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Emergency ultrasonography in patients with clinically suspected soft tissue infection of the legs

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INTRODUCTION We aimed to retrospectively review the ultrasonography (US) findings of patients with clinically suspected soft tissue infection of the legs and to determine whether there is a correlation between US diagnosis and further clinical management.

METHODS We reviewed the US findings of consecutive patients with clinically suspected soft tissue infection of the legs who were referred for emergency US during a consecutive two-year period. The indications for US were recorded and the findings evaluated. The effect of the US findings on further clinical management (medication alone versus medication with surgical intervention [SI]) was reviewed.

RESULTS A total of 51 legs from 38 patients were enrolled in the study. The most common indication for US was to rule out necrotising fasciitis (35.3%). The most frequent US diagnosis was isolated cellulitis (21.6%). Both groups of patients (with and without abscess) were treated with medication with or without SI. There was no statistically significant correlation between the presence or absence of abscess and further clinical management ($p = 0.216$), between the size (length and thickness) of the abscess and the type of SI ($p = 0.687$ and 0.243, respectively).

CONCLUSION In our study, the most frequent US diagnosis was isolated cellulitis, and we found no significant correlation between US findings and clinical management (medication or SI). Our results should encourage sonologists to evaluate in detail patients with clinically suspected soft tissue infection of the legs and to provide information regarding each layer of tissue studied.

Keywords: emergency, infection, leg, soft tissue, ultrasonography
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INTRODUCTION

Ultrasonography (US) is a widely used modality for evaluation of musculoskeletal (MSK) pathology. Although it is unable to provide a full visual assessment, US can provide faster results than any other diagnostic modality, particularly for the appendicular skeleton.[1-3] Furthermore, US can be used both in diagnosis and as an aid in performing intervention.[3,4] Fluid collection or abscess formation, which should be considered for surgical indication, is also well detected by US. The addition of colour and power Doppler techniques, including volumetric measurement, makes US an effective modality for diagnosis and follow-up.[3]

Infections of the MSK system are commonly found in clinical practice, and in some instances, as medical emergencies. Soft tissue infections mostly respond rapidly to appropriate therapy (rest, elevation of limb, pain relief and antibiotics), but more advanced cases with irreversible tissue damage may need urgent and radical surgery as a life-saving procedure. Prompt diagnosis and treatment are therefore important. We conducted this study in order to review US findings in patients with clinically suspected soft tissue infection of the legs, and to determine whether there is a correlation between US diagnoses and further clinical management.

METHODS

This was a cross-sectional, retrospective review of the US findings in patients with clinically suspected soft tissue infection of the legs, who underwent emergency US in the Department of Radiology, Ramathibodi hospital, Thailand, in a consecutive two-year period. This study was approved by the Ethical Review Board of the hospital. Inclusion criteria were all patients who had clinically suspected soft tissue infection of the legs or needed to rule out this condition, and who requested emergency US. Exclusion criteria were patients with unavailable or incomplete clinical data and those with unknown definite diagnosis or treatment.

During office hours, US was performed by a radiology resident under supervision of the radiology fellow or staff. After office hours, it was performed by a senior radiology resident and reviewed by the staff the next day. The US findings were classified into six patterns: (1) swelling of the skin and subcutaneous tissue, including cobblestone appearance; (2) perifascial fluid; (3) thickened fascia > 4 mm or distorted fascia; (4) fluid accumulation in the fascial planes; (5) muscle swelling to ill-defined hypoechogenicity; and (6) localised fluid collection (abscess).

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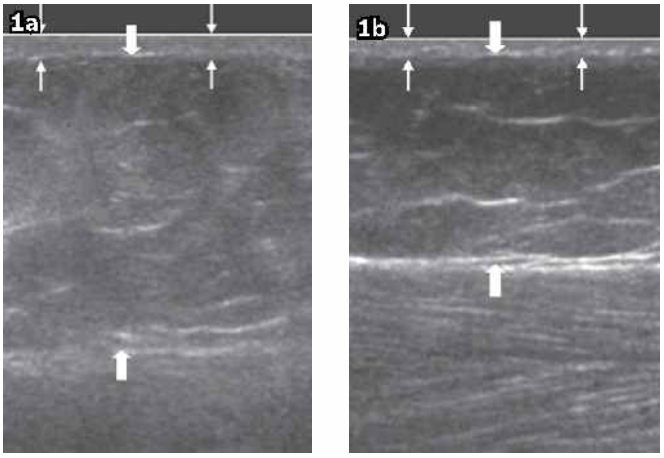

Fig. 1 a) US finding of cellulitis. Longitudinal image at the right calf shows (a) thickening of the skin (between thin arrows) and subcutaneous fatty tissue swelling (between thick arrows) with generalised increased echogenicity; and (b) normal skin (between thin arrows) and normal subcutaneous fatty tissue (between thick arrows) on the other side for comparison.

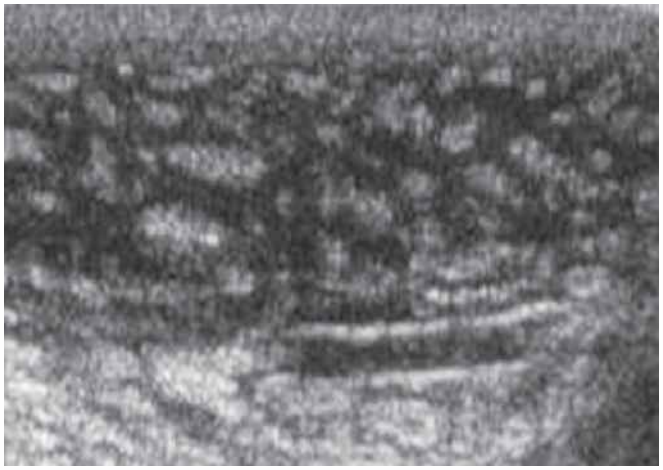

Fig. 2 US finding of cellulitis. Longitudinal image at the dorsum of the right foot shows cobblestone appearance, created by fluid (hypoechogenicity) traversing among and separating the fat lobules (look like hyperechoic nodules).

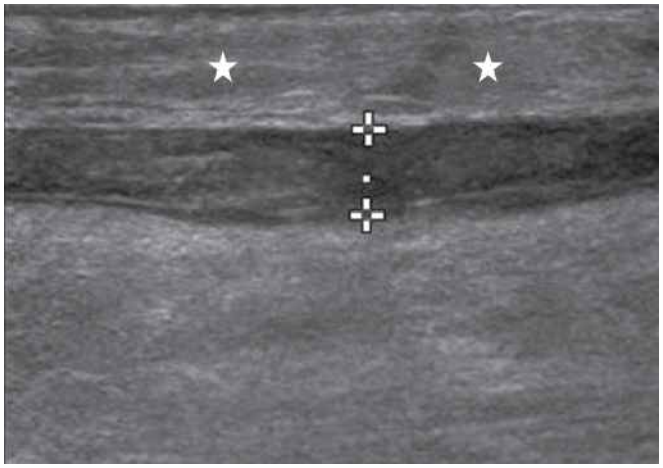

Fig. 3 US finding of fasciitis. Longitudinal image at the left calf shows turbid fluid within the fascial planes (measured). Accompanying subcutaneous tissue swelling (cellulitis) is also detected (stars).'+' denotes markers for measurement.

Cellulitis was defined as the swelling of skin and subcutaneous tissue, including cobblestone appearance alone or together with perifascial fluid on US.[5-7] The US appearances ranged from thickening of the skin with increased echogenicity of subcutaneous tissue to the stage when there were hypoechoic strands (fluid) that traversed among the hyperechoic subcutaneous fat lobules, resulting in a cobblestone appearance (Figs. 1 & 2). There may be a thin layer of fluid outlining the adjacent fascias. Doppler or colour images helped identify hyperaemia of the diseased tissue, although they could not differentiate between inflammation and infection.

Fasciitis was defined as the presence of thickened fascia > 4 mm or distorted fascia alone, fluid accumulation in the fascial planes alone, or both (Fig. 3).[8,9] Variable swelling of the subcutaneous tissue and muscle was identified. Myositis was defined as the appearance of muscle swelling to ill-defined hypoechogenicity alone on US. In the early stage, there was ill-defined hypoechogenicity within the muscle due to inflammatory process (Fig. 4). Hyperechogenicity was also found, which represented muscle swelling. If left untreated, there would be liquefaction of the hypoechoic area, causing fluid collection or abscess formation.[3,4] Abscess formation was defined as the presence of localised fluid collection (abscess) alone. An abscess was a localised collection of fluid filled with inflammatory cells, necrotic tissue and bacterial organisms.[4,8] It had variable sonographic appearances ranging from ill-defined hypo-echogenicity to a localised fluid collection with hyperaemic wall (Fig. 5).

Three models of US machines were used: Prosound SSD-5000 (Aloka, Tokyo, Japan); HDI-5000 system and iU 22 system (Philips, Amsterdam, The Netherlands). The transducers were 5.0–12.0 MHz linear array transducers available for examining small body parts. The images were stored in the Picture Archiving and Communication System and/or Radiology Information System. The patients' history, clinical indications for emergency US and the US diagnoses were recorded. Further clinical management was reviewed from the medical records until the patients were discharged, and were classified into medication alone (mainly antibiotics), medication with surgical intervention (SI), which could be aspiration, incision and drainage (I/D), or open surgery (e.g. fasciotomy, debridement). The discharge status was classified as improved, stable or died.

Data was analysed by the following methods: (1) The primary result was a descriptive study for patient characteristics such as gender, age, underlying disease, history and presenting symptom, along with clinical indication for emergency US; (2) US findings and diagnoses, using descriptive statistics; (3) Correlation between US diagnosis (presence or absence of abscess) and further clinical management (medication alone or with SI), and correlation between the size of abscess and the type of SI, using Pearson's chi-square test, with $p < 0.05$ considered statistically significant.

RESULTS

A total of 40 patients were enrolled over a consecutive two-year period. Two patients were excluded due to incomplete data, thus resulting in 38 patients (51 legs). Emergency US of both legs was

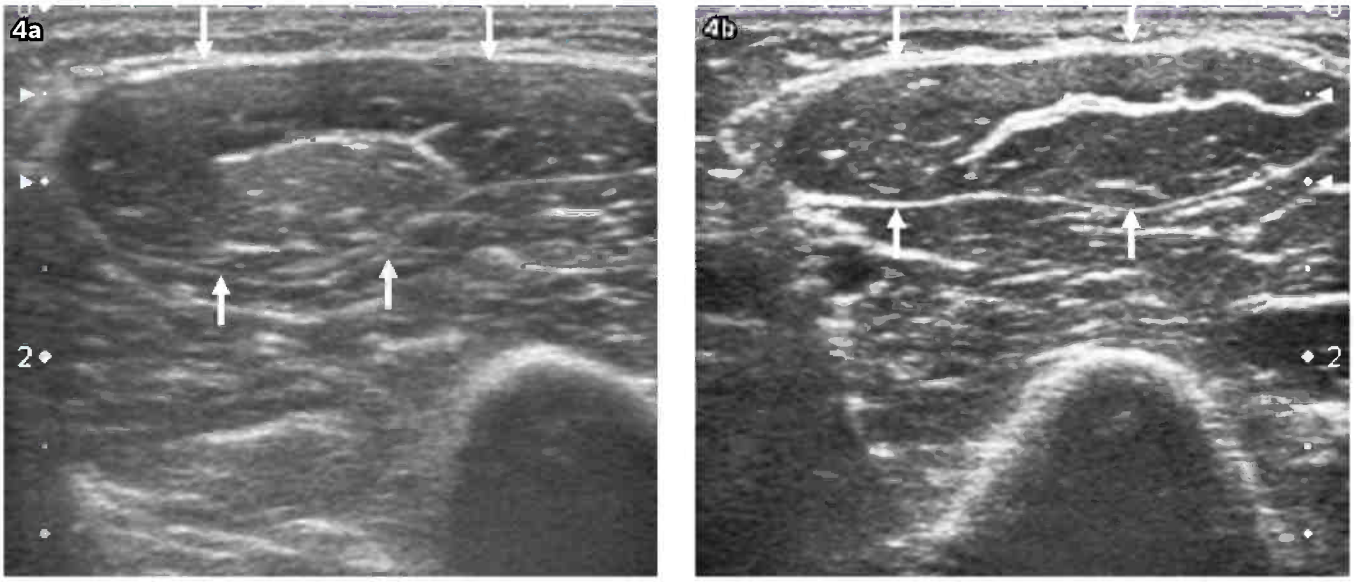

Fig. 4 US finding of myositis. Transverse image at the volar side of the right arm of a patient with calf infection shows (a) swelling of the biceps brachii muscle with decreased echogenicity (between arrows), as compared to (b) the normal left side.

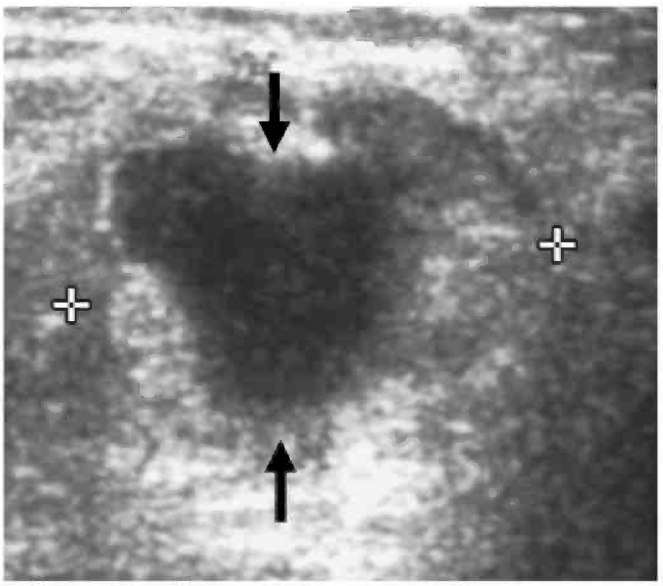

Fig. 5 US finding of fluid collection/abscess. Transverse image at the left calf shows an irregular-shaped localised fluid collection (between arrows). '+' denotes markers for measurement.

Table I. Clinical features of the patients.

Clinical feature	No. (%)
Gender (n = 38)	
Male	25 (65.8)
Female	13 (34.2)
Presence of underlying disease (n = 38)	33 (86.0)
Clinical symptom (n = 38)	
Sign of local inflammation of the leg*	38 (100.0)
Fever	24 (63.1)
Indications for emergency US (n = 51 legs)	
Necrotising fasciitis	18 (35.3)
Collection/abscess formation	16 (31.4)
Myositis	10 (19.6)
Nonspecific	7 (13.8)
Side (n = 51 legs)	
Left leg	27 (52.9)
Right leg	24 (47.1)
Discharge status (n = 38)	
Improved	29 (76.3)
Died	8 (21.1)
Stable	1 (2.6)

* Symptoms include swelling, redness, warmth, tenderness
US: ultrasonography

requested in 13 patients (26 legs). The age range of the patients was 2–90 (mean 52.95 ± 23.01) years. The duration of symptoms before emergency US was 1–16 (median 3) days. Table I shows the clinical features of the patients. 33 (86%) patients had underlying disease (diabetes mellitus [DM], hypertension, end-stage renal disease, HIV infection, hepatitis C viral cirrhosis, and malignancy). Six out of 51 legs (11.8%) had previous history of trauma, and all studied patients presented with local inflammatory symptoms; 24 out of 38 patients (63.1%) had fever. The most frequent diagnosis was isolated cellulitis, followed by combined cellulitis and myositis, and isolated fasciitis (Fig. 6). Medication with SI was provided more frequently than medication alone, even in cases of patients without abscess (Table II). Two patients who received medication alone were treated with vitamin K, fresh frozen plasma and packed red cells to correct coagulation without using antibiotics. One patient who received medication with SI was treated by sequestrectomy due to osteomyelitis.

The patients were divided into two groups according to the presence or absence of abscess, resulting in 15/51 (29.4%) and 36/51 legs (70.6%), respectively (Table III). The group with abscess was treated by medication alone in 5/15 legs (33.3%) and medication with SI in 10/15 legs (66.7%). An equal number of patients from the group without abscess was treated by medication alone and medication with SI (18/36). There was no statistically significant correlation between the presence/absence of abscess and further clinical management (Pearson's chi-square test; $p = 0.216$), and between the size (length and thickness) of the abscess and the type of SI ($p = 0.687$ for the length and 0.243 for the thickness of the abscess, respectively) (Table IV).

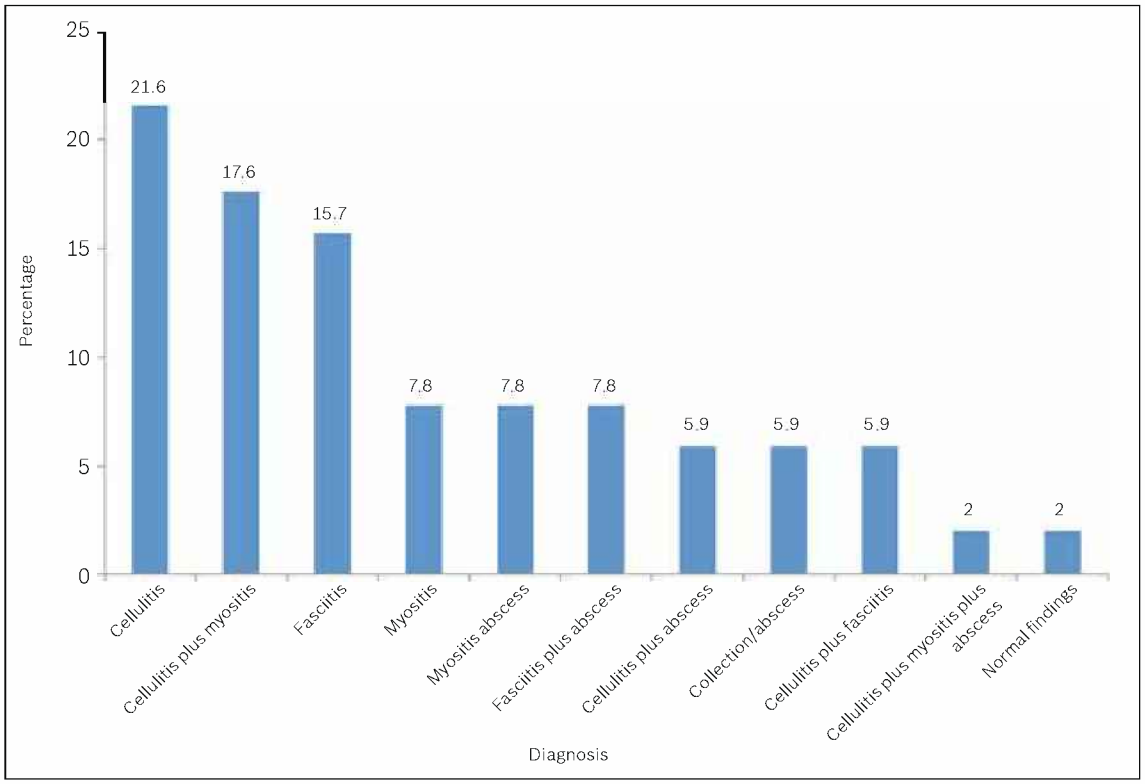

Fig. 6 Bar graph shows US diagnoses in percentage. The most common diagnosis is isolated cellulitis, followed by combined cellulitis and myositis, and isolated fasciitis.

Table II. Further clinical management after emergency ultrasonography diagnosis.

Management	No. of legs (%) (n = 51)
Medication with surgical intervention	
Open surgery (fasciotomy, debridement)	14 (27.5)
Aspiration	11 (21.6)
Incision and drainage	3 (5.9)
Medication alone	23 (45.1)

Table III. Correlation between ultrasonographic diagnosis and further clinical management.*

US diagnosis for abscess	Further clinical management		Total
	Medication with SI†	Medication alone	
Presence	10	5	15
Absence	18	18	36
Total	28	23	51

*Pearson's chi-square test; p = 0.216
†SI: surgical intervention (aspiration, incision and drainage, open surgery)

Ten of the 38 patients (26.3%) were re-evaluated by US in the same clinical setting. Out of these ten patients, six underwent grey-scale US and four underwent colour Doppler scanning to rule out deep vein thrombosis (DVT), all of whom tested negative. One out of 51 legs that was diagnosed as cellulitis and myositis by US underwent further multi-detector computed tomography (MDCT) on the same day in order to rule out fluid collection. MDCT revealed cellulitis and myositis without fluid collection, which corresponded to the previous US finding. The patient's symptoms worsened due to sepsis, and an operation was performed on the same day for debridement, which yielded turbid fluid from the subcutaneous layer under the thickened skin. The patient died two days later from ventricular tachycardia. The discharge status is shown in Table I. Eight of the 38 patients (21.1%) died due to multifactorial causes.

DISCUSSION

In cases of soft tissue infections, rapid diagnosis with prompt and proper management is necessary to prevent morbidity or mortality.[2,3,8] Direct or minor trauma is known as a contributing factor for infection involving soft tissue of the extremities,[10,11] which was found in six out of 51 legs (11.8%) in our study. The entity that was of most concern in this study was necrotising fasciitis (NF), which presented in 35.3% of patients. The pre-disposing factors for NF include older age (> 50 years), impaired immunity, DM, alcoholism, intravenous drug use, peripheral vascular disease and underlying infection.[12,13] Although NF is relatively rare, it is a rapidly progressive, life-threatening condition with a 30%–70% mortality rate.[3,13,14] About 10% of the cases are caused by group A *Streptococcus* spp. and can lead to toxic shock, thus requiring early recognition and emergent surgical debridement.[3,5,11,13,15] No antibiotic or supportive measure can substitute operative debridement in NF.[6,8] The infected limb in NF is oedematous and warm, with erythema and mottled skin.[3,12-14] Formation of bulla, particularly haemorrhagic bulla and cutaneous necrosis, is found in late NF due to the necrotising process from the deeper fascial spread.[6,12,14] Typically, the diagnosis of NF is based primarily on the clinical

Table IV. Correlation between the size of the abscess and the type of surgical intervention.*

Abscess No.	Size of abscess (cm)		Type of surgical intervention†
	Length	Thickness	
1	2.1	1.1	Antibiotics
2	1.0	0.7	Aspiration
3	3.8	1.7	I/D
4	4.6	1.3	Antibiotics[a]
5	3.4	1.5	Antibiotics[a]
6	6.5	1.9	Antibiotics[b]
7	0.8	0.6	Antibiotics
8	3.0	2.8	I/D
9	1.7	1.5	I/D
10	1.8	0.6	Aspiration
11	1.1	0.2	Aspiration
12	2.1	0.4	Aspiration
13	2.4	0.3	Aspiration
14	0.8	0.8	Open surgery[c]
15	0.8	0.4	Aspiration

* Pearson's chi-square test; p = 0.687 for the length and 0.243 for the thickness of the abscess
† All types of surgical intervention were accompanied by antibiotics.
[a] Patients had DM and hypertension.
[b] Patients had DM, hypertension and status post thromboembolectomy.
[c] Patients had necrotic skin 2 cm, and open debridement was performed.
I/D: incision and drainage

diagnosis, particularly pain that is out of proportion from the clinical findings.[6,12,14] Severe pain may precede skin changes by 24–48 hours, and is present in more than 97% of patients.[16] The plain radiographic findings of NF could be similar to cellulitis or may be normal. The presence of air in soft tissue has 39% sensitivity, 95% specificity and 88% negative predictive value for NF;[17] the absence of gas does not exclude infection.[5,15,18]

The US findings of NF can be similar to those of cellulitis and fasciitis, due to the additional involvement of deep fascial planes between muscle bundles.[5,17] It is important to differentiate between NF and cellulitis, as the latter can be treated with antibiotics alone. Cellulitis can be easily differentiated by normal-appearing fascia and muscle on US. However, it is difficult to differentiate NF from deep fasciitis by US, as the finding of fasciitis is observed in both cases.[17] A hallmark of NF on computed tomography (CT) is soft-tissue air with fluid collection within the deep fascia, although such a finding is inconsistent. The potential advantages of CT include its ability to detect underlying infectious sources such as diverticulitis, and underlying bony involvement.[13] Magnetic resonance (MR) imaging with gadolinium can differentiate necrotic from inflamed or oedematous tissue.[19,20]

T2-weighted images are considered the best imaging investigation to demonstrate the disease and its extent, but they are more sensitive than specific.[12,21] The limitation of CT and MR imaging is the administration of contrast material, which may be contraindicated in patients with acute renal failure. According to Kothari et al, if the diagnosis of NF is made and aggressive surgical debridement performed within four days of disease onset, the mortality rate decreases from 73% to 12%.[10] This may explain why NF is a cause of concern and the most common indication to consider US in this study. However, we did not find any case of diagnosed NF throughout the study period. The most common US diagnosis in this study was isolated cellulitis, followed by combined cellulitis and myositis, and isolated fasciitis. Fasciitis is usually found in association with changes in subcutaneous tissue and muscle.[4] However, in some cases, US could not reveal histologically apparent inflammation in sub-cutaneous tissue.[21] This may explain the finding of isolated fasciitis in our study.

Patients without abscess were either treated with or without SI. In patients without abscess but reported having fluid traversing in subcutaneous tissue (Fig. 2), aspiration was performed to yield fluid for Gram's stain, antimicrobial culture, and for selection of antibiotics. If turbid fluid or pus was found, continuous aspiration was performed to draw out as much pus as possible, as a form of treatment. We therefore considered aspiration as a type of treatment (SI). We found no statistically significant association between the presence or absence of abscess and further clinical management in this study. One-third of the patients with abscess were treated by medication alone, and two-thirds with SI. As some abscesses were not round and extended along the fascial or muscle planes, calculation of the volume was difficult. Hence, we measured the length and thickness of the abscess, and evaluated the correlation to the type of SI separately. We found that the size of the abscess did not correlate with the type of SI performed (Table IV). The patient's clinical condition had a high impact on the clinician's treatment decision-making. Patients with large abscesses and underlying medical conditions were treated with medication alone, whereas those with small abscesses accompanied with necrotic tissue were treated by open debridement.

This study had some limitations. Firstly, the sample size was small, even though the duration of recruitment of subjects was 24 months. Some patients with early soft tissue infection of the leg had clinical presentations that were similar to DVT; they were sent for emergency Doppler US and hence excluded from our study. Secondly, later SI may result from alteration of the patient's symptoms that may not relate to the initial US diagnosis. Thirdly, the patient's clinical condition had a great influence on the clinician's treatment decision. The finding of no significant correlation between US findings and further clinical management could be attributed to these causes.

In conclusion, the most common indication for emergency US in patients with clinically suspected soft tissue infection of the legs in this study was to rule out NF. It is not possible to exclude NF when the patient has related predisposing factors, pain that is out of proportion to the clinical findings, and demonstration of cellulitis and fasciitis on US. The most common US finding in this study was cellulitis. There was no statistically significant correlation between the presence or absence of abscess and

further clinical management, and between the size of the abscess and the type of SI. The presence of abscess, which was previously thought to be an indication for surgery, may be treated and improved by medication alone in some instances. On the other hand, the absence of abscess, which would otherwise be treated by medication alone, may be treated by aspiration, particularly when fluid is detected in subcutaneous tissue, or by surgical debridement if there is accompanying surgical indication. The result of this study should encourage sonologists to evaluate such patients in detail, and provide information about each layer of tissues studied.

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