



Case Report

Traumatic subcutaneous emphysema of the hand/forearm: A case report

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ABSTRACT

Subcutaneous emphysema is commonly associated with infection caused by gas-producing organisms. In this case report, we describe a rare instance of traumatic subcutaneous emphysema of the hand and forearm caused by a puncture injury to the first web space of the hand. Our objective is to increase awareness of the potential for seemingly minor trauma to cause entrapment of significant air in subcutaneous tissues, thereby decreasing the likelihood that a clinically benign-appearing patient will be started down an unnecessarily aggressive treatment pathway.

A 16-year-old, otherwise healthy white female, presented to the pediatric emergency room with an impressive amount of subcutaneous emphysema that developed over a 12-h period after sustaining an accidental laceration to the first web space of her right hand. She appeared nontoxic and had a clinically benign presentation. A comprehensive work-up was performed. She was splinted by the orthopedic surgery resident on call, and was admitted to the Pediatric Intensive Care Unit for overnight monitoring. She received tetanus vaccination and broad-spectrum antibiotics. The patient was discharged 2 days after admittance, with a splint applied to her right hand and forearm. She undertook home-based physical and occupational therapy. She had a pain-free range-of-motion in the right wrist, elbow and shoulder. The swelling in the right hand subsided completely.

Although initially alarming, traumatic subcutaneous emphysema in an otherwise healthy patient from minor wounds (as featured in this case) does not necessarily mean one ought to proceed down an aggressive treatment algorithm. Careful evaluation of the patient's history, clinical examination findings, and determination of the Laboratory Risk Indicator for Necrotizing Fasciitis score can help guide physicians in the management of traumatic subcutaneous emphysema and potentially avoid unnecessary and costly interventions.

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Introduction

Subcutaneous emphysema is defined as the presence of air or gas within the subcutaneous tissue plane. Subcutaneous emphysema of the hand and upper extremity caused by minor trauma is a relatively rare phenomenon; few authors have published isolated case reports on this subject matter.^{1–16} Subcutaneous emphysema must be carefully differentiated from more serious pathological entities (such as gas gangrene or necrotizing fasciitis) because of the rapid progression and high morbidity and mortality associated with such a lesion. In this case report, we describe an instance of traumatic subcutaneous emphysema resulting from a minor wound

to the first web space of the hand. We delineate current guidelines on how to differentiate benign subcutaneous emphysema of the hand from more serious pathologic entities such as gas gangrene or necrotizing fasciitis.

Case report

A 16-year-old, otherwise healthy white female, presented to the pediatric emergency room with a puncture wound to the first web space of her right hand after attempting to remove a cast applied to her right lower extremity with a kitchen knife at home. The patient stated that she was initially unconcerned with her injury but after approximately 12 h, she noticed that her arm began to develop mild swelling and crepitus. The area of swelling and crepitus was initially confined to the dorsum of her right hand; however, she noticed progressive involvement of the volar and dorsal aspects of her right forearm. She denied any significant pain or drainage from

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the wound site, bullae formation, fever, or other systemic signs concerning for infection.

The patient was hemodynamically stable. She was afebrile with a maximum temperature of 36.8°C. Laboratory tests including a complete blood count, basic metabolic panel, erythrocyte sedimentation rate, and C-reactive protein (CRP) level were obtained, all of which were within normal limits. Her laboratory risk indicator for necrotizing fasciitis (LRINEC) score¹⁷ was zero. Screening for COVID-19, MRSA PCR, and Strep A were also negative. On physical examination, there was a small laceration to the midline of the right first web space without significant erythema or drainage (Fig. 1). There was significant crepitus and swelling that extended dorsally to the mid-forearm and volarly to 5 cm proximal to the wrist crease. The upper extremity was non-tender on palpation. The patient's sensory and motor examinations were grossly intact. The range of motion of all joints in the right upper extremity was full and painless. The vascular examination of the right upper extremity showed that the radial pulse was palpable and there was brisk capillary refill to all digits.

Plain radiographs and MRI of the right upper extremity were obtained. Plain radiographs of the right wrist/hand and forearm demonstrated air confined to the subcutaneous tissue layer which did not appear to divide the muscular tissue planes or have heterogeneous invasion through tissue planes (Fig. 2). T₁-weighted fat saturated MRI sequences demonstrated subcutaneous air along the dorsal surface of the hand superficial to the third through fifth digits without involvement of the flexor tendons (Fig. 3).



Fig. 1. Photograph taken of the patient's first webspace of the right hand showing a small laceration to the midline of the right first webspace without significant erythema or drainage.

The patient was given intramuscular tetanus toxoid and a one-time dose of clindamycin and piperacillin-tazobactam by the pediatric emergency department. Due to concern for possible necrotizing fasciitis, the patient was started on intravenous penicillin, clindamycin, and gentamicin. Her right wrist and hand were immobilized in a splint by the on-call orthopedic surgery resident. She was observed over the following two days when her laboratory infectious markers remained within normal limits. The crepitus improved mildly over the course of her admission. The patient was discharged on a 7-day course of oral clindamycin. She was hemodynamically stable at the time of the discharge. Her follow-up was uneventful and no operative intervention was needed.

Discussion

It is important to differentiate between a benign etiology of subcutaneous emphysema from a more serious one as the treatment and outcome of the two differ widely. Crepitus in the soft tissues occurs in traumatic subcutaneous emphysema but can also be concerning for necrotizing fasciitis – a surgical emergency that carries a high morbidity and mortality.¹⁴ In necrotizing fasciitis, microbial gas production typically evolves within 12–18 h of inoculation therefore gas that is present in the subcutaneous tissue before this time period is unlikely to be from an infectious source.⁸ Patients with necrotizing fasciitis may present with constitutional and vital sign aberrations such as fever, chills, hypotension, and tachycardia.¹⁸ Pain out of proportion to physical exam findings is often cited as the most sensitive sign of this infectious process, and is often the first finding to develop.¹⁸ Skin may be discolored, and edema and bullae may be present.¹⁶ There may also be neurological involvement in the form of sensory and motor deficits. Additionally, there are well-established laboratory changes that include a rise in white blood cell count, CRP, blood creatinine (Cr), blood urea nitrogen, and a decline in blood sodium concentration (Na).¹⁷ Characteristic diagnostic imaging findings include gas formation within the muscle and gas that tracks along several different tissue planes.¹⁸ MRI is particularly sensitive in the diagnosis of necrotizing fasciitis. Typical MRI findings for necrotizing fasciitis include edema along fascial planes (indicating inflammatory edema) and liquefactive tissue necrosis which appears bright on T₂-weighted images.¹⁶

In contrast, gas in a patient with traumatic subcutaneous emphysema may be apparent within 6–8 h of injury, and these patients tend to have a normal physical exam apart from local crepitus, swelling, tenderness, and erythema. Patients with a non-infectious etiology lack the systemic aberrations and laboratory changes seen in necrotizing fasciitis.¹⁹ Diagnostic imaging findings include gas that does not violate the muscular layer and remains localized to the loose areolar soft tissue.^{4,14,17}

We emphasize that the diagnosis of traumatic subcutaneous emphysema should be one of exclusion. It is important to rule out the presence of necrotizing fasciitis because, if missed, it can rapidly result in limb amputation or death.^{14,17} Additionally, misdiagnosing traumatic subcutaneous emphysema as necrotizing fasciitis may lead to unnecessary surgery and secondary morbidity.^{3,4,14,18}

Although CT, MRI, and frozen-section biopsy have been shown to be useful in the early recognition of necrotizing fasciitis, the routine application of these modalities in the evaluation of potential cases of necrotizing fasciitis are limited by cost and availability.²⁰ As a result, Wong et al.¹⁷ developed a diagnostic scoring system for distinguishing necrotizing fasciitis from other soft tissue infections based on routine laboratory tests. This score, known as LRINEC, awards points for specific values obtained from 6 common laboratory parameters of interest: CRP, white blood cell count, hemoglobin, Na, Cr, and glucose. A score greater than or equal to 6 is

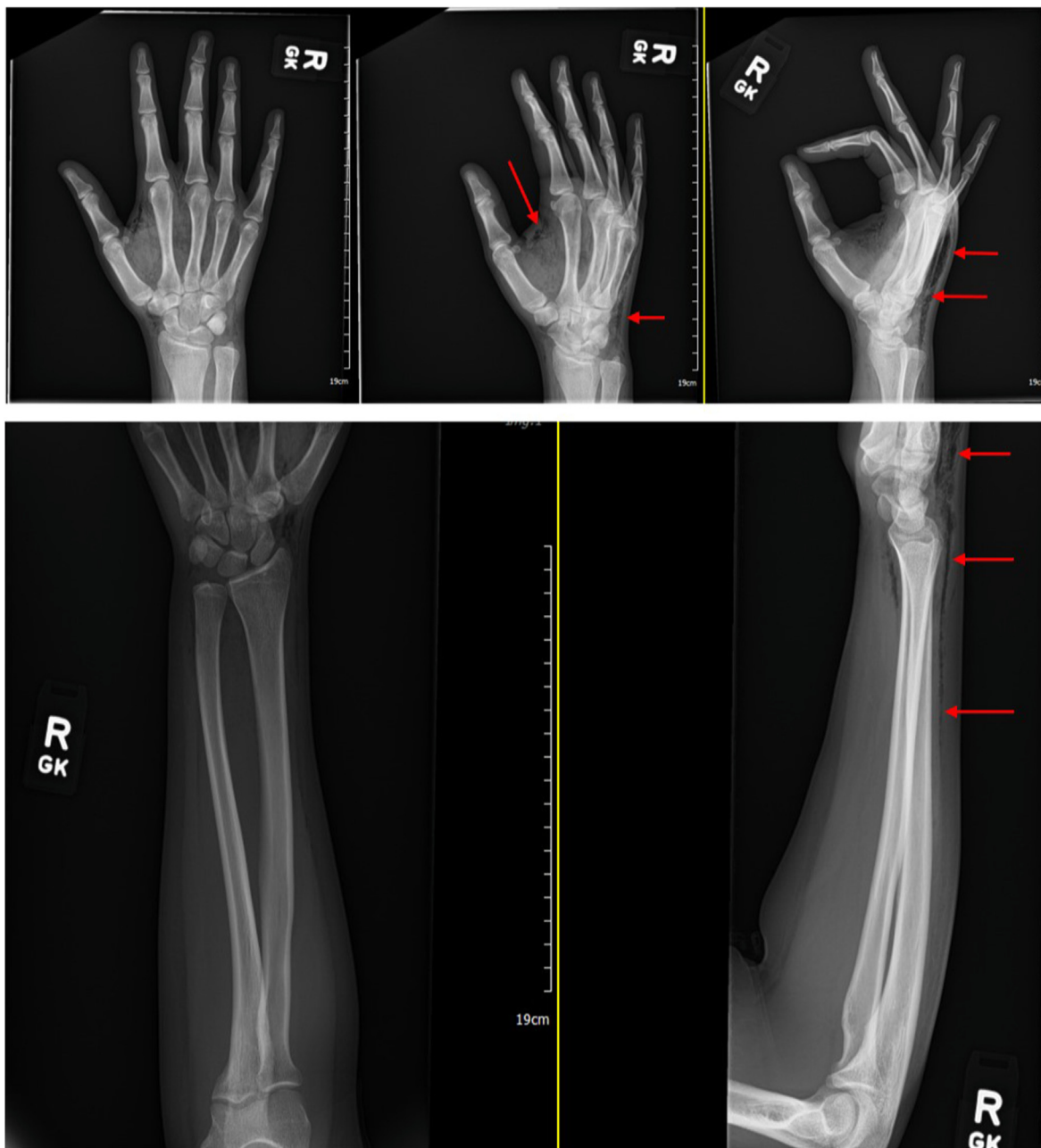


Fig. 2. Plain radiographs of the right hand and forearm demonstrating air confined to the subcutaneous tissue layer that does not appear to divide the muscular tissue or have heterogeneous invasion through various tissue planes.

concerning for necrotizing fasciitis, while a score greater than 8 is strongly predictive of the disease. Furthermore, a score greater than 6 has a positive predictive value of 92% and a negative predictive value of 96% for necrotizing fasciitis.¹⁷ In the patient featured in our case report, the LRINEC score was 0 which carries a very small likelihood of serious infection.

In the present case, the location of the puncture wound offers a possible explanation for the etiology of the patient's clinical presentation. In previous studies, it has been demonstrated that a seemingly trivial puncture wound or laceration can act as a one-way valve to allow air entry into tissues in a manner similar to the generation of a pneumothorax.¹ Most authors agree that traumatic subcutaneous emphysema results when air is sucked through

a break in the skin which acts like a 'ball-valve' type mechanism.^{3–5,8,12–14}

In our case, abduction of the thumb likely led to the generation of negative pressure within the subcutaneous space of the dorsum of the hand, allowing air in the ambient environment through the wound into these tissue layers.²¹ With adduction of the thumb, the break in the skin collapses thereby compressing the soft tissue in the web space, forcing the trapped air along the loose areolar tissue planes of the dorsal and volar aspects of the hand and forearm. This process would have been repeated each time the thumb was abducted and adducted leading to the impressive amount of subcutaneous emphysema found in our patient upon presentation to the pediatric emergency department. This is why the mainstay of treatment for these "sucking wounds" is immobilization, so that

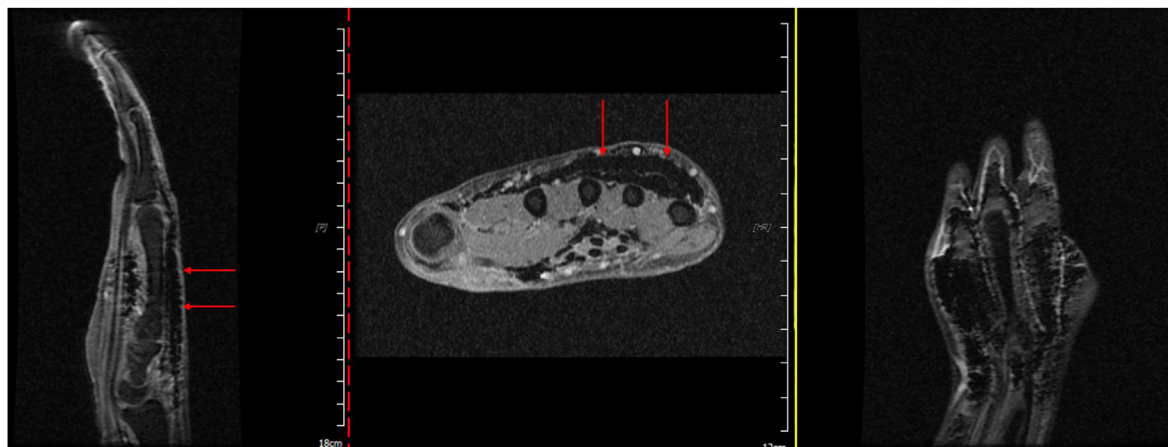


Fig. 3. T₁-weighted fat saturated MRI sequences (sagittal, axial, and coronal views) demonstrating subcutaneous air along the dorsal surface of the hand superficial to the third through fifth digits without involvement of the flexor tendons.

further propagation of this pressure cycle is halted.²¹ Of note, puncture wounds or lacerations in other areas, such as the elbow^{3,5,13,15,22} and the wrist,²³ are other common anatomic sites capable of trapping air subcutaneously in this way and should be considered if subcutaneous emphysema is present in a clinically benign-appearing patient.

There is a general consensus that the majority of patients with uncomplicated traumatic subcutaneous emphysema are able to be treated by conservative measures consisting of an appropriate dressing and a course of antibiotics.⁸ Wound care must be tailored to the specific injury. In contaminated wounds, irrigation and debridement are required, along with a course of broad-spectrum antibiotics. As mentioned previously, after the wound is appropriately dressed, the affected extremity should be immobilized in order to prevent further infiltration of air into the subcutaneous tissues. Whatever air is already trapped within the tissue is typically absorbed by the body over a period of 1–3 weeks without any deleterious health effects.¹⁵

This case report highlights the importance of clinical judgment when faced with a patient presenting with a symptom commonly associated with a surgical emergency. Treatment for traumatic subcutaneous emphysema includes broad-spectrum antibiotics (until an infectious etiology has been ruled out) followed by close observation.^{7,24} Additionally, tetanus toxoid administration should be considered for cases of penetrating trauma. Calculating the LRINEC score of the patient can help the clinician determine if necrotizing fasciitis is a likely diagnosis. If the clinical diagnosis is equivocal, the physician should err on the side of surgical intervention due to the rapid progression of necrotizing fasciitis.¹⁹ We recommend that if the patient does not clinically appear toxic, a full work-up should be completed before serious interventions are undertaken. With proper clinical judgment, work-up, and the appropriate use of therapeutic intervention, traumatic subcutaneous emphysema can be identified and accordingly managed.

A possible weakness of our study is that the patient was only followed up at 10 months after discharge (for a complaint unrelated to traumatic subcutaneous emphysema), and therefore there is no intermittent follow-up data available. Therefore, information regarding the resolution of her symptoms such as the time it took for her subcutaneous emphysema to resolve is unable to be assessed. Nevertheless, this study demonstrates how a minor wound can generate an alarming amount of subcutaneous emphysema, and provides an opportunity to model an appropriate treatment pathway for the pathophysiology described.

In conclusion, a high index of clinical suspicion for the diagnosis of necrotizing fasciitis must be maintained in patients who present with subcutaneous emphysema, swelling, crepitus, and skin discoloration. A detailed history and identification of typical clinical features can help in the diagnosis of traumatic subcutaneous emphysema. A timely diagnosis can help avoid unnecessary surgical intervention as most cases can be treated by supportive measures, such as local dressing, irrigation and debridement (if deemed necessary), and a course of broad-spectrum antibiotics. Our case report highlights the importance of recognizing the fact that not all cases of subcutaneous emphysema of the upper extremity are due to gas gangrene or necrotizing fasciitis.

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Ethical statement

Informed consent has been obtained and all data were confidential except for academic communication.

Declaration of competing interest

All the authors declared no competing interest.

Author contributions

Stephen Saela: Conceptualization, design; acquisition, analysis, interpretation of data; drafting, revision of manuscript; final approval of manuscript; corresponding author; Alexander Decilveo: Conceptualization; acquisition, analysis of data; drafting of manuscript; final approval of manuscript; Roman Isaac: conceptualization, design; analysis, interpretation of data; revision of manuscript; final approval of manuscript; Deepak V. Patel: conceptualization, design; analysis, interpretation of data; revision of manuscript; final approval of manuscript.

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