POINT-OF-CARE ULTRASOUND IN THE EARLY DIAGNOSIS OF NECROTIZING FASCIITIS

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ABSTRACT

The aim: To detect the ultrasonographic signs of necrotizing fasciitis (NF) suitable for its early diagnosis. **Materials and methods:** Eigty two patients with soft tissue infection, including 14 with necrotizing faciitis, were examined by ultrasonography at the admission. Ultrasonografic features were compared to intraoperative findings by the same surgeon.

Results: The thickening of subcutaneous tissue had high sensitivity (100%), but low specificity (5.8%). The hypoechoic and hyperechoic zones had the shape of "cobblestone" with sensitivity – 78.5%, specificity – 33.8%. Higher specificity (69.1%) had sign of "cobblestone separation" on two layers. The presence of fluid above the fascia (sensitivity – 71.4%; specificity – 69.1%), thickening of the fascia (sensitivity – 85.7%; specificity – 58.8%), indistinctness of the fascia edges (sensitivity – 85.7%; specificity – 66.1%) and loss of fascial homogeneity (sensitivity – 71.4%, specificity – 66.1%) were noted in early stages of NF. Advanced cases of NF were accompanied by the dissection of thickened fascia (sensitivity – 28.5%), specificity – 92.6%) and accumulation of a fluid under the fascia (sensitivity – 28.5%, specificity – 95.5%). The muscles thickening (sensitivity – 28.5%; specificity – 67.6%), skin thickening (sensitivity – 57.1%; specificity – 58.8%), and loss of the skin's lower edge clarity (sensitivity – 57.1%; specificity – 63.2%) don't have diagnostic value without other signs of NF.

Conclusions: Point-of-care ultrasonography allows visualization of soft tissue changes that may be hidden in the initial stages of necrotizing fasciitis and should be recommended for implementation as mandatory method of examination in patients with suspected surgical soft tissue infection.

KEY WORDS: soft tissue infection, necrotizing fasciitis, ultrasound, early diagnosis

INTRODUCTION

Necrotizing fasciitis is a life-threatening surgical infection of soft tissues. The primary pathological process develops in the depth of the tissues, between the deep and superficial fascia, and gradually spreads horizontally along these structures without involving the overlying skin at an early stage. Due to this feature, the manifestation of external skin evidence of necrotizing fasciitis lags in time from the actual course of the destructive process in the thickness of soft tissues. Even with the appearance of the first skin symptoms, their visual evaluation is very subjective to establish this threatening diagnosis. Only with the appearance of late markers, blisters with cloudy contents, and skin necrosis, which are combined with systemic dysfunction, the diagnosis of necrotizing fasciitis become evident. Unfortunately, the diagnosis of necrotizing fasciitis at this late stage is far too late for effective surgical treatment. It has been proven that when surgical intervention is performed later than 24 hours after the onset of the disease, mortality due to necrotizing fasciitis significantly increases [1]. Therefore, the key to the successful treatment of necrotizing fasciitis is its early diagnosis. Modern medical technologies offer several methods that allow the doctor to see the deep layers of subcutaneous fat and fascia, where the initial destructive changes occur in necrotizing fasciitis, from ultrasonography to computer tomography (CT) and magnetic resonance imaging (MRI). Today, CT and MRI allow us to visualize any hidden to the naked eye pathological process in the human body, including necrotizing fasciitis [2]. However, the cost of this examination, the ability to perform it only in specially equipped rooms, waiting for the interpretation of the results, and side effects (irradiation, a significant magnetic field) substantially narrow the possibilities for using these methods for a quick, early, and screening examination of patients with suspected necrotizing fasciitis. Until recently, ultrasonography had the same limitations regarding its use for necrotizing fasciitis diagnosis. Although a quarter of a century has passed since the first publication analyzing the possibility of using ultrasound diagnostics for the early detection of signs of necrotizing fasciitis, this idea did not gain popularity for a long time [3]. It was due to the considerable cost and dimensions of ultrasonography devices, which occupied separate, specially equipped rooms and the examinations were performed and interpreted by a radiologist. The appearance of

© Aluna Publishing Wiadomości Lekarskie, VOLUME LXXV, ISSUE 10, OCTOBER 2022 portable, mobile, and even pocket ultrasonography devices changed the monopoly of radiologists on their use.

It led to the development of a separate direction in medicine: point-of-care ultrasound (POCUS), which means performing ultrasound diagnostics by a doctor of any specialty at any stage of providing medical care: from the ambulance to intraoperative use. As a natural result, the number of scientific publications devoted to ultrasonographic characteristics of soft tissue infections has increased in the past five years [4-6]. At the same time, performing ultrasonographic findings may be useful for identifying previously unnoticed additional criteria for early ultrasonographic diagnosis of necrotizing fasciitis.

THE AIM

To detect the ultrasonographic signs of necrotizing fasciitis suitable for early diagnosis, based on the comparison of ultrasonographic, local clinical, and intraoperative signs of necrotizing fasciitis.

MATERIALS AND METHODS

The study was carried out in the surgical clinics of the Danylo Halytsky Lviv National Medical University for 12 months from August 2021 to July 2022. Point-of-care ultrasound (POCUS) was performed in patients with suspected surgical soft tissue infection using portable ultrasound devices with 12-MHz linear probe. In all patients, the examinations were performed personally by surgeons with ultrasonographic examination skills, who later participated in the surgical intervention and were able to compare the ultrasonographic and intraoperative findings. Results of ultrasonography, external local clinical signs, and intraoperative findings of the patients were recorded in a database and later analyzed retrospectively. The medical data of 82 patients who consented to processing their medical and graphic data were enrolled in the analysis, including 14 patients with necrotizing fasciitis and 68 patients with other forms of surgical soft tissue infection who underwent surgery, and their diagnosis was confirmed intraoperatively. Patients with demarcated accumulations of fluid in soft tissues in the form of an abscess were not included in the study. For each ultrasonographic sign, sensitivity and specificity were calculated using an online calculator (medcalc.org).

RESULTS

After analyzing the ultrasonographic changes in patients with necrotizing fasciitis and comparing them with preoperative visually noticeable signs of the skin and intraoperative findings, we identified a few characteristic features in different anatomical layers of soft tissues.

For surgical soft tissue infection, one of the earliest clinical symptoms is local swelling or infiltrate. Ultrasonographically, it is manifested by thickening of the subcutaneous tissue, which we observed in all 14 patients with necrotizing fasciitis (sensitivity -100%). However, this symptom is not unique to necrotizing fasciitis and can occur in cellulitis, lymphostasis, anasarca, allergic edema, and many other conditions not associated with surgical infection. Despite the detected low specificity (5.8%), this symptom should not be neglected. Thickening of the subcutaneous tissue should pay attention to the area of the potential problem and encourage the physician to look for other ultrasonographic signs in that anatomic area.

In patients with initial manifestations of necrotizing fasciitis, one of the very characteristic ultrasonographic signs was the appearance of the "cobblestone" symptom. This name is caused by the graphic similarity of the ultrasonographic image with hypoechoic zones that pass between hyperechoic zones of the subcutaneous tissue with the contours of irregularly shaped stones (Fig.1).

In our study, we found the "cobblestone" sign in 11 (78.5%) patients with necrotizing fasciitis (sensitivity -78.5%, specificity -33.8%). In the literature, this ultrasonographic sign is considered more characteristic of cellulitis [7].

However, in contrast to cellulitis, in the initial stage of necrotizing fasciitis, we found other regularities.

In particular, with necrotizing fasciitis, the hypoechoic zone prevails in the lower half of the subcutaneous tissue, which, in our opinion, is more characteristic of necrotizing fasciitis, in contrast to cellulitis and swelling of the subcutaneous tissue. We suggest paying attention to such a feature as a separate symptom of the "separation of cobblestone" into two layers. The sensitivity of this symptom was 78.5%, and the specificity -69.1%.

It should be noted that with the progression of necrotizing fasciitis and the formation of visually noticeable signs of skin necrosis, the symptom of "cobblestone" and "dissection" may disappear around necrotic changes, at the same time, they can be detected along the perimeter, on the border with undamaged soft tissues.

© Aluna Publishing Wiadomości Lekarskie, VOLUME LXXV, ISSUE 10, OCTOBER 2022 The progression of necrotizing fasciitis and the fluid accumulation in the lower layers of the subcutaneous tissue finally led to the formation of a well-visible (>2 mm) layer of fluid over the deep fascia. This feature is very important for the diagnosis of necrotizing fasciitis because it is accompanied by enough high indicators of both sensitivity (71.4%) and specificity (69.1%). These data are very close to the data described in the literature (75.0% and 70.2%, respectively) [8].

Of course, in patients with necrotizing fasciitis, ultrasonographic changes in the fascia deserve the most attention.

The early stage of necrotizing fasciitis is characterized by swelling and thickening of the fascia >2mm, which has enough high sensitivity (85.7%), but insufficient specificity (58.8%). Usually, swelling of the deep fascia is combined with indistinctness and unevenness of the fascia edges (sensitivity – 85.7%, specificity – 66.1%) and loss of homogeneity (sensitivity – 71.4%, specificity – 66.1%).

With the progression of colliquative necrosis, two more ultrasonographic signs are added, which we consider being very important criteria in the diagnosis of necrotizing fasciitis – a dissection of thickened fascia with a strip of fluid (sensitivity – 57.1%, specificity – 92.6%) and accumulation of a fluid layer under the fascia (sensitivity – 28.5%, specificity – 95.5%) (Fig.2).



Fig. 1. Ultrasonographic sign of necrotizing fasciitis at the initial stage with early skin manifestation

a. thickening of the subcutaneous tissue

b. "cobblestoning" and its separation into two layers

c. fascial thickening, loss of homogenity, indistinctness of the fascia edge,

d. thickening of the skin and indistinctness of the skin lower edge.

Fig. 2. Ultrasonographic sign of the advanced stage of necrotizing fasciitis.

a. dissection, swelling and heterogeneity of the deep fascia,

b. hypoechoic shadow under the fascia (fluid strip),

c. thickening and hypoechoic zones of muscle tissue

d. thickening of the skin and unevenness of its lower edge.

These findings are primarily valuable due to their high specificity, which is the highest among other ultrasonographic signs we were able to detect in this study. In our opinion, these symptoms arise due to the fascia losing its barrier function and resistance. In such patients, during surgical intervention, the fascia is easily dissected under the surgeon's finger, which has received the name of the well-known "finger test" [9]. At the same time, a cloudy exudate in the form of "dishwater fluid" is released. For a long time, these clinical tests were the only method to confirm or deny necrotizing fasciitis. For this purpose, it was proposed to make a small diagnostic incision under local anesthesia and by finger or surgical clamp to dissect the soft tissues at the level of the fascia. The disadvantage of this manipulation is its invasive nature.

Therefore, we interpret such ultrasonographic findings as a dissection of the thickened fascia with a strip of fluid and/ or the presence of fluid under the fascia as a non-invasive analog of the "finger test".

When the fluid penetrates under the deep fascia, we also noted certain ultrasonographic changes in the muscle layer – thickening of the muscles and changes in the echogenicity of the muscle. However, both signs were accompanied by low sensitivity (28.5%) and insufficient specificity (67.6%).

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In patients with necrotizing fasciitis, the skin changes are secondary to the underlying pathological process in the deeper layers of the soft tissues. In patients with necrotizing fasciitis, ultrasonographic skin changes may be accompanied by skin thickening and loss of clarity of the skin's lower edge. We observed these symptoms only in combination with other above-described changes in the subcutaneous tissue. Skin thickening had a sensitivity of 57.1% and a specificity of 58.8%, and loss of clarity of the skin's lower edge was 57.1% and 63.2%, respectively. We do not consider these ultrasonographic signs characteristic for the diagnosis of necrotizing fasciitis. However, in combination with other signs, we suggest considering them because they can be an addition to the early manifestations of necrotizing fasciitis. We always noted them in areas of changed skin in the form of "lemon peel".

As we observed, in necrotizing fasciitis, ultrasonographic changes were not uniform on all surfaces. Usually, the area with the largest number of ultrasonographic signs was noted, around which excentrically extended zones with less expressed signs or their smaller number. In our opinion, changes in these peripheral areas, almost at the border with healthy skin, can provide valuable information for the analysis of tissue changes inherent in the early stage of necrotizing fasciitis.

DISCUSSION

For the first time, the idea of using ultrasonography for the early diagnosis of necrotizing fasciitis was described in the literature by Tsai CC et al. in 1996. He described ultrasonographic changes in five patients and suggested relying on such ultrasonographic signs as 1) irregularity of the fascia; 2) abnormal fluid collections along the fascia plane; and 3) diffuse thickening of the fascia when compared with the control site in the normal limb [3].

Despite this, the idea did not have a general application for a long time. At the same time, the diagnostic capabilities of computed tomography and magnetic resonance imaging for visualization of hidden to the eye changes in soft tissues in patients with necrotizing fasciitis are being described [2,10,11].

However, these methods were also not useful for the early diagnosis of necrotizing fasciitis due to inaccessibility for routine use by doctors in the emergency department, high cost, and considerable waiting time for the description of the examination results.

Only after the appearance on the market of more portable ultrasonography devices, tenfold decrease in their price for the last decades, opened new opportunities in the use of point-of-care ultrasonography by emergency physicians and general surgeons. Developers of pocket devices that have appeared on the market in the last three years claim that soon insonation will be considered as important a component of the initial examination of the patient as palpation, percussion, auscultation, and the ultrasound device is called the "stethoscope of the 21st century" [12-14].

Evidence of this is the introduction of numerous pointof-care ultrasonography protocols: FAST, RUSH, BLUE, CAUSE, etc. [7]. Naturally, the idea about the possibilities of ultrasonographic diagnosis of soft tissue infections, in particular, necrotizing fasciitis, was revived [15-18].

In our opinion, performing point-of-care ultrasonography personally by a surgeon at the stage of preoperative diagnosis and comparing the findings with clinical manifestations and intraoperative signs, gives a much better chance of detecting changes that may seem unimportant to a radiologist.

During ultrasonography of soft tissues, it is important to compare the detected signs with a similar area in a symmetrical part of the body. It will allow reducing the number of false positive signs.

We understand that the small study group of our study may have influenced the calculated sensitivity and specificity of each sign. At the same time, we hope that our study made it possible to pay attention to other ultrasonographic signs that were not previously described. For example, separation of the "cobblestone" into two layers in the subcutaneous tissue, thickening and loss of clarity of the dermis lower edge.

It should be noted, that in any of the clinical cases, we did not find described in the literature hypoechoic inclusions with an acoustic shadow, which are characteristic of the air accumulation in the subcutaneous tissue and anaerobic forms of necrotizing fasciitis [19].

© Aluna Publishing Wiadomości Lekarskie, VOLUME LXXV, ISSUE 10, OCTOBER 2022 Ultrasonographic symptoms with high specificity – the dissection of the fascia with fluid and the presence of a fluid layer under the deep fascia, should be interpreted as "severe" ultrasonographic criteria of necrotizing fasciitis. Additional signs can be the symptom of a cobblestoning with dissection on two layer and a fluid layer over the fascia with a specificity of 69.1%. In doubtful cases, if there is a fluid layer over the fascia, a puncture and aspiration of the fluid can be performed under the control of ultrasonography for visual assessment and bacteriological examination. We are convinced that this additional manipulation under ultrasound control will be able to significantly increase the accuracy of the preoperative examination when necrotizing fasciitis is suspected.

CONCLUSIONS

Point-of-care ultrasonography allows visualization of changes in soft tissues that may be hidden in the initial stages of necrotizing fasciitis and should be recommended for implementation as mandatory method of examination in patients with suspected surgical infection of soft tissues.

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