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Bedside Focused Ultrasound in Necrotizing Fasciitis: The "Black-hole Sign"

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Authors' contributions

This work was carried out in collaboration among all authors. Author AT designed the study and wrote the first draft of the manuscript. Authors AT and RG collected and managed the data. Author RG managed the literature searches. Author NGS supervised the manuscript and obtained research funding. All authors read and approved the final manuscript.

Case Study

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ABSTRACT

Introduction: Necrotizing fasciitis (NF) is a life-threatening infection of soft tissues, requiring prompt diagnosis and an aggressive management.
The role of ultrasonography (US) in emergency setting for early diagnosis of NF was reported in literature, its accuracy being estimated 92% both before and without gas production.
Presentation of the Case: A 65-year old man, with pulmonary metastasis from colon-rectal cancer, treated with chemotherapy, complained of dyspnoea, fever and a dull pain in his left calf for 3 days. Skin was spared and no evidence of tactile alterations or edema was found.
Bedside US focused on the painful zone revealed a small hypo-anechoic area in deep subcutaneous tissue with blurred contours and posterior shadowing ("black-hole sign"), referable to soft tissue necrosis. Thickness and hyperechogenicity of surrounding subcutaneous tissue, due to diffuse inflammatory infiltrate and edema, and thin distal fluid collection along the fascia, were also detected, without gas artifacts. Surgery debridement was performed, tissue cultures yielding *Escherichia Coli*, maybe due to the disruption of bowel mucosal wall.
Discussion and Conclusion: Bedside goal-directed US performed by emergency physician can exclude alternative aetiologies to NF in severe localized pain of the lower extremity. The depiction of blurred focal changes in the soft tissue, configuring an US

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"black-hole sign" and referable to fat necrosis and suppurative infiltration, may represent the main early finding of NF, especially in the idiopathic form. Its identification should alarm physicians, inducing further investigations and close monitoring. The employment of bedside goal-directed US should be stressed in Emergency Department.

Keywords: Necrotizing fasciitis; ultrasound in soft tissue; critical ultrasound; emergency ultrasound; gas gangrene;

1. INTRODUCTION AND AIMS

Necrotizing fasciitis (NF) is a rare but life-threatening bacterial infection of the soft tissues and the deep fascia, sometimes involving the underlying muscles. It requires prompt diagnosis and aggressive multifactorial care, to be started shortly after the patient's admission to the Emergency Department (ED), especially in immunodeficient. Establishing the diagnosis in the early stages of the disease remains the greatest challenge, particularly in idiopathic forms and without skin alterations.

Bedside goal-directed ultrasonography (US) was used in emergency setting in patients with sneaking suspicion of NF, in order to detect early signs and to exclude alternative aetiologies, according to the recent literature report.

2. PRESENTATION OF THE CASE

A 65-year old man, suffering from active colon-rectal cancer with pulmonary metastasis, recently treated with chemotherapy, resorted to the ED complaining of dyspnoea, a worsening dull pain in his left calf for the past 3 days and fever for one day (max 38.3° C). He denied previous thromboembolism. Upon first evaluation the patient had no hemodynamic impairment (SBP 100/70 mmHg, HR 98 beats/minute) and his temperature was normal. The left lower limb appeared to be normal: in particular no evidence of discoloration areas or tactile alterations or unilateral edema was found, in contrast with the severe spontaneous pain also caused by palpation. Routine laboratory and blood tests showed normal white cell count, low platelets and mild anemia. EKG resulted normal.

Because of the high clinical probability of pulmonary embolism based on common clinical decision rules (Wells and revised Geneva scores), a blood gas analysis was carried out, revealing hypoxemia, hypocapnia. Furthermore, in order to exclude deep vein thrombosis, a bedside goal-directed compression ultrasonography (CUS) of the left lower limb was performed by an emergency physician (A.T.) using an Acuson X150™ ultrasound system (Siemens, Erlangen Germany) equipped with a 10.0 MHz small parts probe. CUS evinced no deep vein thrombosis also completed by an examination of the distal veins, but the bedside goal-directed US examination of the patient's left calf didn't identify any alternative diagnosis including hematoma, muscle rupture, arterial damage or popliteal cyst either. However, focused US study revealed as main finding a hypo-anechoic small area with blurred contours and marked edge shadowing, arising from deep subcutaneous tissue and corresponding to the region of the maximum pain produced by pressure of the probe. Thickness and hyperechogenicity of surrounding subcutaneous tissue, due to diffuse inflammatory infiltrate and edema were also depicted (Fig. 1). No typical gas artifacts were detected, but distally a slight fluid collection around the distal fascia was identified. Computed tomography (CT) showed asymmetric thickness of subcutaneous on the left leg

with edema, inflammation and separation of muscular fascia, and identified the distal perifascial fluid collection. Neither muscular involvement nor soft tissue gas were found, substantially confirming the diagnostic suspicion of NF (Fig. 2).

The patient underwent prompt surgical debridement with clinical benefit: soft tissue necrosis and muscle ischemia were confirmed. Several tissue cultures and hemocultures were collected and both of them yielded Escherichia Coli. An antibiotic therapy was promptly started, with meropenem, clindamycin and teicoplanin. During the following days leg tissues, including muscles, became more and more necrotic so that the surgeons suggested the amputation of the left leg, which was refused by the patient and his relatives. A conservative and palliative treatment was chosen, so the physicians tried to stop the necrotic process and infection spreading through empiric local application of antiseptic alcohol solution, thus leading to a “chemical amputation”, without any result. The patient was discharged to family care.

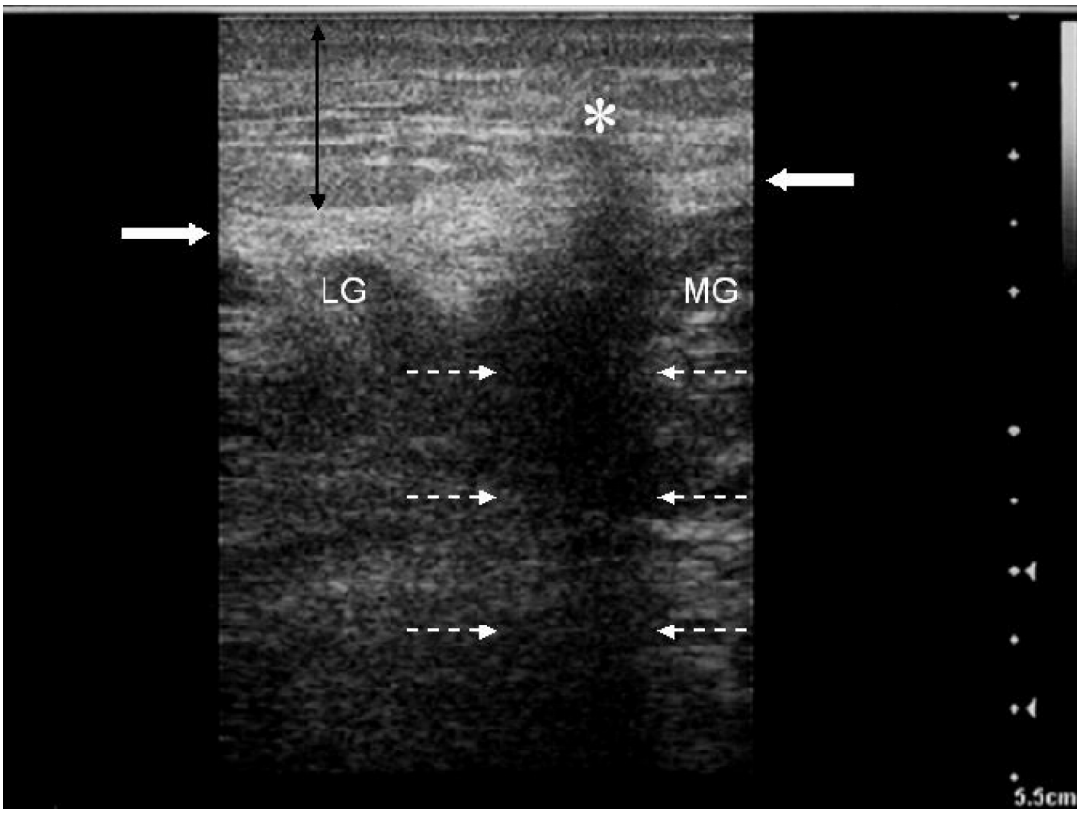

Fig. 1. Bedside focused US on left calf in necrotizing fasciitis manifesting as a vague anechoic area in superficial soft tissue (*), due to fat necrosis and suppurative infiltration, with posterior shadowing (broken opposing white arrows) which seems to break the underlying fascia. Subcutaneous tissue appears thick and hyperechoic due to diffuse inflammatory infiltrate (vertical arrow).

Legend: LG=lateral gemellus muscle; MG=medial gemellus muscle.

Fig. 2. CT imaging of left and right calf showing the asymmetric thickness of subcutaneous on the left side (white arrow), where edema, inflammation and separation of muscular fascia are present. Neither muscular involvement nor soft tissue gas were present. Distal slight fluid collection was detected (not shown in this image).

3. DISCUSSION

NF is a rare, lethal form of cellulitis, its mortality varying from 16% to 24%, involving the subcutaneous tissue and fascia, sometimes involving the underlying muscles, for which a laboratory risk indicator score was also proposed in order to distinguish necrotizing from non-necrotizing soft-tissue infections [1]. However, establishing the diagnosis in the early stages of the disease remains the greatest challenge. In fact, at the onset, patients usually complain of spontaneous intense local pain disproportionate to the physical findings, including the normal appearance of the skin. Due to toxemia and systemic inflammatory response syndrome (SIRS), progression of disease is often very rapid [2].

NF epidemiology has changed in recent years. We notice a reduction in the number of cases related to wounds, probably due to better management and the availability of antibiotics. Conversely, there has been an increase in the number of idiopathic NF, because of the growing number of people with immunodeficiencies [2].

Idiopathic NF diagnosis may be particularly challenging because it occurs in the absence of a known cause or without a recognized portal of entry for bacteria. Related conditions include diabetes mellitus, alcoholism, remote infection, pregnancy, age over 55, presence of comorbid illnesses like chronic renal failure, cancer and congestive heart failure [3,4,5], while female gender, presence of malignant disease, and diabetes mellitus were found to be associated with increased mortality [5].

Extremities, perineum and abdomen are affected in decreased order of incidence. The majority of patients has polymicrobial infections: group A Streptococci, Staphylococcus aureus, E. coli, Pseudomonas, Enterobacter, Klebsiella and Proteus. Among the anaerobic bacteria Bacteroides, Clostridium and Peptostreptococcus could be responsible of NF [1].

NF requires prompt diagnosis and aggressive multifactorial care, to be started as soon as possible, even upon first evaluation in ED [6]. Prompt surgical debridement of necrotic tissues and antibiotic therapy are crucial.

MRI, or tissue biopsy, should be considered the gold standard for diagnosis of NF, and its application with fat suppression can help distinguish between cellulitis and NF, demonstrating fascia involvement in the latter [7]. However, often MRI examination is not available in ED. Moreover, performing these examinations takes too long, delaying treatment.

CT scan findings may be minimal in the early stage. However, CT remains the main imaging modality to detect even small fluid, air collections and asymmetric fascial thickening in ED [2]. US is an increasingly widespread tool in emergency setting, notably useful for evaluation of musculoskeletal infections because it is rapid, low cost, safe, accessible to bedside, and effective even when performed by novice physicians [8]. Moreover, US images are not disturbed by metallic or motion artifacts (as with CT and MRI) [9].

US, in comparison to plain radiography, can detect “gas sign” as well, if gangrene occurs. Moreover, it can provide imaging details of: a) diffuse thickening of subcutaneous tissue, b) irregularity and thickening of the fascia, and c) abnormal fluid collection along the fascial plane; moreover, US can depict abnormal muscle architecture, if myonecrosis occurs and provide assistance to fine-needle aspiration [2,9,10,11]. On the other hand, US can help to exclude alternative diagnosis of disproportionate localized pain, including thrombosis, hematoma, muscle rupture, popliteal cyst, thus inducing to perform further studies. Finally, bedside goal-directed US is a dynamic study, which combines clinical information with the imaging findings.

US limitations include its lower specificity than CT and MRI, inability to explore unapproachable or deep sites, the difficulty to perform US in very painful zones or to investigate superficial lesions, and poor objectivity [12].

In our case report, the small anechoic area producing distal shadowing, corresponding to the painful area and referred to focal fat necrosis and suppurative infiltration, was the most evident US sign in the early stage of NF. This sign, although aspecific since mimicking malignancy or abscess, was not previously described in NF. Due to its sonographic presentation as “a region from which tissue texture prevents any US beam from escaping”, we named it “black-hole sign”.

The portal of entry for infection by *E. Coli* was probably the disruption of bowel mucosal wall due to the colorectal cancer in our patient. The germ penetrates into the blood stream and causes in such areas as the calf a vasculitis with thrombosis of regional vessels, then toxins cause inflammation of the skin, subcutaneous fat and fascia that those vessels supply.

In literature cases were described of NF caused by *E. Coli* positive for K1 antigen, that provides the germ with a polysaccharide capsule that helps to evade phagocytosis and escape complement-mediated killing. K1 antigen was found in approximately one quarter of *E. Coli* blood culture isolate and particularly the cases of *E. Coli* sepsis [13].

4. CONCLUSION

Differentiation of NF from a less dangerous soft tissue infection is not easy based exclusively on physical examination. In fact crepitus is found very late and in only 12-36% of patients with NF. Even plain radiography can detect gas in the soft tissues only in 17-57% of patients [14]. The role of bedside goal-directed us in ED for early diagnosis of NF has been previously reported in literature, its accuracy being estimated at 92% both before and without gas production [15]. Emergency US can also distinguish air contamination of a penetrating wound in soft tissue [16] from a gas-producing bacterial infection [17]. It is recommended to include the “black-hole sign”, the vague hypo-anechoic area with posterior shadowing due to soft tissue necrosis and inflammatory cells infiltration, among the US signs generally recognized in early stage of NF. Bedside US employment should be stressed in the ED in order to avoid loss of time for the prompt management of these life-threatening situations.

CONSENT

Not applicable.

ETHICAL APPROVAL

All authors hereby declare that data collection have been performed without risk for the patient and in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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