Article

Advanced Diagnosis and Treatment Methods of High-Pressure Injection Injury: A Single-Center Retrospective Case Series Study

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AIM: This article emphasizes the essential role of radiological imaging in high-pressure injection injury (HPII) management and assesses the results of Magnetic Resonance Imaging (MRI) examinations in providing better details about foreign material extension and assisting surgeons in visualizing operational movement during surgery. Additionally, it shares the authors' experience in managing 16 HPII patients and investigates the application of bone cement in the treatment of injection injuries.
METHODS: Data collection of HPII patients was performed between January 2020 and June 2022 in our department, with 16 HPII patients hospitalized with mild to severe high injection injuries. We presented four cases in detail and briefly summarized all 16 cases. The previously reported HPII cases were also investigated to provide a better conclusion and comparison.
RESULTS: MRI examinations can provide vital details about the extent of foreign material extension, helping surgeons achieve better outcomes. Four detailed cases and a summary of 16 cases are presented. The study also found that polyurethane materials were commonly injected with a low amputation rate, and bone cement application was beneficial in reducing inflammation and infection.
CONCLUSIONS: The study highlights the importance of MRI in diagnosing HPII and the potential benefits of using bone cement to control infections and decrease the number of surgeries. The comprehensive approach described ensures better outcomes and reduces the rate of severe consequences like amputation.

Keywords: high-pressure injection injury; polyurethane material; paint injection injury; bone cement

Introduction

High-pressure guns (HPGs) are widely used across various industries, featuring different designs, shapes, and injection pressures, including pressure washers, paint sprayers, and grease guns. Despite their ease of use and perceived safety, accidental injuries can occur when HPG materials are mistakenly injected into the hand, which is called high-pressure injection injury (HPII) [1]. The pressure plays a crucial role in delivering and distributing materials deeply within the tissue. The number of HPII cases is increasing, surprisingly not just due to the rapid industrial revolution, but also due to ignorance in the use of HPGs and study has shown that pressures as low as 100 psi can penetrate the skin [2], and at higher pressures, a severe injury known as high-pressure injection injury can occur. The index, middle fingers, and palm are continuously reported as the most common injury sites, and manual man laborers make up most of the patients [3]. Initially, the high pressure leads to a small size wound externally and massive damage internally by comprising digits or palm tissues, tendons, nerves, and vessels (neurovascular bundles), and could cause an inflammatory reaction, which will further increase the internal pressure and leads to compartment syndrome and amputation. Different materials are used in these guns, such as paint, automotive grease, solvents, diesel oil, air, and water. The risks associated with these materials vary, ranging from simple secondary infections to more complex issues like ischemia with necrosis, which can ultimately lead to amputation [3,4]. Paints and paint thinners are more hazardous than grease and oil-based compounds because they penetrate tissues rapidly, leading to severe inflammatory

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responses and extensive tissue damage, often resulting in higher amputation rates. Air and water injection injuries have excellent healing rates, where in most cases, close observation and therapeutic intervention are enough to manage the damage [5,6]. Relying on the doctor's experience to identify the HPII in the emergency room (ER), early recognition of the injury and the type of substance within a maximum of six hours can significantly reduce the damage at the injury site [5]. The percentage of compromised function and amputation in the affected areas increases with delayed diagnosis [7]. The primary assessment of HPII is made by plain radiographs, but that depends on the type of materials. Some materials are visible and present a proper evaluation of the damage. Although X-ray has been widely used to evaluate HPII because of its high spatial resolution, it could not detect the materials invasion and the damaged tissue that other radiological images show [8,9]. The post-processing image of computed tomography (CT) enables us to distinguish between foreign materials and surrounding tissue and also improves the density resolution of these materials. The superiority of Magnetic Resonance Imaging (MRI) in soft tissue resolution makes it the key role for assessing foreign materials extension and appropriate for evaluating the damage that HPII causes to the blood vessels, ligaments, tendons, and other structures [10]. A previous study by Collins *et al*. [10] found that post-operative MRI can be used to investigate abscess formation related to retained grease deposits. High-pressure injection injuries all require anti-infective treatment with broad-spectrum antibiotics and tetanus toxoid. Surgical procedures included decompression, extensive debridement, and removal of injection material [2].

This article aims to identify and analyze better radiological images for HPII diagnosis, surgical planning, and management. In addition, we are sharing our experience in managing 16 HPII patients.

Materials and Methods

Most previous articles have yet to investigate the best radiological imaging techniques that provide more details about HPIIs and guide surgeons and emergency physicians. In addition, no cases that present the advantages of applying bone cement to injection injury. Therefore, data collection of HPII patients was performed between January 2020 and June 2022 in our department; the results showed that 16 HPII patients were hospitalized with mild to severe high injection injuries. We have presented four cases in detail, and briefly summarized all 16 cases (Table 1). Furthermore, we have investigated the previously reported HPII cases to provide a better conclusion and comparison. Written informed consent was obtained from the patients to publish clinical details and clinical images.

HPII Diagnostic Method

High-pressure injection injuries (HPII) require prompt and accurate diagnostic methods to ensure effective treatment. The diagnostic process begins with a clinical examination, which involves assessing the patient's history and the physical signs of injury, often revealing a small puncture wound that may not reflect the extent of internal damage. A small puncture wound may cause an inexperienced physician to underestimate the true extent of injury, leading to delayed or inappropriate treatment [10].

Plain radiographs serve as an initial diagnostic tool, capable of detecting radiopaque materials and providing a basic evaluation of the injury, but they are limited in their ability to detail soft tissue injuries and the spread of foreign substances. CT scans are more advanced, offering the differentiation of foreign materials from surrounding tissues, improved density resolution, and the benefit of three-dimensional reconstruction [11]. This technology is particularly useful for diagnosing HPII, as it aids in surgical planning by identifying the remaining injected materials and offering a detailed view of the soft tissues, bones, and surrounding structures. MRI is paramount in HPII management due to its superior soft tissue resolution. MRI not only provides critical details on the extent of foreign material spread but also assists in visualizing the surgical field, making it ideal for assessing damage to blood vessels, ligaments, tendons, and other structures [10]. Additionally, MRI can detect impurity components within injected materials and the presence of purulent fluid, which is vital for gauging the severity and progression of the injury.

HPII Treatment Method

The management of HPII is a complex and critical process that involves a combination of urgent surgical intervention and meticulous postoperative care. Early recognition and prompt surgical debridement are essential, aiming to remove foreign substances and necrotic tissues to prevent further tissue damage and infection [12]. Due to the potential for ongoing inflammation and infection, multiple debridement surgeries may be necessary, performed every 3–5 days, to minimize complications and preserve the affected part. Special attention must be paid to preserving neurovascular structures during these procedures, as severe damage to these can lead to amputation.

Results

We have presented four cases in detail, and briefly summarized all 16 cases (Table 1).

These patients, predominantly manual laborers, experienced injuries primarily to the hand, particularly the index and middle fingers, and the palm, with a variety of injected materials including paint, lubricating grease, solvents, diesel oil, air, and water. The severity of the injuries varied significantly, necessitating different treatment approaches and highlighting the complexity of HPII management.

Table 1. A brief summary of HPII cases and radiological imaging evaluation in our department.

Sex	Age	Hand part	Type of materials	Radiological finding
Male	46	Palm of the right hand	Polyurethane material	MRI: positive
Male	49	Right dorsum of hand and the index finger	Polyurethane material	MRI: positive
Male	53	Left Index finger	Lubricating oil	CT: positive
Male	49	Right middle finger	Grouting fluid	CT: negative
Male	36	Right Palm and dorsum of the hand	Polyurethane material	X-ray: positive
Male	39	Right index finger	N/A	N/A
Male	40	Ulnar side of the left palm	Polyurethane material	MRI: positive
Male	49	Right index finger	Polyurethane material	X-ray: positive
Male	43	The palm of the right hand	Polyurethane material	X-ray: positive
Male	33	The palm of the right hand	Polyurethane material	MRI: positive
Male	69	The palm of the left hand	Polyurethane material	N/A
Male	57	Left thenar crease	Polyurethane material	MRI: positive
Male	33	The back of the right hand	Polyurethane material	MRI: positive
Male	52	The palm of the right hand	Polyurethane material	MRI: positive
Male	45	The palm of the right hand	Polyurethane material	MRI: positive
Male	49	The palm of the right hand	Polyurethane material	MRI: positive

HPII, high-pressure injection injury; MRI, Magnetic Resonance Imaging; CT, computed tomography; N/A, polyurethane material.

Cases

Case 1

A 33-year-old right-handed male presented to our emergency department (ED) after experiencing polyurethane material perfusion injury to the back of his right hand for four days due to a high-pressure gun explosion. Immediately after the injury, the patient went to a local hospital and received symptomatic treatment (details are unknown). However, it was ineffective, so he visited our hospital. Physical examination found a small wound and circumferential edema of the right hand accompanied by limited movement, numbness, and pain. MRI showed extensive soft tissue edema and hyperintensity TW2 signals (Fig. 1A,B). No bone fracture was detected, and the joint was in position with a normal articular surface. The patient was hospitalized and underwent two surgeries to remove the foreign substance and necrotic tissues (Fig. 1C,D). After post-surgical observation, the patient was discharged with a stable condition. During the one-month follow-up, he had no considerable difficulties with hand function, including motor and sensory functions.

Case 2

Two months ago, a 52-year-old male underwent foreign body debridement surgery at a local hospital due to a work accident where polyurethane was injected into his right palm at high pressure. After the operation, the patient's right palm wound repeatedly exuded with limited hand movement caused by tendon contracture and ulnar deviation (Fig. 2C). Therefore, the patient came to our hospital for further diagnosis and treatment. MRI of the right hand was performed, and the results showed swollen ulnar soft tissue with multiple abnormal signal shadows in the form of patches and strips. There was hyperintensity of T2-weighted imaging (T2WI) signals, but no bone fracture was detected (Fig. 2A,B). He was admitted to the hospital for further investigation and surgical intervention. The patient underwent two surgeries, where several sinus tracts with purulent exudation were found in the right palm and fingers. Necrotic tissue and glue were removed, and ulnar nerve compression was relieved (Fig. 2C,D). Finally, the wound closed up, and the patient was discharged. Outpatient follow-up showed an improvement in right-hand movement with no pain.

Case 3

A 49-year-old male was admitted to the emergency department after accidentally injecting polyurethane material into his right palm due to a pipeline explosion. A small skin lesion with a small amount of bleeding was observed. At the time of admission, the patient felt the dorsal part of the right hand expand consciously, and the right index finger gradually swelled with bearable pain, accompanied by numbness of the right limbs. MRI showed abnormal signals on the dorsal side of the second metacarpophalangeal joint of the right hand, with a low signal on T1-weighted imaging (T1WI) and a high signal on T2-weighted imaging (T2WI) (Fig. 3A,B). Chronic ulcer repair, debridement, irrigation, peripheral nerve entrapment and lysis surgeries were performed. During the operation, many yellow irregular foreign bodies (polyurethane) were found in the wound and removed along with the necrotic tissue (Fig. 3C,D). The flexor tendon, vascular and nerve bundles of the index finger were injured, with severe damage to nerve bundles on the ulnar side. Symptomatic treatment was prescribed to the patient, such as detumescence, pain relief, antibiotics, and nerve nutrition. The patient underwent several surgeries to ensure the complete removal of the small-sized

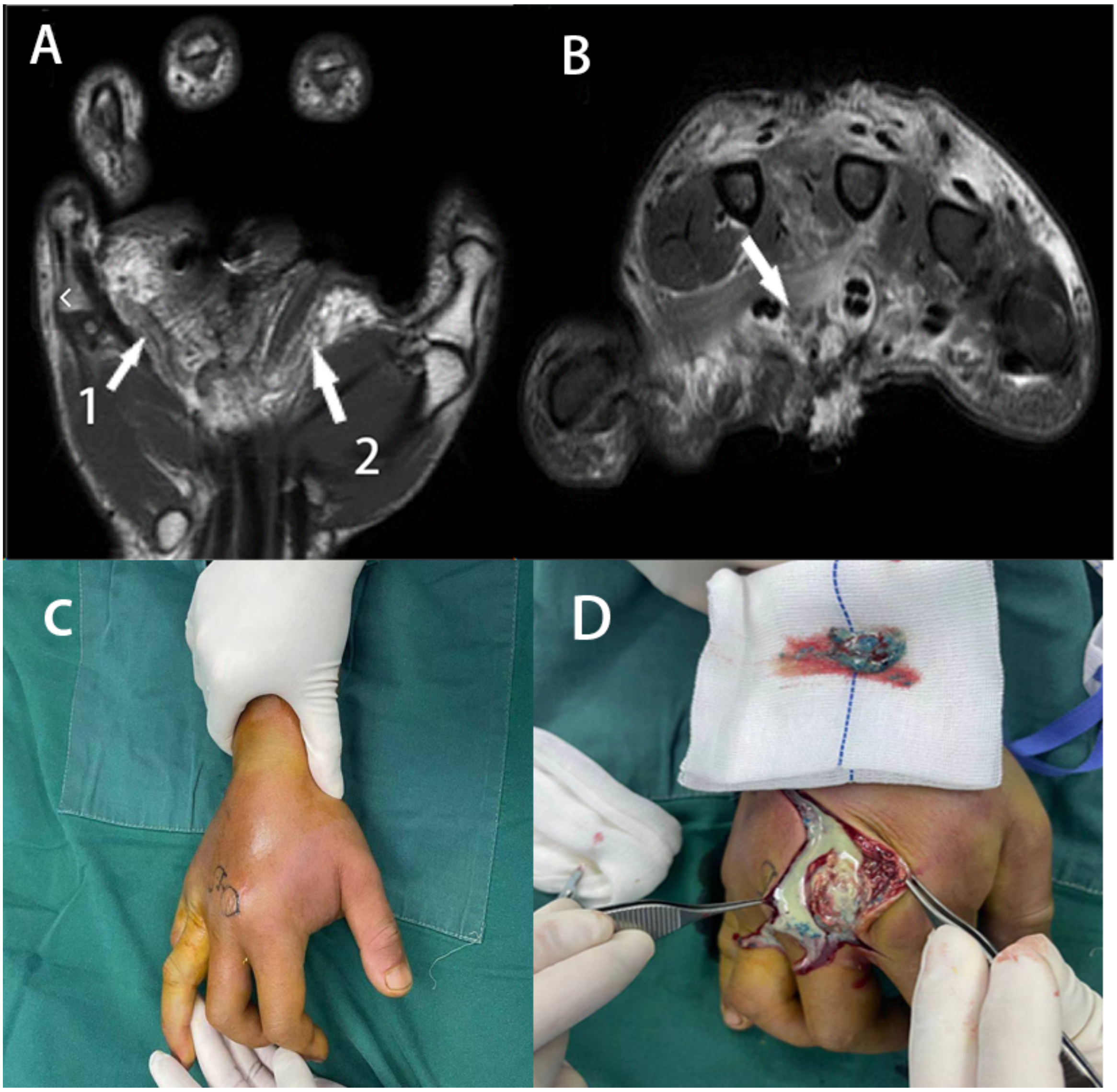

Fig. 1. Preoperative MRI images and intraoperative pictures. (A) Arrow 1 presented the extension of the foreign materials within the right hand. Arrow 2 shows edema high signal. (B) Arrow showed slightly low signal, which was considered as a foreign body. (C) External appearance of HPII wound. (D) Polyurethane material in the back of the right hand.

polyurethane. During the operations, the adhered tendons were released (tenolysis), and the injured nerves were repaired (Fig. 3D,E). A local pedicled flap was designed to repair the defect and close the dorsal metacarpal wound (Fig. 3F). Bone cement was placed at the finger web of the right index. The digit amputation was avoided in this patient.

Case 4

A 46-year-old male presented to our hospital with swelling and pain in his right hand, caused by inadvertently injecting polyurethane material into his right palm. The patient did not experience skin redness, fever, or chills, and the movement of his fingers was fine with normal blood supply. MRI revealed hyperintensity T2WI signals at the first metacarpal and trapezium, with a slightly increased local signal of the median nerve (Fig. 4A). The patient underwent a debridement surgery of the right hand, during which necrotic tissue was removed, and the tendon, vessels, and nerves were explored at the injury site (Fig. 4B). Postoperative observation showed a stable condition, and the patient was subsequently discharged.

In all cases, HPII starts with early recognition, as HPII is often underestimated due to its small external wound, while internal damage can be severe. High-pressure injection injury common features include swelling, pain, and tissue damage. Initial assessment typically involves clinical examination and radiological imaging, particularly MRI, which assists surgeons in minimizing amputation rates and performing better debridement procedures by providing a clear view of the foreign substance extension and assessing the extent of the damage. Prompt surgical debridement is critical within 6 hours of injury to minimize damage, especially for more dangerous substances like paint and grease,

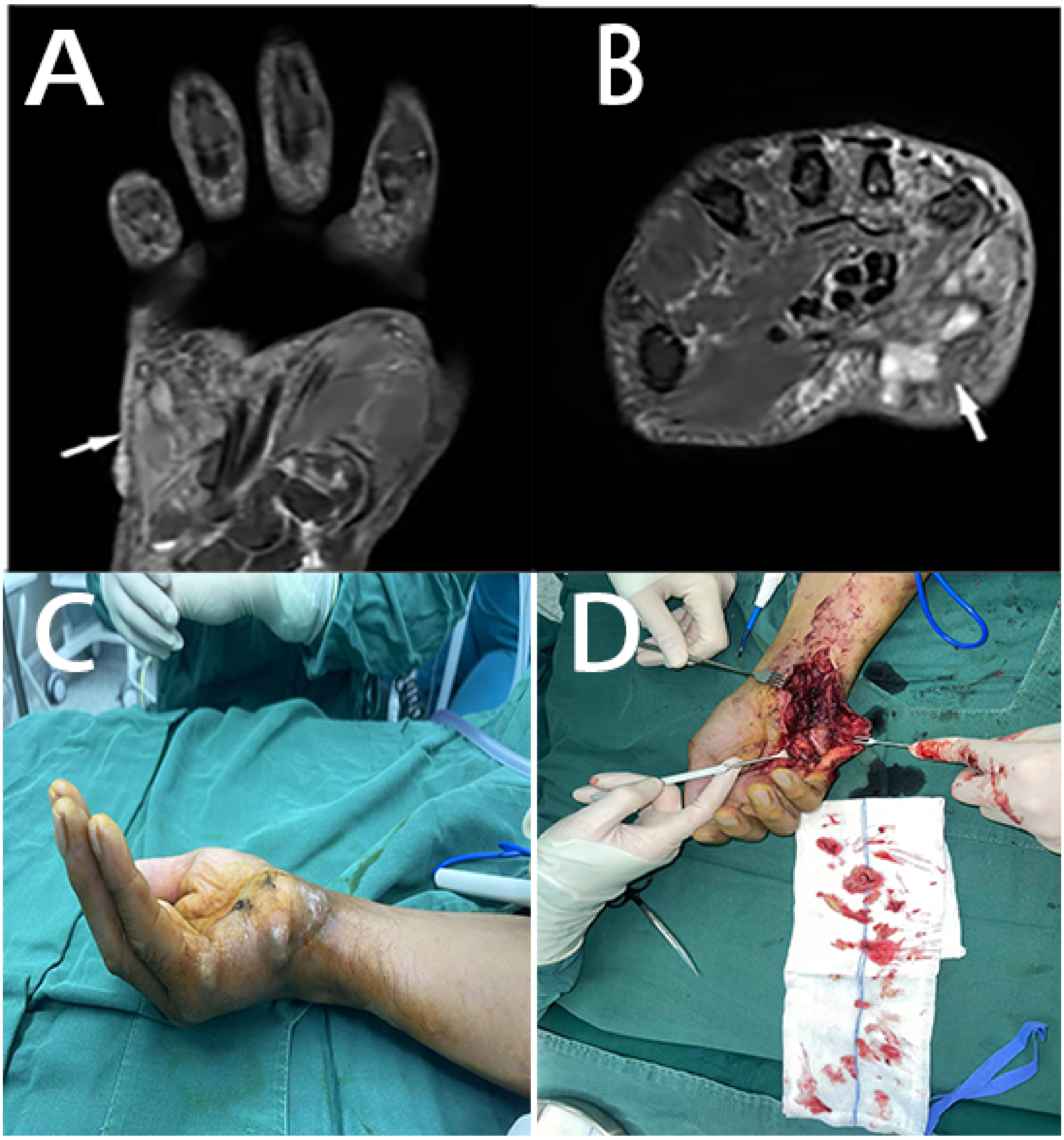

Fig. 2. Preoperative MRI images and intraoperative pictures. (A,B) MRI images indicate edema of the ulnar soft tissue with multiple abnormal signal shadows and Hyperintensity of T2-weighted imaging (T2WI) signals (arrows). (C) External appearance of HPII with tendon contracture. (D) Surgical debridement of the right-hand palm.

which are associated with higher inflammation and amputation rates. During surgery, foreign materials and necrotic tissues are carefully removed, with attention to preserving the neurovascular structures to avoid further complications like compartment syndrome or amputation. In severe cases, multiple surgeries may be necessary. Following surgery, postoperative care includes infection control, typically using bone cement with antibiotics to reduce the risk of infection and inflammation. The wound is managed with light dressing, and immobilization of the injured area helps in recovery. Close observation is required for complications, such as abscess formation or nerve damage, which may require additional surgical interventions like nerve repair or tenolysis in cases of tendon adhesion. Rehabilitation and hand therapy are essential components to restore mobility and strength, with follow-up MRI helping assess recovery progress. This comprehensive approach ensures better outcomes and reduces the rate of severe consequences like amputation. When foreign substances solidify, they can cause the tendons and tissue to contract, resulting in loss of function and hand contraction. Removal of the substance may not be feasible in cases where it has attached to blood vessels, as attempts to remove it could damage the vessel and lead to loss of blood supply. We observed that many patients tend to ignore these injuries until they become severe, which can increase the extent of damage and the need for surgical intervention or even amputation.

Local hospital doctors often prescribe antibiotics and bandage the wound, but lack of awareness about the injury and its deceptive appearance can lead to inappropriate treat-

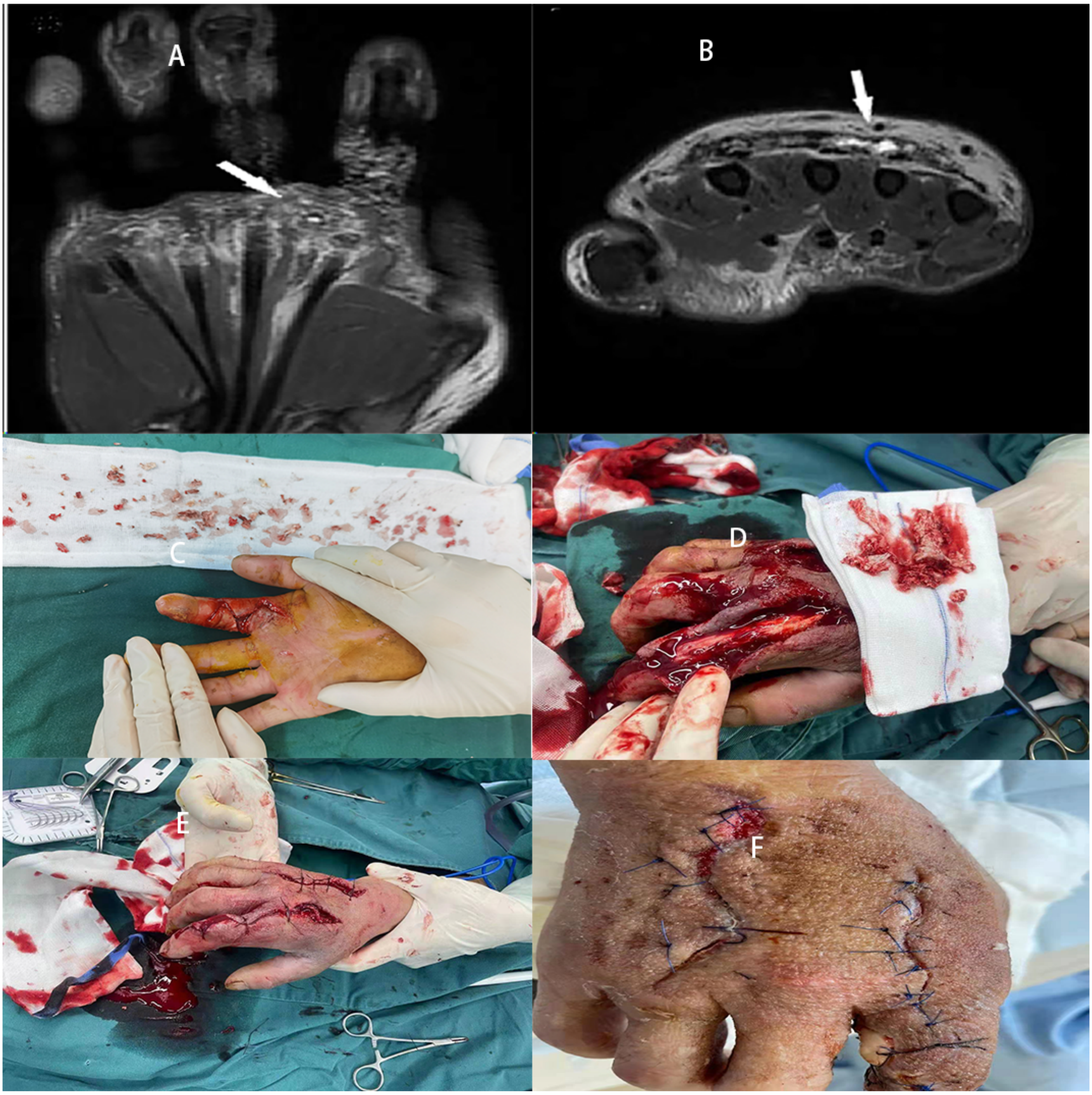

Fig. 3. Preoperative MRI images and intraoperative pictures. (A,B) Abnormal signals can be seen on the dorsal side of the second metacarpophalangeal joint of the right hand, with high signals on T2WI (arrows). Debridement and irrigation procedures (C–F), (C) index finger; (D) the dorsal part of the right hand; (E) the wound was sutured, the skin flap was accomplished, and bone cement was placed at the finger web of the right index; (F) Wound condition 2 weeks after operation.

ment. Our research also showed that the dominant hand is most commonly injured, contrary to previous reports. Polyurethane materials were found to cause the most injuries but had a low amputation rate. Additionally, bone cement application was found to be helpful in reducing inflammatory reactions and infections associated with HPII.

Discussion

HPII is most prevalent in the industrial sector, with minimal initial symptoms. The first documented case of this injury was caused by accidental diesel fuel injection into the hand [10]. Adult manual laborer men are frequently injured compared to women [13,14]. The primary causes of HPII include attempting to clean a high-pressure gun nozzle with a nondominant hand, recklessness, not wearing special gloves, and using low-quality HPG. Inexperienced individuals who unfamiliar with the operation of HPGs are also at risk of HPII. The index, middle fingers, and palm are the most vulnerable sites to injury, depending on the way of using high-pressure guns (Table 2, Ref. [6,10,15–35]).

The location of HPII affects the management and outcomes of the injury. For instance, fingertip injection injuries are

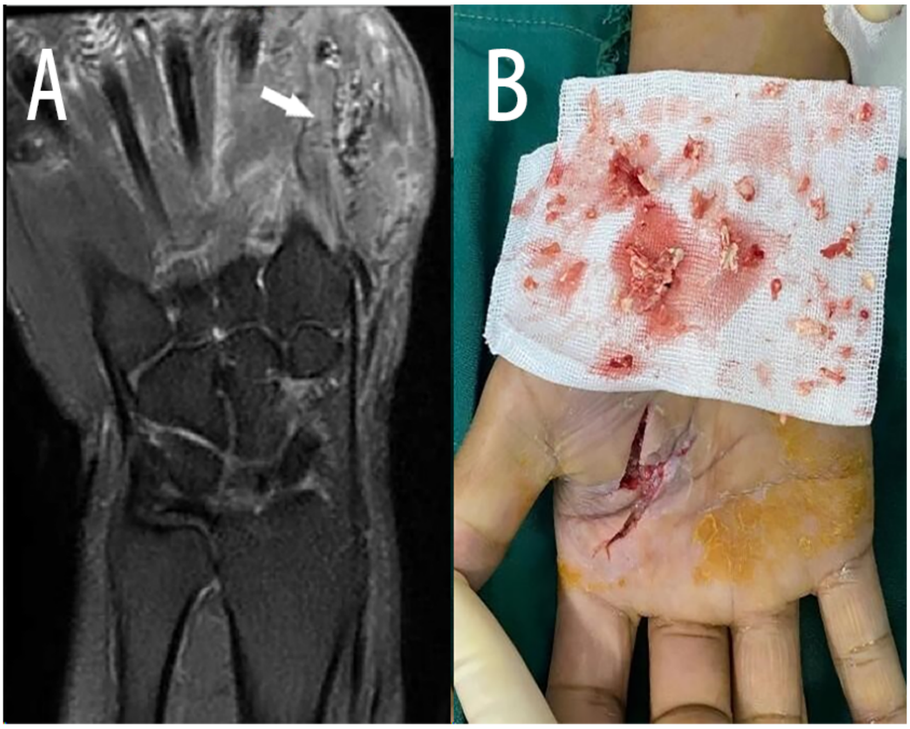

Fig. 4. Preoperative MRI images and intraoperative pictures. (A) MRI presented long T2 signals at the basal part of the first metacarpal bone (arrow), with high local median nerve signals. (B) Right-hand debridement surgery, where the polyurethane materials were removed along with necrotic tissue.

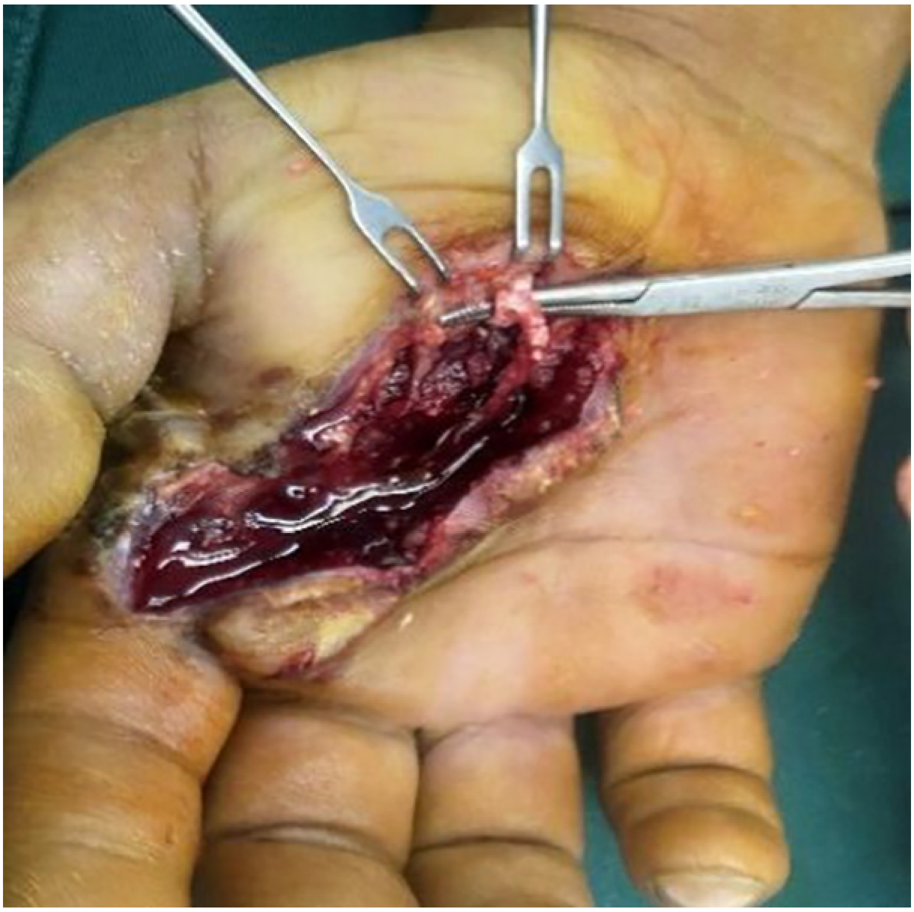

Fig. 5. Polyurethane material surrounding the blood vessels.

Table 2. A collection of previously reported cases.

Sex	Age	Hand part	Type of materials	Radiological finding
Male	60	Left thumb	Paint	X-ray: positive [15]
Male	39	Right thenar crease	Molten metal mixture	X-ray: positive [16]
Male	57	Radial aspect of the right long finger	Latex paint	X-ray: positive [17]
Male	46	Thenar eminence of the right hand	Air injury	X-ray: positive [18]
Male	34	Left ring finger	Water swelling sealant	X-ray: positive
Male	57	Left index finger	Lubricant injector	X-ray: positive [19]
Female	39	Third finger web	Disinfectant filling machine	N/A [20]
Female	38	The right thenar.	Air-injection injury	X-ray: positive [21]
Male	43	Palm of right hand	Molten metal	X-ray: positive [22]
Male	26	Dorsum of the left hand	Cement injection injury	X-ray: positive [23]
Male	28	Palm of the left hand, long finger and dorsum of the ring, finger	Grease injection injury	MRI: positive [10]
Female	28	Left index finger	Air injection injurie	X-ray: positive [24]
Male	21	Second web space of his right hand	Heated plastic injection injury	X-ray: positive [25]
Male	25	Right palm	Paint injection injury	X-ray: positive [26]
Male	50	Palm of left hand	Water injection injury	N/A [27]
Male	54	Base of the radial index finger of the left hand	Air injection injury	X-ray: positive [28]
Male	33	Left palm and fingers	Paint	X-ray: positive CT: positive [29]
Male	36	Left index finger	Grease injury	MRI: positive [30]
Male	31	Left ring finger	Newton 103-S (liquid cement)	N/A [31]
Female	45	Left index finger	Lithium-ion battery explosion	X-ray: positive [32]
Male	42	Left hand	Ferric oxide	X-ray: positive [33]
Male	46	Right index finger	Paint	MRI: positive [34]
Male	30	Left hand	Electric cigarette explosion	X-ray: positive [35]
Male	42	Left hand	Water injection injury	X-ray: positive [6]

more likely to lead to amputation than proximal hand parts, such as the thumb and palm [7,36–38]. HPII can occur not only in the hand but also rarely in the oropharyngeal region, feet, chest, etc. However, the tissue damage caused by HPII is not the only factor that affects symptom development and treatment but also the physical response to foreign materials.

Identifying the type of substance is essential in determining its toxicity level, time-related damage, and proper management. Among the injected materials, grease, paint, and diesel fuel are the most commonly used and are associated with poor outcomes (Table 2). A previous study revealed a 48% amputation rate for injuries caused by these substances [13]. Compared to diesel fuel and grease, paint thinner has the highest prevalence of amputation. In contrast, grease injection injuries exhibit the lowest inflammatory reaction and are less likely to result in a chronic granuloma [36]. Grease was found to have the worst outcome among HPII injuries that did not result in amputation, followed by paint thinner. Post-injury, paint injection injuries can immediately trigger severe pain or progress within hours. Conversely, grease injection injuries result in a gradual increase in pain sensation [39]. Enlargement of lymph nodes (lymphadenitis), infection of the lymphatic channels (lymphangitis), leukocytosis, and fever are common symptoms accompanying paint and paint solvent injuries because some of their substances can be absorbed into the bloodstream [40]. Fortunately, many HPII caused by water and air have a good outcome with a minimum amputation rate and can be treated without emergency surgery. However, it should be noted that contaminated water and air injuries may require an operation [5,6,18,28]. In our article, polyurethane material was the most commonly injected substance with a low amputation rate (Table 1). The high pressure produced by injected foreign materials leads to immediate swelling and eventual inflammatory response with an edematous area. As a result, the tissue becomes white and necrotic due to vascular supply irritation, vascular spasm, venous obstruction from compression, and tissue necrosis. Additionally, oleogranulomas, foreign body granulomas (mostly related to grease injury), and fibrohistocytic tumors (related to paint and paint thinner) can develop around the injury site as a chronic reaction to the foreign materials. Advanced HPII may present with ulcers, and malignant changes are rare [40]. The time between injury and surgical intervention is essential in determining the final outcome. It is favorable to have surgical debridement within 6 hours of injury; otherwise, the amputation rate increases, especially with paint thinner and grease. However, this concept does not necessarily apply to water and air injection injuries, which may be effectively treated with IV antibiotics and close observation [3].

Initial care (pre-operative) can be provided by planning surgery based on radiological images and applying warm,

Fig. 6. HPII of the index finger with bone cement to control the inflammatory response and decrease the amputation rate.

wet dressings to the injured hand while preparing for surgery. It is important to avoid using a digital block or local anesthesia as they may cause further swelling and vasospasm. Applying a tourniquet is a better option as the fluid pressure at the injured site may increase if Bier block or digital blocks are applied [2]. Surgical exploration and debridement of the toxic materials should be done with extreme awareness of the blood circulation and nerve condition. Multiple debridement surgeries should be performed to minimize complications caused by the injury and to preserve the affected part. Preferably, surgery should be done every 3–5 days, depending on the type of material, injection power, and site of injury, with partial removal of the necrotic tissue and toxic materials performed. Full attention should be given while exploring the tendon sheath and neurovascular bundle [12]. We have noticed that the injected substance, such as polyurethane material, is difficult to remove from the area around the vessels or nerves. If the neurovascular bundles are severely damaged, amputation may be necessary. Therefore, to avoid neurovascular damage and amputation, we do not recommend heavy debridement (Fig. 5). Skin graft or flap, open wound packing, or vacuum-assisted closure of the wound can be considered after complete debridement to maintain better recovery [41,42]. In addition, Hand or finger immobilization in a suitable position depending on the injury and light dressing with observation should be done as postoperative management [39,43]. Stiffness in the injured part should be taken into account postoperatively, with limited mobility compared to other normal parts. Tenolysis surgery is performed in severe adhesion cases [5]. During and after treatment, patients may be very anxious about hand strength and sensation. Wieder *et al.*'s study [9] showed that weakness of the digit and mild to moderate sensation loss are foreseeable. Additionally, incomplete debridement can lead to oleogranulomas, fibrohistiocytic tumors, and chronic tunneling wound formation, necessitating further surgical intervention [40]. Previous studies recommended a broad-spectrum antibiotic, analgesics, and tetanus prophylaxis as the patient reaches the emergency department and during treatment to face the risk of secondary inflammation related to ischemia and necrotic tissue. Small vessel thrombosis can be managed by steroids, but the benefits of steroid use are contentious. Study has pointed out the possibility of infections with the use of steroids, while others have shown no risk of amputation and infection related to steroid use [3].

Based on the potential for inflammatory reactions and infections to cause damage to the injured site and increase the risk of amputation, we recommend using bone cement to control and prevent infections. Bone cement acts as a drug delivery system, containing specific substances that have particular effects. Antibiotics are among the substances that can be added to bone cement, and they are released directly to the injured site after fixation, thereby minimizing the risk of infection without exposing the body to high antibiotic levels. Additionally, bone cement loaded with antibiotics serves as a prophylactic against acquiring new infections, resulting in a lower amputation rate and better HPII recovery [44,45]. According to our research, no previous article suggests the use of bone cement in HPII patients (Fig. 6). A complete debridement is crucial for ensuring satisfactory recovery, which cannot be achieved without visualizing and evaluating the extension of foreign materials and associated complications internally. MRI provides superior soft tissue resolution compared to X-ray and CT, making it the preferred imaging modality for assessing the extent of HPII. Based on our experience and recent studies, MRI provides critical details related to high-pressure injection injuries (HPII), aiding surgeons and emergency physicians in determining the urgency of management steps. These injuries often extend to the neurovascular bundles and tendon sheaths, potentially progressing proximally. MRI's multi-sequence, multi-parameter imaging capabilities and high soft tissue resolution make it the ideal modality for HPII, as it can distinguish injected materials and monitor their evolution within tissues. Furthermore, MRI excels in identifying various toxic foreign materials and detecting purulent fluid (abscesses) through diffusion-weighted imaging (DWI), which evaluates water balance at the cellular level. This sensitivity is crucial, as viscous fluids can cause significant tissue damage and promote opportunistic infections due to immunosuppression [30]. Surgeons must pay close attention to surrounding tissues, neurovascular integrity, skin condition, and bone irritation (Table 1) to better plan surgical interventions. Additionally, ultrasonography may be advantageous for assessing superficial injected foreign bodies and evaluating blood circulation in the surrounding tissue due to its excellent anisotropic properties.

The limitations of this study include the small sample size of only 16 patients, which may limit the generalizability of the findings to broader populations. Additionally, the retrospective design can introduce biases related to data collection and analysis, as patient outcomes may not have been uniformly documented. Future research should focus on larger, multi-center studies to validate the effectiveness of MRI in managing HPII across diverse demographic groups. Furthermore, prospective studies could explore the long-term functional outcomes of patients treated with various imaging modalities and surgical techniques, including the use of bone cement, to establish standardized protocols that optimize recovery and minimize complications.

Conclusions

Several HPII cases from our department and other reported cases (in PubMed and Web of Science) were observed to draw the awareness of emergency doctors, surgeons, and radiologists to the earnestness of HPII and to evaluate the better radiological image that assists in performing a successful operation with minimum damage and postoperative complication. MRI imaging has several characteristics that make it superior to other radiological imaging modalities in diagnosing HPII. MRI can differentiate and evaluates the injected materials and also detects impurity components and purulent fluid. DWI has an essential role in recognizing the high viscosity of injected materials and infection detection. Finally, applying bone cement helps in controlling the infection and decreases the number of surgeries.

Availability of Data and Materials

The data underlying this article are available in the article.

Author Contributions

WZ, HL, AA, SHAE, MHAHA and JL, designed the study, CY, XZ, VGK, ZW, OA and MHAHA performed literature collection, SHAE, AA, HZ, and HL wrote the original draft, ZW, XZ, JL, HZ, CY, OA and VGK edited the draft, HL, AA, SHAE, HZ, and ZW analyzed the result, HL, AA, HZ, XZ, SAA and SHAE did supervision. VGK, OA, CY, XZ, and SAA analyzed data. All authors have been involved in revising it critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

Written informed consent was obtained from the patients for the publication of any potentially identifiable images or data included in this article. The study was approved by The First Affiliated Hospital of Zhejiang University, School of Medicine (2019990). All procedures involving human, subiects were conducted in accordance with the Declaration of Helsinki, ensuring ethical standards were maintained.

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Conflict of Interest

Hui Lu is serving as one of the Editorial Board members of this journal. We declare that Hui Lu had no involvement in the peer review of this article and has no access to information regarding its peer review. Other authors have no conflicts of interest.

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