-arm nerve blocks

Introduction

High-pressure injection injuries of the hand are rare but must be considered surgical emergencies and promptly treated with surgical debridement of all injected material and ischemic tissue (1). On average, they represent 1:600 of hand traumas and affect 1 to 4 patients presenting annually at hand surgery centers(2)(3). The patient affected by this type of injury is commonly a young male worker who suffers a trauma during cleaning, lubrication, or painting activities(4).These injuries are caused by high-pressure guns used to inject paint, grease, plastic materials, oil, fuels, solvents, air, and water(4)(1)(5). These guns emit jets at pressures exceeding hundreds of atmospheres, and the injected material is forced through minimally distensible structures, dissecting the tissues along planes of least resistance and spreading along the fascia, tendon sheaths, and neurovascular bundles with potentially destructive consequences(2)(4)(6).The deleterious effect of the injected materials can be due to the direct toxic effect, the high-speed mechanical impact, ischemia, secondary infections, and compartment syndrome(2)(4)(7)(8).These injuries can often be unidentified due to their initially benign appearance. In fact, the clinical symptoms often are limited to small punctiform skin lesions and symptomatic hand or finger(9)(10). The amputation rate for these injuries is higher than 30-48% in the absence of adequate treatment(11).

Case report

On October 30, 2023, a 46-year-old right handed farmer presented at our emergency department. He reported suffering an injury to his right hand about a week earlier due to a grease tube bursting in his hand while he was working on the maintenance of a farming tool. Seven days before, the patient had already been evaluated at another hospital and had been discharged with a diagnosis of contusive trauma to the second finger. He was subsequently reassessed by his general practitioner, who prescribed NSAIDs and antibiotic therapy.

X-rays of the right hand ruled out fractures. Ultrasound examination (Figure 1) revealed a moderate edematous thickening of the subcutaneous soft tissues that extended deep to the plane of the flexors. The flexor apparatus appeared compressed but intact.

On physical examination, diffuse circumferential edema was evident throughout the right hand's second finger with partial extension to the palm, the second finger positioned in flexion with reduced nail bed refill and tenderness on passive extension. Additionally, a small punctiform lesion was noted on the volar aspect of the F1 as a possible outcome of a small entry point. The patient reported recently exacerbated throbbing pain with a Visual Analogue Scale (VAS) score of 10, hyperalgesia, and allodynia.

Among the diagnostic hypotheses considered were phlegmon of the flexor sheaths of the second finger, compartment syndrome of the finger, and high-pressure injection injury, conditions for which urgent surgical intervention would be necessary.

The patient was informed about his clinical condition and the necessity of surgical intervention, along with a high probability of complications and amputation given the delay in treatment. Similarly, he was evaluated and informed about the chosen anesthesiological approach after a thorough specialist visit.

Following monitoring of vital parameters (NIBP, pulse oximetry, ECG, body temperature using a spot-on sensor) and sedation with Midazolam IV 0.03 mg/kg, targeted regional anesthesia was performed. Due to unfavorable anatomical conformations of the cervical region and a history of untreated recurrent spontaneous right pneumothorax without pleurodesis, a combination of mid-humeral blocks guided by ultrasound and ENS (radial, median, and ulnar nerve blocks) (Figure 2 and 3) was chosen, using Mepivacaine 4 mg/kg, 15 ml in total distributed at various points of interest.

Once proper regional anesthesia was ensured, an Esmarch bandage was applied distally to the carpus, and a palmar incision according to Brunner was made along the entire second finger up to the mid-distal palm, with immediate outpouring of abundant foreign material.

The application of saline irrigations and the use of orthopaedic curettes allowed the removal of foreign material and ischemic tissue while sparing nerve and vascular structures (Figure 4). A second dorsal incision from the IPP to the MCP allowed treatment of the dorsal site and the extensor of the second finger. The dermis appeared degenerated and of a lardaceous consistency, tending to detach from the very weak and flaking skin layer with minimal pressure. Cultures were taken for subsequent examination. A glove drainage was placed before the primary closure of the surgical wound with wide stitches; the hand was finally positioned in a palmar splint in an intrinsic plus position.

The day after the operation, the glove drainage was removed, and the patient was discharged with empirical oral antibiotic therapy at home. The pain was significantly reduced and controlled with NSAIDs.At a follow-up after 5 days, the wound was in good primary healing condition without infection. The dorsal splint was then removed, preserving active and passive movements of the finger. The intraoperative cultures were negative. About 1 month later, the patient returned for clinical follow-up, presenting a flare-up of symptoms. A new debridement was performed, and material was taken for culture, with a negative result.

In subsequent follow-ups, removal of superficial necrotic demarcation areas was performed, with evidence of good underlying re-epithelialization (Figure 5). Functional motor and sensory recovery, supported by targeted physio-kinesitherapy, was complete. However, neuropathic pain persisted.

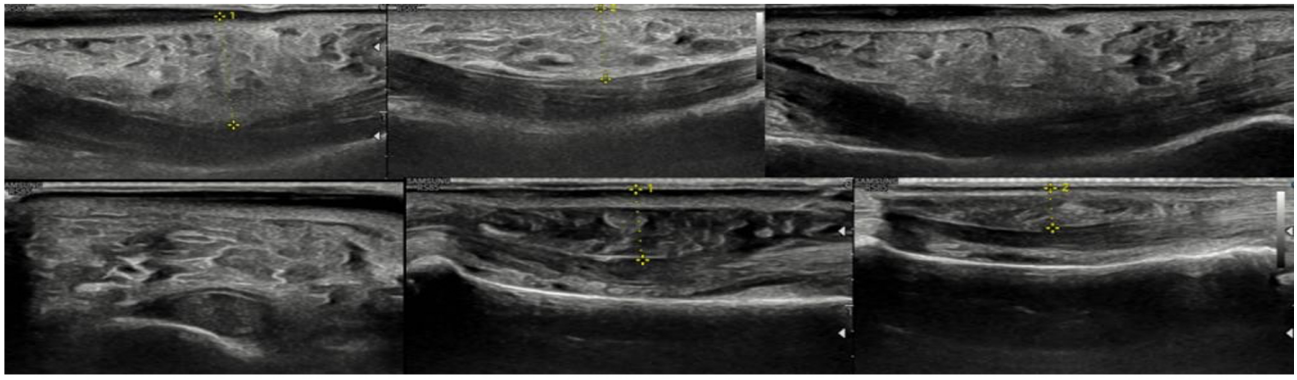

Figure 1: Edematous thickening of the subcutaneous soft tissues on ultrasound examination.

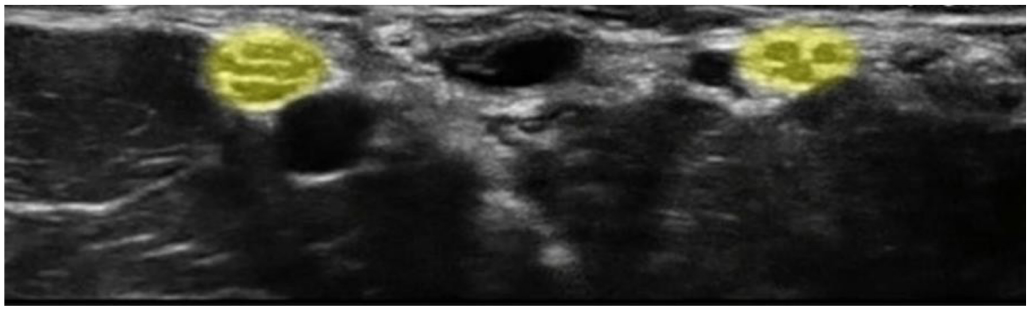

Figure 2: Ultrasound-guided block of the median nerve (highlighted in yellow at the top left) and the ulnar nerve (highlighted in yellow at the top right), 5 ml per site.

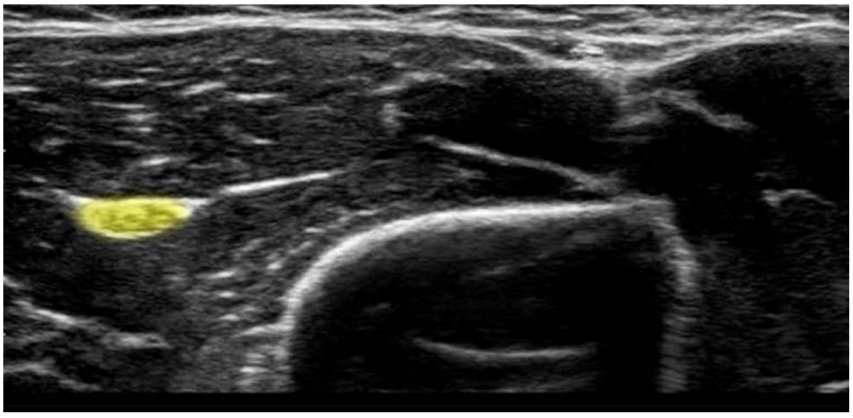

Figure 3: Ultrasound-guided block of the radial nerve (highlighted in yellow at the top left), 5 ml.

Figure 4: Surgical phases.

Figure 5: Post-operative healing

Discussion

High-pressure injection injuries are rare, with an incidence of 1 in 600 hand injuries(1). More than 50% affect the second finger(2). Despite their rarity, their morbidity is extremely high, with amputation rates reaching more than 30-48%(11). Pinto et al. highlighted that the amputation rate is high only in cases of delayed diagnosis (3 or more days after the high- pressure injection)(12) .

The mechanisms responsible for irreversible tissue damage vary. A pressure of 7 bar is enough to penetrate the skin. The injection pressure causes tissue dissection along planes of least resistance, following the course of neurovascular bundles(4). This results in mechanical compression of vessels and nerves, causing further tissue damage(7). Secondly, the chemical damage caused by the injected material leads to vasospasm, occlusion of small vessels, and inflammatory effects that exacerbate the injury. All this results in increased pressure with vascular compromise, thrombosis, and ischemia. Some fluids have cytolytic properties and cause tissue destruction, necrosis, and an intense inflammatory response(2)(4)(7).

The injury can be further complicated by infection, which can be primary and introduced directly during the injection or secondary, facilitated, and exacerbated by ischemia and necrosis(8). Diagnosis is based on clinical presentation and instrumental examinations. The initial clinical presentation is misleading and does not reflect the severity of the injury(13). Often, there is only a punctiform skin lesion, minimal pain, and a minimal functional alteration that can lead to underestimation of the damage(9).

Symptoms such as pain, swelling, functional deficits, and neurovascular impairments appear after a few hours(2)(14).

Instrumental diagnosis is based on radiographic and ultrasonographic examinations. Preoperative X-ray shows the quantity and distribution of radiopaque fluids, while the distribution of radiotransparent materials can be highlighted by subcutaneous emphysema(2).

Ultrasound is effective in the early diagnosis of finger injection injuries, helping to define the neurovascular status, the volume of injected material, and its distribution timely, thus influencing the treatment. Ultrasound can demonstrate the infiltration of substances within the subcutaneous fat, increasing echogenicity and tissue thickness. Dynamic ultrasound is useful in diagnosing complications such as adhesions between tendons and adjacent infiltrated soft tissues(15).

A detailed history regarding the type of injected material, the pressure of the used gun, and the volume of the liquid should be collected. Water injection usually causes minor damage and often has good outcomes even without surgical treatment(11)(16). In contrast, paints and solvents are more irritating substances with a broad cytolytic effect(6)(17) .

Patients should receive broad-spectrum antibiotics and tetanus prophylaxis. The specific type of antibiotic to be used is not described in the literature, but third-generation cephalosporins are the most common choice(14). Regarding treatment, Wong et al. classified high-pressure injection injuries as mild, moderate, and severe. This classification is based on the type of injected material, the time elapsed from trauma to treatment, the degree of soft tissue involvement, and the neurovascular status(18).

Non-surgical treatment is reserved for injection injuries caused by water, air, or animal vaccines that require surgical treatment only in case of compartment syndrome(4). Hogan et al. showed that debridement

within the first 6 hours of organic solvent injection resulted in a low amputation rate, unlike cases where surgical intervention was delayed by more than 6 hours. In case of injection of toxic substances such as paint, diesel, thinner, or gasoline, the timing of debridement had a significant impact on the survival of the affected body part, and in cases where the intervention was performed with a delay of more than a week, the risk of amputation was 88%(11).

The surgical treatment of a distal pressure injury involves extensive exposure through a Bruner type access and complete debridement of all involved and devitalized tissues and all injected material. Decompression of tissue compartments, exploration of tendon sheaths, and abundant irrigation with saline solution are performed(12)(4). Neurovascular structures must be isolated and preserved(19). Pinto et al. performed, where necessary, further debridement within the next 24 and 72 hours(12).

During the surgical procedure, the use of a tourniquet should be avoided due to the risk of further necrosis in the injured tissues(20). The Esmarch band should be applied only distally to the carpus, avoiding applying pressure to the fingers and hand to prevent the spread of injected material along the tendon sheaths and neurovascular bundles(2).

Proper anesthesiological management, preferably based on regional techniques when possible, should avoid performing local anesthesia, such as a Bier block, and a trunk block due to the increased risk of exacerbating existing damage due to further pressure increase within the injured zone(4)(21) and the possible need to extend the debridement to adjacent areas .

Early mobilization and targeted physio-kinesiotherapy are essential elements to restore as much functionality as possible to the affected segment(2)(4).

The outcome of high-pressure injection injuries to the fingers is often disappointing. Feldman et al. described a reduction of the ROM of the affected finger in 50% of patients, with sensory alteration in 7 out of 8 patients and neuropathic pain in all patients(22). Bekler et al. noted that at the final follow-up, 4 out of 14 patients were unable to actively flex the affected finger, showing restrictions in active and passive movement of the interphalangeal joints and a 44% reduction in grip strength compared to the contralateral finger(18).

Christodoulou et al. reported a reduction in grip strength in 19% of patients, and 4 patients had to change their occupation, with a reduction in both static and dynamic parameters(17).

Conclusion

High-pressure injection injuries of the fingers are rare injuries but can have devastating consequences in terms of morbidity and loss of function, representing a surgical emergency.

Diagnosis may be delayed due to the initial clinical presentation, leading to an underestimation of the injury, resulting in a delay in surgical treatment. In case of delayed treatment, the risk of amputation increases exponentially, and the remaining functionality of the affected anatomical district decreases.

The severity of the injury is determined by the level of entry of the injected material, the injection pressure, the volume of the substance, and its chemo-physical characteristics.

Surgical treatment, performed using general or preferably plexus anesthesia when possible, consists of surgical exploration with complete and meticulous debridement of all necrotic tissue and injected material, followed by close follow-up and an intensive rehabilitation program aimed at the best possible functional recovery.

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