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Case Report

"Pellet storm": a case of 'mis-lead-ing' foreign body removal

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ABSTRACT

Retained lead foreign bodies from industrial blast injuries pose dual challenges: complexity of immediate surgical extraction and long-term systemic lead toxicity risk (plumbism). Lead pellet injuries can result in blood lead levels (BLL) exceeding safe thresholds (>10 µg/dl adults), with severe toxicity at BLL >80 µg/dl. Surgical decision-making must balance the risks of invasive extraction against the risks of retained metallic lead. A 40-year-old male sustained a workplace blast injury when a lead welding machine exploded. He presented with a 5×6×2 cm wound on the lateral right thigh with active hemorrhage, partially charred subcutaneous tissue, and visible lead pellets. Initial radiographs demonstrated 98 round radio-opaque foreign bodies scattered throughout the right femur, thigh musculature, and one pellet in the left thumb. Primary survey confirmed hemodynamic stability (GCS 15/15, BP 122/80 mmHg, SpO_2 97%). Femoral and popliteal pulses were intact bilaterally. Following re-suscitation and wound stabilization, exploratory surgery under C-arm fluoroscopic guidance achieved extraction of 78 pellets from vastus lateralis and medialis via medial and lateral thigh incisions. Approximately 20 pellets adjacent to the neurovascular bundle in the posterior com-partment were deliberately left in situ to avoid iatrogenic vascular or nerve injury. Estimated blood loss: 600 mL; intraoperative transfusion administered. Postoperative course complicated by wound infection on day 5, managed with debridement, culture-directed antibiotics, vacuum-assisted closure (VAC) therapy, and split-thickness skin graft. Patient discharged in haemody-namic stable status and, ambulatory with healed wound. Two-month follow-up showed no signs of infection, sinus tract formation, or clinical plumbism (patient subsequently lost to follow-up). This case illustrates the surgical challenge of balancing maximal foreign body extraction against the risk of neurovascular injury in penetrating trauma with multiple retained projectiles. The decision to leave ~20% of pellets in situ near critical structures reflects established trauma principles prioritizing preservation of neurovascular function over complete foreign body re-moval. Long-term plumbism risk remains uncertain; prospective data on lead toxicity from re-tained pellets are limited, though existing case series suggest elevated BLL can persist for months to years. Clinical and serological surveillance (serum lead levels, complete blood count) is recommended but was not completed in this case due to loss of follow-up

Keywords: Lead foreign body, Blast injury, Plumbism, Workplace trauma, Vacuum-assisted closure

INTRODUCTION

Retained lead foreign bodies resulting from industrial blast injuries, firearm wounds, or explosive trauma present a unique dual-threat clinical scenario: the immediate surgical challenge of foreign body extraction from deep soft tissue and vascular structures, and the delayed but potentially severe risk of systemic lead poisoning (plumbism). Unlike inert metallic foreign bodies, lead is toxic; prolonged contact with body fluids facilitates leaching of elemental lead into the bloodstream, with resultant accumulation in bone, soft tissues, and the central nervous system.

The threshold for lead toxicity is well-defined: blood lead levels (BLL) exceeding 10 µg/dl in adults and 3.5 µg/dl in children are considered elevated, with severe toxicity manifesting at BLL >80 µg/dl.[1] Clinical manifestations of chronic lead exposure include gastrointestinal disturbances (anorexia, vomiting, abdominal pain, constipation), neurological deficits (encephalopathy, peripheral neuropathy, cognitive impairment), hematological abnormalities (anemia, basophilic stippling), and in children, irreversible developmental delays.[2]

Surgical decision-making in cases of multiple retained lead projectiles must balance two competing risks: aggressive surgical exploration with potential for iatrogenic neurovascular injury, versus conservative management accepting retained foreign bodies with long-term plumbism risk. Existing literature provides limited prospective data on the natural history of retained lead pellets, though retrospective case series suggest that BLL can remain elevated for months to years, with some patients requiring chelation therapy.[3,4]

We report a case of workplace blast injury resulting in 98 lead pellets embedded in the right thigh musculature, managed with selective foreign body extraction under fluoroscopic guidance, deliberate retention of 20 pellets adjacent to neurovascular structures, and subsequent wound complication requiring vacuum-assisted closure and skin grafting. This case highlights the surgical and toxicological challenges inherent to "pellet storm" injuries.

CASE REPORT

Incident and initial presentation

A 40-year-old male was brought to the emergency department (EMD) in a tertiary care medical hospital with an alleged history of blast injury sustained during workplace welding activity. The patient was operating a lead welding machine when it exploded without warning, propel-ling lead pellets and metallic debris. He sustained a single apparent entry wound over the lateral aspect of his right knee, with immediate-onset pain and progressive limitation of knee flexion due to discomfort. He denied loss of consciousness, chest pain, dyspnea, or injury elsewhere. No significant past medical, surgical, family, or allergic history was elicited (Figure 1).

Figure 1: Entry wound.

Primary survey

The advanced trauma life support (ATLS) primary survey revealed: airway - patent, no compromise; breathing: bilateral air entry present and equal; normal vesicular breath sounds; SpO_2 97% on room air; circulation: pulse rate 98 beats/min (regular); blood pressure 122/80 mm Hg; all peripheral pulses palpable and symmetric bilaterally; disability: alert and fully oriented; Glasgow coma scale (GCS) 15/15 (E4V5M6); pupils bilaterally equal and reactive to light; no focal neurological deficits; patient unable to flex right knee due to pain; and exposure: core temperature 37.0°C (98.6°F); no additional injuries identified on full-body examination.

Secondary survey and local examination

Systemic examination

Abdomen was soft, nontender, no organomegaly, bowel sounds present and normal. No spinal deformity or bony fractures palpable.

Local wound examination (right thigh)

Entry wound: 5×6×2 cm defect on the lateral aspect of right thigh, just proximal to the knee joint; surrounding skin: burnt and abraded with soot deposition, consistent with close-range blast mechanism; active hemorrhage: moderate venous bleeding from wound base; wound depth: partially charred, blackened subcutaneous tissue with multiple visible spherical lead pel-lets embedded in fascia and muscle; palpable foreign bodies: additional pellets palpable in sub-cutaneous tissue proximal to the wound, tracking along the lateral thigh; no exit wound identi-fied; neurovascular status: femoral and popliteal pulses strong and equal bilaterally; no weak-ness or sensory deficit in right lower extremity (patient's pain limited functional testing); and additional injury: one small pellet palpable in the pulp of the left thumb.

Diagnostic imaging and laboratory investigations

Radiographic imaging was obtained to delineate the extent of foreign body burden and rule out fractures or vascular injury.

X-ray right lower limb (anteroposterior and lateral views): 98 discrete round radio-opaque for-eign bodies (consistent with lead pellets) scattered throughout the soft tissues of the right thigh, concentrated in the mid-thigh musculature with some tracking proximally and distally. No frac-tures of the femur, tibia, or fibula. No periosteal reaction or cortical breach (Figure 2).

X-ray left hand (AP and oblique views): one radio-opaque pellet in the soft tissue of the left thumb pulp.

X-ray pelvis and bilateral hips: no foreign bodies in the pelvis; acetabuli and femoral heads in-tact.

X-ray chest (PA view): no thoracic foreign bodies; normal cardiomediastinal silhouette; no pneumothorax or hemothorax.

Laboratory investigations on admission showed elevated total leucocyte counts. No other de-ranged blood parameters.

Figure 2: Preoperative X-ray.

Following stabilization in the emergency department and completion of diagnostic workup, the patient was admitted to the general surgery ward under antibiotic coverage (piperacillin-tazobactam 4.5 g IV every 8 hours, metronidazole 500 mg IV every 8 hours) for 48 hours prior to planned surgical exploration. Informed consent was obtained from the patient after detailed explanation of: the surgical plan for maximal foreign body extraction, the inherent risk of incomplete extraction given proximity of pellets to neurovascular structures, the risk of iatrogenic nerve or vascular injury during dissection, and the long-term risk of lead toxicity from retained pellets.

The decision to pursue surgical exploration was based on: the large foreign body burden (98 pellets), superficial and mid-depth location of the majority of pellets amenable to extraction, concern for lead toxicity with prolonged retention, and patient preference for maximal removal despite surgical risks.

Surgical procedure

Wound margins of the original 5×6 cm entry wound were freshened and debrided of devitalized tissue.

Vertical incisions (approximately 12 cm each) were made on the medial and lateral aspects of the mid-thigh to provide access to the vastus medialis and vastus lateralis compartments, respectively.

Blunt dissection between muscle fibers was performed under C-arm guidance to localize and extract deeply embedded pellets.

Seventy-eight (78) lead pellets were successfully removed from the vastus lateralis and vastus medialis muscles. Pellets were deeply embedded within muscle bellies, requiring meticulous sharp and blunt dissection (Figure 3).

Approximately 20 pellets located in the posterior compartment in close proximity to the femoral artery, femoral vein, and sciatic nerve were identified on fluoroscopy but deemed inaccessible without unacceptable risk of major neurovascular injury. The decision was made intraoperatively to leave these pellets in situ (Figure 4).

One pellet was extracted from the left thumb pulp via a small incision under local anesthesia prior to thigh exploration.

Estimated blood loss: 600 ml. One unit of packed red blood cells was transfused intraoperatively.

Hemostasis was achieved with electrocautery and ligature of small muscular vessels.

A Romovac suction drain (size 14 Fr) was placed in the lateral thigh wound to prevent hematoma formation.

Wounds were irrigated copiously with 3 L normal saline and closed in layers.

Figure 3: Pellets extracted.

Figure 4: Postoperative X-ray.

Initial recovery was uneventful through postoperative day 4. The patient was ambulating independently with minimal pain.

On postoperative day 5, the lateral thigh wound demonstrated signs of infection: purulent se-rosanguineous discharge, erythema extending 3 cm beyond wound margins, warmth, and tenderness on palpation. Wound swab was obtained for culture and sensitivity. Empirical antibiotic therapy was escalated to injection meropenem 1 g IV every 8 hours. Sutures were removed to allow drainage; the wound was left open and managed with twice-daily normal saline wet-to-dry dressings and limited debridement of superficial necrotic tissue.

Culture results revealed methicillin-sensitive *Staphylococcus aureus* (MSSA) sensitive to cefazolin, clindamycin, and vancomycin. Antibiotic regimen was de-escalated to injection cefazolin 2 g IV every 8 hours based on culture sensitivities. Despite systemic antibiotics and aggressive local wound care, the wound failed to show significant granulation tissue formation over the subsequent 10 days.

Given persistent wound bed contamination and poor granulation tissue formation, the decision was made to employ negative-pressure wound therapy (NPWT). On postoperative day 15, the patient underwent wound re-debridement under spinal anesthesia. All remaining necrotic tissue and slough were excised sharply, and the wound bed was prepared. A VAC dressing (KCI V.A.C. Therapy system) was applied at continuous negative pressure of −125 mm Hg. The VAC dressing was maintained for 10 days with dressing changes every 3 days (Figure 5).

Figure 5: VAC dressing.

The VAC dressing was removed and wound inspection revealed a healthy granulating bed with 90% coverage of granulation tissue, measuring approximately 10×8 cm. The wound bed was deemed suitable for skin grafting (Figure 6).

Figure 6: Post VAC dressing.

The patient underwent split-thickness skin grafting (STSG) under spinal anesthesia. A split-thickness skin graft (0.012 inches thick) was harvested from the anterior aspect of the left thigh using a Humby knife. The graft was meshed and applied to the right thigh wound bed. The graft was secured with staples and covered with a non-adherent petrolatum gauze dressing, followed by a bulky cotton bolster dressing secured with circumferential crepe bandage. The donor site was dressed with a hydrocolloid dressing (Figure 7).

Postoperatively, the patient was instructed to maintain strict bed rest with right lower extremity elevation for 5 days to optimize graft take. The graft dressing was removed on postoperative day 5, revealing >95% graft take with only small areas of marginal graft loss.

Figure 7: Post STSG 95% graft uptake.

Discharge and follow-up

The patient was discharged on postoperative day 40 from initial surgery, in good general condition with a well-healed skin graft and ambulatory status restored. The patient was counseled extensively regarding:

Risk of chronic plumbism from the approximately 20 retained lead pellets.

Need for serial monitoring of blood lead levels (BLL) at 1, 3, 6, and 12 months post-injury.

Signs and symptoms of lead toxicity: abdominal pain, constipation, fatigue, cognitive changes, peripheral neuropathy

Risk of sinus tract formation or recurrent infection at sites of retained pellets.

Immediate return to emergency department if experiencing fever, wound discharge, or neurological symptoms

The patient was followed in the outpatient department for 2 months for graft site dressing and monitoring. During follow-up visits, there was no evidence of wound infection, sinus tract formation, or clinical signs of lead poisoning (no gastrointestinal symptoms, no neurological deficits, no anemia). However, baseline and serial blood lead levels were not obtained due to unavailability of the assay at the institution. The patient was counseled to seek external laboratory testing for BLL measurement but did not comply. The patient was subsequently lost to follow-up after 2 months.

DISCUSSION

Epidemiology and mechanism of lead pellet injuries

Retained lead foreign bodies most commonly result from firearm injuries (gunshot wounds with retained bullet fragments), though industrial blast injuries—as in this case—represent a less frequent but equally complex mechanism. Lead welding machines contain significant quantities of metallic lead in the form of pellets or powder; explosive failure of these devices can propel dozens to hundreds of lead projectiles into adjacent soft tissues at high velocity. Unlike low-velocity injuries, blast mechanisms impart significant kinetic energy, driving foreign bodies deep into muscle compartments and creating extensive soft tissue disruption.

Surgical decision-making: extraction vs. observation

The management of multiple retained lead foreign bodies requires individualized surgical decision-making that balances three competing considerations: risk of lead toxicity from retained pellets, technical feasibility and safety of extraction, and morbidity associated with aggressive surgical exploration.

Arguments favoring extraction include: prevention of plumbism (particularly relevant for intra-articular or intravascular pellets with enhanced lead dissolution), removal of nidus for chronic infection or foreign body reaction, and patient preference for removal. Arguments favoring conservative management include: low systemic absorption from encapsulated pellets in muscle or subcutaneous tissue, risk of iatrogenic neurovascular injury during deep dissection, and potential for multiple reoperations with diminishing returns.

In this case, the surgical team elected for partial extraction: aggressive removal of 78 accessible pellets (80% of total burden) while accepting retention of 20 pellets (~20%) adjacent to the femoral neurovascular bundle and sciatic nerve. This approach reflects established trauma surgery principles prioritizing preservation of limb function over complete foreign body clearance.[5] Literature supports this strategy; McQuirter et al demonstrated that encapsulated lead pellets in soft tissue have limited bioavailability, with the majority of systemic lead absorption occurring from pellets in synovial fluid, cerebrospinal fluid, or in direct contact with vascular structures.[6]

Lead toxicity: pathophysiology and clinical manifestations

Lead exerts toxicity through multiple mechanisms: competitive inhibition of calcium-dependent enzymes (particularly δ-aminolevulinic acid dehydratase in heme synthesis, resulting in anemia with basophilic stippling), disruption of glutamatergic neurotransmission (causing encephalopathy and cognitive deficits), renal tubular damage (Fanconi syndrome, chronic interstitial nephritis), and interference with bone metabolism.[1]

Acute lead poisoning (plumbism) manifests with gastrointestinal symptoms (anorexia, nausea, vomiting, severe abdominal pain, constipation) and neurological findings ranging from headache and irritability in mild cases to stupor, seizures, and coma in severe cases (lead encephalopathy). Chronic low-level exposure produces insidious symptoms: fatigue, myalgias, cognitive slowing, peripheral neuropathy (classically wrist drop or foot drop), and reproductive dysfunction. In children, even low-level chronic exposure (BLL 5–10 μg/dl) causes permanent neurodevelopmental impairment.[2]

Thresholds for clinical intervention are well-established. The Centers for Disease Control and Prevention (CDC) defines elevated BLL as ≥5 μg/dl in children and ≥10 μg/dl in adults. Chelation therapy with succimer (DMSA), dimercaprol (BAL), or calcium disodium edetate (EDTA) is indicated for: BLL >45 μg/dl (with stronger recommendation for BLL >100 μg/dl), or symptomatic lead toxicity at any BLL.[7] Severe encephalopathy (stupor, seizures, coma) warrants emergent chelation regardless of BLL.

Natural history of retained lead pellets: evidence from the literature

Prospective data on lead toxicity from retained projectiles are limited. The most comprehensive study to date is by Moazeni et al, who prospectively followed 25 patients with retained lead pellets for 6 months and compared them to age-matched controls.[3]

Key findings include the following.

Mean BLL in patients with retained pellets: 38.6±16.8 μg/dl (range 3–70 μg/dl) at 1 month post-injury.

Mean BLL in controls: 10.5±9.7 μg/dl ($p<0.001$).

BLL remained elevated at 3 months (mean 42 μg/dl) and 6 months (mean 36 μg/dl), suggesting ongoing leaching from retained pellets.

Clinical symptoms

20 patients (80%) experienced local pain at 1 month, decreasing to 3 patients (12%) at 6 months; 5 patients (20%) reported radicular pain; 15 patients (60%) developed "heating" sensation at pellet sites. No patient developed overt encephalopathy, though neurocognitive testing was not performed.

Gerhardsson et al reported a case of chronic lead poisoning following shotgun injury, with BLL peaking at 65 μg/dl at 3 months post-injury and remaining elevated (45–50 μg/dl) for over 1 year despite encapsulation of pellets.[4] The patient required chelation therapy with EDTA to reduce BLL to acceptable levels.

Küchnel et al described a delayed malignancy arising adjacent to a retained lead pellet: a patient developed squamous cell carcinoma of the maxillary antrum 50 years after sustaining a facial gunshot wound, with the tumor arising in direct contact with the encapsulated pellet.[8] While a definitive causal relationship cannot be established, this case raises concern for chronic foreign body carcinogenesis.

Limitations

This case is limited by the absence of serial blood lead level measurements, which would have provided objective data on the degree of systemic lead absorption from the 20 retained pellets. Ideally, BLL should have been measured at baseline (within 24–48 hours of injury), at 1 month, 3 months, 6 months, and 12 months post-injury. The patient's loss to follow-up after 2 months precludes assessment of long-term plumbism risk, development of sinus tracts, or late infection at retained pellet sites.

Additionally, the wound infection and requirement for VAC therapy followed by STSG prolonged hospitalization and recovery. Whether earlier aggressive debridement or primary closure with prophylactic drains would have prevented infection remains speculative. The infection likely resulted from a combination of factors: blast-related tissue devitalization, heavy bacterial contamination from the industrial environment, and retained foreign material (lead and debris) serving as a nidus for infection.

CONCLUSION

This case of "pellet storm" workplace blast injury resulting in 98 retained lead foreign bodies illustrates the dual surgical and toxicological challenges inherent to this injury pattern. Successful management required: aggressive but selective surgical extraction of 78 accessible pellets under fluoroscopic guidance, acceptance of 20 retained pellets adjacent to neurovascular structures to avoid iatrogenic injury, management of postoperative wound infection with VAC therapy and split-thickness skin graft, and counseling regarding long-term plumbism risk. While the patient recovered with restored ambulation and healed wound, the absence of serial blood lead level measurements represents a missed opportunity to document systemic lead absorption and guide potential chelation therapy.

As industrial use of lead-containing machinery remains common in developing countries with limited occupational safety standards, surgeons should be prepared to manage complex lead foreign body injuries. A multidisciplinary approach involving trauma surgery, toxicology, and long-term follow-up is essential to optimize both immediate surgical outcomes and long-term patient safety.

Recommendations

Based on this case and review of existing literature, we propose the following management algorithm for patients with multiple retained lead pellets from blast or gunshot injuries: baseline blood lead level (BLL) within 24–48 hours of injury, then serially at 1, 3, 6, and 12 months; complete blood count (CBC) with peripheral smear to assess for anemia and basophilic stippling; comprehensive metabolic panel (CMP) to assess renal function; radiographic documentation of pellet number and anatomical location (plain X-rays ± CT for complex cases); surgical extraction of accessible pellets under fluoroscopic guidance, with preservation of neurovascular structures as the overriding priority; acceptance of retained pellets in high-risk anatomical locations (adjacent to major vessels, nerves, or within bone); patient counseling regarding long-term plumbism risk, signs/symptoms of toxicity, and need for serial BLL monitoring; chelation therapy if BLL >45 μg/dl or if symptomatic, in consultation with toxicology; and long-term clinical surveillance (minimum 12 months) for sinus tract formation, chronic infection, or delayed neurological symptoms.

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