Case Report
Gas Gangrene in Orthopaedic Patients

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Clostridial myonecrosis is most often seen in settings of trauma, surgery, malignancy, and other underlying immunocompromised conditions. Since 1953 cases of gas gangrene have been reported in orthopaedic patients including open fractures, closed fractures, and orthopaedic surgeries. We present a case of 55-year-old obese woman who developed rapidly progressive gas gangrene in her right leg accompanied by tibial plateau fracture without skin lacerations. She was diagnosed with clostridial myonecrosis and above-the-knee amputation was carried out. This patient made full recovery within three weeks of the initial episode. We identified a total of 50 cases of gas gangrene in orthopaedic patients. Several factors, if available, were analyzed for each case: age, cause of injury, fracture location, pathogen, and outcome. Based on our case report and the literature review, emergency clinicians should be aware of this severe and potentially fatal infectious disease and should not delay treatment or prompt orthopedic surgery consultation.

1. Introduction

Emergency physicians and surgeons are confronted with patients of gas gangrene so uncommon in civilian practice that many are unfamiliar with its signs and symptoms and do not recognize its development quickly and accurately. The difficulties in diagnosis not only lie in unfamiliarity with the signs and symptoms of gas gangrene but also in the lack of differentiation between contamination and infection and to the confusion between gas gangrene and various clostridial infections and other bacterial and nonbacterial lesions simulating gas gangrene [1, 2]. Gas gangrene occurs in a variety of clinical settings that can be subdivided into three major types: posttraumatic origins, postoperative origins, and spontaneous occurrences. Clostridial myonecrosis, also known as true gas gangrene, is the most devastating kind of clostridial infection which requires aggressive, early surgical management. Its onset is insidious and subsequent progressive rapidly. Spontaneous types occurred in patients with compromised medical conditions including uncontrolled diabetes mellitus and various forms of malignancy, the more commonly reported being leukemia and breast cancer [3]. Clostridium septicum is the major cause of nontraumatic spontaneous gas gangrene in patients with immunosuppressive diseases [4].

2. Case Report

A 55-year-old obese female farmer (BMI 35) presented to the Emergency Department with a two-day history of the right leg progressing sensory deprivation and swelling. Eight days ago she had a car accident which caused her right tibial plateau fracture. Two days after her hospitalization, elective surgery for the fracture was performed at a local hospital. Afterwards, the patient felt increasing pain out of proportion to physical findings accompanied by progressive swelling, numbness, and weakness of the limb. She was unable to move her right lower extremity and had no sensation below the knee joint level. These signs were not taken seriously.
Knee joint was present. Laboratory evaluations showed that muscle compartments of the right leg reaching to the level of the leg. Extensive gas formation throughout all the knee to ankle. Roentgenograms revealed gas in the interfacial length of the limb and the skin discoloration spread from the incision (Figure 1). Subcutaneous crepitus extended along the length of the limb and the skin discoloration spread from knee to ankle. Roentgenograms revealed gas in the interfacial planes of the leg. Extensive gas formation throughout all the muscle compartments of the right leg reaching to the level of the knee joint was present. Laboratory evaluation showed that white blood cell count was \(22.2 \times 10^9/L\), hemoglobin was \(83 \text{ g/L}\), platelet count was \(183 \times 10^9/L\), a serum glucose of \(324 \text{ mg/dL}\), \(C\)-reactive protein was \(48.0 \text{ mg/dL}\), and serum creatinine was \(155 \mu\text{mol/L}\). Examination of a needle aspirated from the incision showed gram-positive bacilli.

A diagnosis of gas gangrene was made and the patient was started on broad spectrum antibiotic coverage with intravenous penicillin, clindamycin, metronidazole, and fluid resuscitation. Urgent surgery was carried out immediately. Upon incision, the musculature was found to be extensive necrotic, foul smelling, and crepitant (Figure 2). An above-the-knee amputation remained the single best life-saving treatment and was performed, followed by extensive debridement of the remaining necrotic tissue. Then she was sent to the adult intensive care unit and all the wounds were kept open postoperatively. Two days later, the patient was taken to the operating room again for wound exploration. At this time, the muscle and tissue were found to be viable without evidence of spreading infection, and the wound was closed in a standard fashion. Hemocultures both superficially and deep.

**Figure 1:** The limb was severe swollen and skin was brownish with bullae exuding from the incision.

**Figure 2:** The muscle was found to be necrotic, foul smelling, and crepitant both superficially and deep.

### 3. Review of Published Gas Gangrene in Orthopaedic Patients

All published, English language and full-text available, Medline-reported orthopaedic patients with gas gangrene were included in this review. Several factors, if available, were analyzed for each case: age, cause of injury, fracture location, pathogen, and clinical outcome. As seen in Table 1, we identified a total of 50 cases of gas gangrene in orthopaedic patients. Of these, 24 (48%) cases were caused by *C. perfringens*. Average age is 28.75 years old (range from 5 to 76).

In our review of published orthopaedic gas gangrene literature, we found that conditions related with gas gangrene in orthopaedic patients can be grouped into three major categories: infection with clostridial myonecrosis, nonclostridial myonecrosis, unidentified; 38 patients survived, of which 25 survived with amputation, while 12 patients died. Gas gangrene followed by simple fracture occurred in 25 patients; 3 cases presented with gas gangrene after elective orthopaedic surgery and the rest cases were resulted from compound fracture. As for fracture location, most gas gangrene cases were involved with tibia and/or fibula fracture while forearm fractures were ranked in the second place and following were femur, ankle, knee, and pelvic. Especially 5 patients developed gas gangrene with no fractures (three were elective orthopaedic surgeries, one was nail piercing, and the other one was soft tissue injury (see Table 2)).

### 4. Discussion

Gas gangrene is generally regarded as a disease associated with war or other mass casualty situations and is seldom a feature of normal peaceful time medical practice. The cause of gas gangrene could be grouped into following different types: clostridial myonecrosis, clostridial cellulitis, nonclostridial lesion simulation gas gangrene. Clostridial myonecrosis is the preferred term to denote the clinical syndrome of true gas gangrene [27]. More than 90% of these lesions occur in the extremities, thigh, shoulder, and so on. Clostridial cellulitis has been confused with clostridial myonecrosis by clinicians. Clostridial cellulitis has been noted to be a septic crepitant process involving epifascial, retroperitoneal, or other connective tissues, and its onset has been generally more gradual than clostridial myonecrosis. It is usually little pain, no edema, and little systemic toxicity. The wound is foul with brownish seropurulent exudates, and gas is found diffused through the tissues and bubbling up in the wound. The gas is much more evident than in clostridial...
Table 1: Gas gangrene infections in traumatic orthopaedic patients.

| Source                  | Cause                        | Age | Fracture                        | Soft tissue             | Pathogen                           | Outcome                  |
|-------------------------|------------------------------|-----|---------------------------------|-------------------------|------------------------------------|--------------------------|
| Fee, 1977 [5]           | Fall from a tree             | 8   | Closed, forearm                 | A small laceration      | Gram-positive Spore-forming rods   | Lived with disarticulation |
|                         | Fall from a tree             | 10  | Open, right forearm             | Two small lacerations   | Clostridium perfringens            | Lived with amputation    |
|                         | Fall from a tree             | 11  | Open, right forearm             | A puncture wound        | Clostridium perfringens            | Lived with amputation    |
|                         | Fall from a roof             | 12  | Open, right forearm             | Two openings            | Clostridium perfringens            | Lived with preserved forearm |
|                         | Fall on the street           | 52  | Open, left radius               | A puncture wound        | Gram-positive rods                 | Lived with amputation    |
| Buchanan and Gordon, 1980 [6] | Fall from 5 stories         | 19  | Compound fracture of right tibia and fibula | Contaminated with dirt, gravel | Clostridium perfringens            | Lived with amputation    |
| Fulford, 1969 [7]       | Traffic accident             | 19  | Open, right femur               | Contaminated, No detail | Unknown                            | Lived with preserved limb |
| Lucas et al., 1976 [8]  | Kicked on right shin in a tackle | 24  | Tibia and fibula                | 7 cm wound              | Clostridium septicum               | Lived with preserved limb |
| Woolley et al., 2004 [9] | Fall from high place         | 39  | Open, left tibia, and fibula    | Gustillo Grade III      | Clostridium septicum (no gas gangrene) | Lived with preserved limb |
| Werry and Meek, 1986 [10]| Unknown                      | 32  | Distal radius                   | Abrasion of the volar wrist skin | Clostridium perfringens            | Lived with amputation    |
| Goon et al., 2005 [11]  | Local accident               | 76  | No fracture                     | No traumatic history    | Clostridium septicum               | Died                     |
| Taylor et al., 2011 [12]| High-speed motor vehicle collision | 21  | Closed, right femur with traction pin | Multiple organ injuries | Clostridium perfringens            | Died                     |
| Mulier et al., 1993 [13]| Fall from a height of 8 feet | 45  | Closed, femoral fracture        | Unknown                 | Clostridium septicum               | Survived with disarticulation |
| Lorea et al., 2004 [14] | Muscle transfer for opponensplasty | 49  | No fracture                     | Normal muscle surgery   | Clostridium perfringens, Sordellii | Survived with preserved forearm |
| Sevitt, 1953 [15]       | Playing football              | 26  | Closed, left ankle              | Unknown                 | Clostridium perfringens            | Survived with amputation |
| HILL, 1959 [16]         | Fall from a gate             | 6   | Left forearm fracture           | A small wound on the forearm | Unknown                            | Survived with amputation |
| Aufranc et al., 1969 [17]| Struck by a rotating truck wheel | 29  | Open, right tibia               | Wringter-type injury of leg. | Presence of gram-positive rods     | Survived with preserved limb |
| Source                     | Cause                                      | Age | Fracture                                      | Soft tissue | Pathogen             | Outcome               |
|---------------------------|--------------------------------------------|-----|-----------------------------------------------|-------------|----------------------|-----------------------|
| Automobile accident       | 13 Compound, left tibia, and fibula        |     |                                               | Unknown     | Bacilli welchii      | Died                  |
| Fall from window to ground| 24 Compound, left tibia                    |     |                                               | Unknown     | Bacilli welchii      | Survived with amputation |
| Automobile accident       | 37 Compound, left tibia, and fibula        |     |                                               | Unknown     | Bacilli welchii      | Died                  |
| Hooked by a cow           | 6 Compound, right forearm                  |     |                                               | Unknown     | Bacilli welchii      | Survived with amputation |
| Street accident           | 52 Compound, left tibia, and fibula        |     |                                               | Unknown     | Positive culture, detail Unknown | Survived with amputation |
| Truck Accident            | 21 Compound, left tibia, and fibula        |     |                                               | Unknown     | Positive culture, detail Unknown | Survived with preserved limb |
| Motorcycle accident       | 18 Compound, right tibia, and fibula       |     | Compound, upper extremity, left femur, left tibia, and fibula | Unknown     | Bacilli welchii | Survived with amputation |
| Struck by a truck         | 5 Compound, both legs                      |     |                                               | Unknown     | Bacilli welchii      | Died                  |
| Street-car accident       | 13 Compound, both legs                     |     |                                               | Unknown     | Bacilli welchii      | Died                  |
| Knee joint fracture from gun-shot | 30 Knee joint fracture                  |     |                                               | Unknown     | Positive culture, detail Unknown | Survived with amputation |
| Auto accident             | 36 Compound, right tibia, and fibula       |     |                                               | Unknown     | Positive culture, detail Unknown | Survived with amputation |
| Falling from freight train| 16 Compound, both legs                     |     |                                               | Unknown     | Positive culture, detail Unknown | Survived with amputation |
| Motorcycle accident       | 40 Compound, left tibia, and fibula        |     |                                               | Unknown     | Positive culture, detail Unknown | Survived with preserved limb |
| Automobile accident       | 25 Compound, both legs                     |     |                                               | Unknown     | Positive culture, detail Unknown | Died                  |
| Gun-shot                  | 20 Compound, right ulnar, and radius       |     |                                               | Unknown     | Negative culture     | Died                  |
| Source                              | Cause                      | Age | Fracture                  | Soft tissue | Pathogen             | Outcome                        |
|------------------------------------|----------------------------|-----|---------------------------|-------------|----------------------|--------------------------------|
| Brume and Ijagha, 1985 [19]        | Unknown                    | 9   | Closed Colles' Fracture   | Unknown     | Unknown              | Survived with amputation       |
| Unknown                            | 27                         | Closed, medical malleolus | Unknown     | Unknown              | Survived with amputation       |
| Unknown                            | 30                         | Closed, tibia and fibula  | Unknown     | Unknown              | Died                           |
| Unknown                            | 14                         | Closed Colles' Fracture   | Unknown     | Unknown              | Survived with amputation       |
| Moehring, 1988 [20]                | Automobile accident        | 13  | Right ankle region        | Marked soft tissue swelling | *Clostridium perfringens*      | Lived with preserved limb      |
| Oncel and Arsoy, 2010 [21]         | Nail pierced the skin of hand | 16  | No fracture               | A small wound on the hand | Gram-positive rods             | Survived with amputation       |
| Hoffman et al., 1971 [22]          | Working accident           | 25  | Tibia fracture            | Muscle and skin lacerated | *Clostridium welchii*          | Survived                       |
| Source                          | Cause                      | Age | Fracture                              | Soft tissue                  | Pathogen                        | Outcome                     |
|--------------------------------|----------------------------|-----|---------------------------------------|-----------------------------|--------------------------------|------------------------------|
| DeHaven and Evarts, 1971 [23] | Fall from horseback        | 10  | Open, both bones of forearms          | Mild damage of soft tissue  | Clostridium perfringens         | Survived with amputation     |
|                                | Automobile accident        | 44  | Open, Bilateral tibia, and fibulae    | Damaged and contaminated severely | Pseudomonas, Klebsiella et al. | Survived with amputation     |
|                                | Fall from running          | 21  | Open, both bones of forearms          | Mild damage of soft tissue  | Clostridium perfringens         | Survived                    |
|                                | Automobile accident        | 19  | Open, tibia, and fibula               | Severe damage of soft tissue| Bacillus subtilis, Proteus      | Survived with amputation     |
| Johnson et al., 1994 [24]     | Arthroscopic knee surgery  | 36  | No fracture                           | No                          | Clostridium septicum            | Survived with amputation     |
|                                | Hip Arthroplasty           | 57  | No fracture                           | No                          | Clostridium Septicum            | Survived                    |
| Dykes, 1977 [25]              | Hip nailing                | 71  | Transcervical fracture of femur       | No                          | Clostridium welchii             | Died                        |
|                                | Hip nailing and plate fixation | 68 | Subtrochanteric fracture of femur     | No                          | Unknown                        | Died                        |
|                                | Hip nailing                | 79  | Transcervical fracture of femur       | No                          | Unknown                        | Died                        |
| Miller et al., 1993 [26]      | Iliac crest bone graft transplantation | 55 | Nonunion of closed fracture of clavicle | No                          | Clostridium perfringens         | Survived                    |

(1) Compound fracture indicates open fracture, while simple fracture means closed fracture.
(2) Bacillus welchii is another expression of Clostridium perfringens.
(3) Clostridium perfringens (formerly known as C. welchii).
Table 2: Clinical outcome, pathogens, fractures locations, fractures, or surgeries types.

(a) Clinical outcome after infection with gas gangrene

| Outcome                | Survived with amputation | Survived with no amputation | Died |
|------------------------|--------------------------|-----------------------------|------|
| Number                 | 25                       | 13                          | 12   |

(b) Pathogen of gas gangrene accompanied with traumatic orthopaedic patients

| Pathogen                  | Clostridium myonecrosis | Non-clostridial myonecrosis | Unidentified |
|---------------------------|-------------------------|-----------------------------|--------------|
| Number                    | 28                      | 3                           | 19           |

_Clostridium myonecrosis_ including Clostridium perfringens and septium while nonclostridial myonecrosis including culture negative; unidentified indicates no detail about the infection pathogen were reported.

(c) Fractures locations together with gas gangrene

| Location                | Tibia and/or fibula | Forearm | Femur | Ankle | Clavicle | Knee | Pelvic | None |
|-------------------------|---------------------|---------|-------|-------|----------|------|--------|------|
| Number                  | 21                  | 14      | 7     | 2     | 1        | 1    | 1      | 5    |

One case involved multiple locations of fractures: forearm, tibia and fibula, and femur; forearm including both or single bones of the forearm.

(d) Fractures or surgeries types associated with gas gangrene

| Fracture severity     | Simple fracture | Compound fracture | Elective orthopaedic surgery |
|------------------------|-----------------|-------------------|-----------------------------|
| Number                 | 25              | 22                | 3                           |

Compound (open) fracture: the bone breaks and pieces of the bone go through the internal soft tissue of the body and break through the skin from the inside.

Table 3: Clinical consideration when gas gangrene is present.

(I) Clostridial myonecrosis (true gas gangrene)
   (A) Localized: crepitant or noncrepitant
   (B) Diffuse: crepitant or noncrepitant together with toxemia

(II) Clostridial cellulitis: anaerobic or crepitant

(III) Nonclostridial
   (A) Bacterial: aerobic aerogenic infections; Staphylococcal fasciitis; anaerobic streptococcal infections
   (B) Nonbacterial: mechanical trauma; infiltration from air-hose injury

myonecrosis, but it has never been found to be intramuscular. Also a large number of other bacterial and nonbacterial lesions which resemble clostridial myonecrosis may be seen in routine clinical practice. Many of these are diagnosed as gas gangrene and diagnostic skill knowledge is necessary for their differentiation [28]. For example, Streptococcal myonecrosis, which clinically resemble a subacute form of clostridial myonecrosis, is the second variety of anaerobic myonecrosis. Clinical considerations are listed in Table 3 when gas gangrene present.

The most common causative organism of clostridial myonecrosis is _C. perfringens_ while _C. septicum_ is considered as the second most frequent agent. _C. perfringens_ is commonly found in the human gastrointestinal tract, including the oral cavity. Myonecrosis resulting from _C. perfringens_ alone after surgical procedures is rather uncommon. Clostridium myonecrosis following orthopaedic surgery is associated with a definite set of conditions: underlying malignancies, hematological and gastrointestinal solid tumors primarily, diabetes mellitus and atherosclerotic disease, and severe peripheral vascular disease [29].

Gas gangrene is an acute and life threatening infection characterized by fever, sudden onset of prominent pain, massive local edema, severe extensive myonecrosis, and the accumulation of gas at the site of infection. The typical manifestation of this disease usually starts with excruciating pain, out of proportion to physical findings, not relieved by pain killers. As the infection progresses, myonecrosis is accompanied by necrotizing fasciitis and cutaneous and muscle necrosis. The appearance of the skin around the site of infection usually becomes tense and changes from pale to bronze initially and then to purplish red, and multiple hemorrhagic bullae develop. Paramount to successful treatment for gas gangrene involves prompt recognition of the diagnosis and initiation multiple therapy including supportive measures, antimicrobial therapy, and timely surgical intervention. Despite this, in many cases of _C. perfringens_ induced gas gangrene, radical amputation still remains the treatment of best choice [30]. If not controlled, it will always result in systemic toxemia, hypotension, shock, multiorgan failure, and death [31]. Hyperbaric oxygen therapy is recommended by some experts but is controversial because its effectiveness has not yet been established.

Still we cannot identify the definitive cause of the clostridial myonecrosis in our case, as both postoperative origins and spontaneously occurrences could be possible. Our case is unique in two aspects. First, as we all know, the responsible organism _C. perfringens_ is mostly associated with development of traumatic gas gangrene but also can be associated with the nontraumatic spontaneous gas gangrene in patients with immunocompromised condition including malignancies and diabetes mellitus [2, 32]. Impaired evacuation and motility of the stomach (and the small intestine)
has been described in diabetics with long lasting unsatisfactory diabetes compensation, microangiopathic complications, and diabetic autonomous neuropathy [33]. Postoperative infection of elective surgical wounds with Clostridium species has been linked to gastrointestinal tract lesions. As clostridia can multiply readily in low-oxygen conditions, infections are usually seen in the setting of decreased intestine lining blood supply which could account for a route of entry for hematogenous spread. Second, gas gangrene rarely occurs in the patients undergoing elective surgery. One of the basic principles of orthopedic surgery is that gas gangrene does not develop in closed fractures. Almost all cases of gas gangrene after orthopedic surgery developed in open wounds which was not adequately debrided, in association with peripheral vascular disease and immunocompromised status. Even patients with closed fracture clostridium gas gangrene also had been found [11]. In our case, a possible mechanism is soil contamination of the skin near or at the infection site, as well as the severe injured soft tissue around the fracture together that contribute to the production histohypoxia environment. All these factors such as immunocompromised status, unviability of tissues, and local decrease of blood supply together nourished the gas gangrene. But the exact origin of the germ remains unknown.

5. Conclusion

Based on the case presented in the paper and our review of the literature on gas gangrene in orthopaedics patients, several following points should be emphasized.

(1) Our emergency clinicians should be aware of this severe and potentially fatal infectious disease and should not delay treatment or prompt orthopedic surgery consultation. Gas gangrene, while rare in now peace days, can be a devastating complication of almost any small wound or surgical procedure even one as common as closed reduction of fractures. It is our experience that we should give sufficient extension of the wound to provide adequate visualization of surgical field so as to be certain that all the necrotic or foreign material has been removed.

(2) Strict aseptic techniques should be observed for even the most minor procedure. Clostridial spores are ubiquitous and can reside in hospital environments, possibly on surgeons’ hands, patients’ skin, topical application, and so on.

(3) The best way to prevent gas gangrene is meticulous wound debridement and delayed closure for all potentially contaminated wounds regardless of closed or open fractures.

(4) Once gas gangrene is diagnosed, careful and adequate debridement should be instituted immediately to avoid further deterioration excision of necrotic tissue still the cornerstone of treatment, which should be involved with antibiotics and all other supportive treatments.

(5) Systematic resuscitative efforts should be instituted immediately in whom the diagnosis of incipient gas gangrene is even considered. This cannot be overemphasized.

(6) Recognized that gas gangrene may occur spontaneously and often in a immunocompromised patient, postoperative wounds may also develop gas gangrene due to the local soft tissue damage and decreasing blood supply.

Consent

Written informed consent was obtained from the patient for publication of this case report.

Conflict of Interests

The authors have no conflict of interests to declare.

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