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Ultrasound in Emergency Medicine

BEDSIDE ULTRASOUND IN THE DIAGNOSIS OF COMPLEX HAND INFECTIONS: A CASE SERIES

Brett A. Marvel, MD and Gavin R. Budhram, MD

Department of Emergency Medicine, Tufts University School of Medicine, Baystate Medical Center, Springfield, Massachusetts
 Reprint Address: Brett A. Marvel, MD, Department of Emergency Medicine, Tufts University School of Medicine, Baystate Medical Center,
 759 Chestnut Street, Springfield, MA 01199

Abstract—Background: The red, swollen, infected hand can be a diagnostically challenging presentation in the emergency department (ED). Hand infections are a relatively uncommon ED complaint, and diagnoses may range from simple cellulitis to deep space abscess, and even to suppurative flexor tenosynovitis. The accurate differentiation of these clinical entities is of paramount importance to healing and recovery of function. **Case Series:** In this case series, we review 4 patients with similar presenting complaints of a red, swollen hand, but with much different diagnoses and eventual treatment strategies. We describe how ultrasound was used to assist in making the diagnosis and initiating the most appropriate therapy. Finally, we review techniques for sonographic evaluation of the hand and provide imaging tips to improve visualization and accurate diagnosis. Why should an emergency physician be aware of this? Bedside ultrasound may allow for a more rapid and accurate diagnosis of various hand infections when diagnosis by physical examination is unclear. © 2014 Elsevier Inc.

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INTRODUCTION

Recent data show that 2.6% of all emergency department (ED) visits are due to cellulitis or abscess, and hand

No Institutional Review Board approval or exemption was required by our institution because the case series involves fewer than 4 patients.

infections are a relatively uncommon subset of this group (1). The spectrum of potential diagnoses ranges from a relatively benign superficial cellulitis to the surgically emergent deep space infections and tendon sheath infections. Because coordinated and precise hand movements are required in the daily activities of life and work, missed diagnoses can carry a high cost. Approximately two-thirds of the total first-year cost incurred by patients with hand injuries is due to lost wages (2).

The following is a review of four cases in which patients presented with painful, red, swollen hands. We describe how ultrasound was used to make the appropriate diagnosis and guide subsequent disposition. Finally, we review the literature describing physical examination findings, imaging modalities in hand infections, and investigate bedside ultrasound as a new diagnostic tool that might be beneficial to the emergency physician (EP).

CASE REPORTS

Case 1

A 30-year-old woman was transferred to the ED from an urgent care facility for a complicated hand infection thought to require surgical incision and drainage. The patient had been bitten on the dorsum of her hand several days earlier by her fully vaccinated cat and had noted worsening redness, swelling, and pain. Her ED evaluation

revealed normal vital signs and two small puncture wounds on the lateral aspect of the dorsum of her hand. The EP noted redness and induration covering the first dorsal interosseous space of the hand and spreading proximally to the elbow. No areas of fluctuance were palpable, and she complained of exquisite tenderness with passive range of motion to the fingers and wrist.

As part of her evaluation, the EP performed a bedside ultrasound of the hand and forearm. This showed extensive soft-tissue cobblestoning along the dorsum of the hand, wrist, and distal forearm, but no areas of fluid collection. All tendons were well visualized and were free of surrounding fluid (Figure 1A, B). The patient was treated with 3 grams of intravenous ampicillin/sulbactam in the ED, and the edges of the induration were marked with a skin marker. She was discharged with a prescription for amoxicillin/clavulanate and instructed to return to the ED in 48 hours for a wound check, or earlier if the infection worsened. On her return visit, the redness and induration had markedly improved and the patient reported that her pain was much better. She was

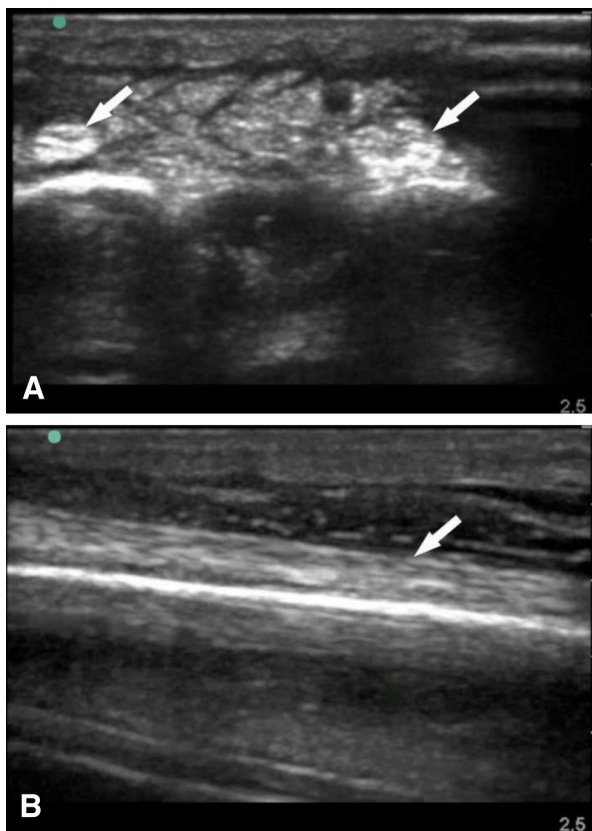


Figure 1. (A) Transverse view demonstrating “cobblestoning.” Thickened and abnormally hyperechoic skin and subcutaneous tissue are interspersed by hypoechoic fluid in a reticular pattern. Tendons (white arrows) are not surrounded by fluid. (B) Longitudinal view of normal tendon without surrounding fluid.

asked to finish the antibiotics and follow up with her primary care physician in a week.

Case 2

A 33-year-old man with a history of intravenous drug abuse presented to the ED after a fall 10 days prior during which he sustained an abrasion to his right hand. Since the injury, the hand had continued to swell and became increasingly painful. At the time of presentation, his temperature was 38.2°C (100.8°F), and all other vital signs were within normal limits. Physical examination revealed extensive erythema, induration, warmth, and tenderness of the entire right hand and right forearm (Figure 2). Pain was exacerbated by any movement of the hand. An old abrasion over the dorsal right third metacarpophalangeal joint was noted, as well as multiple tract marks in the right antecubital fossa. Ultrasound was performed at the bedside, showing cobblestoning of the soft tissues along the dorsal surface of the right hand, and large hypoechoic collections were also noted in the space surrounding the extensor tendons (Figure 3A, B). Antibiotic therapy was initiated and Surgery consulted.

The patient was taken to the operating room (OR) later that day and a large amount of purulent fluid was extruded from the dorsum of the patient’s hand, originating from



Figure 2. Right dorsal hand and forearm are erythematous, swollen, and tender. The left arm has needle marks but does not otherwise appear infected.

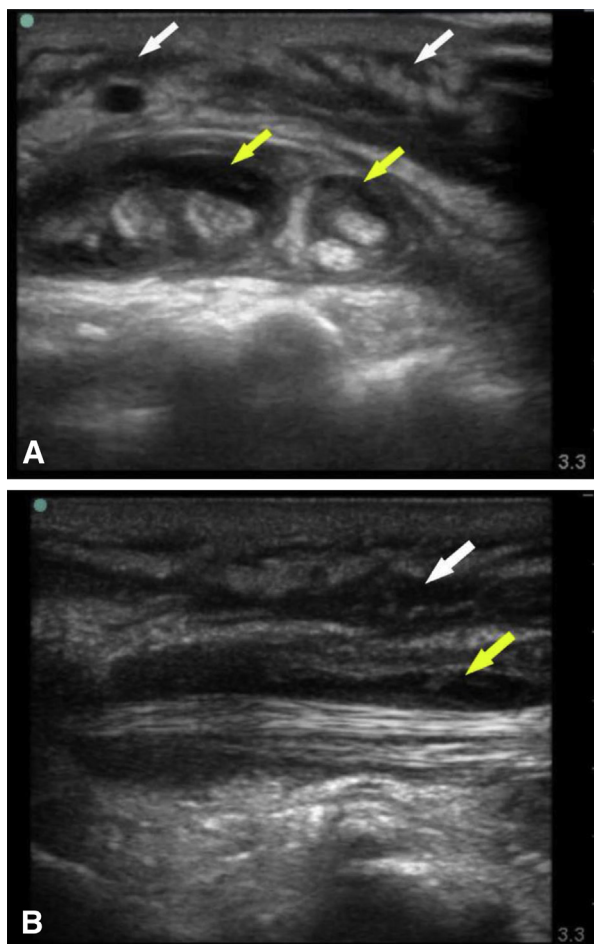


Figure 3. (A) Transverse view demonstrating soft tissue cobblestoning (white arrows) and fluid in the subaponeurotic space surrounding the extensor tendons (yellow arrows). (B) Longitudinal view.

the dorsal subcutaneous and subaponeurotic spaces. He was eventually discharged with outpatient antibiotic therapy and recovered well.

Case 3

A 32-year-old female cat groomer presented to the ED 12 hours after she was bitten in the hand by a cat. She complained of swelling and pain to the lateral hand, with limited range of motion to the thumb. On examination she was afebrile and had two small bite marks on the ventral surface of the hand over the metacarpophalangeal joint of the thumb. There was symmetric swelling of the thumb and fullness over the thenar eminence. Range of motion to the thumb was severely limited due to pain.

Bedside ultrasound demonstrated fluid circumferentially surrounding a single flexor tendon of the thumb but sparing other tendons (Figure 4A, B). Antibiotic therapy was initiated and Orthopedic Surgery consulted. The

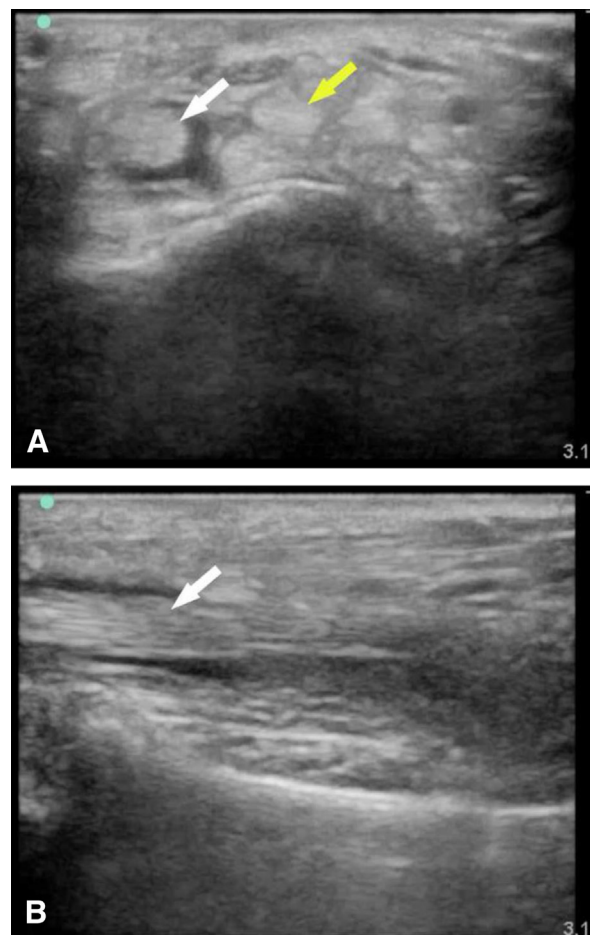


Figure 4. (A) Transverse view showing fluid circumferentially surrounding a flexor tendon of the thumb (white arrow). Other tendons (yellow arrow) are unaffected. (B) Longitudinal view.

surgeon initially doubted tenosynovitis, but took the patient to the OR after reviewing the ultrasound findings. There she was found to have a swollen and cloudy flexor tendon sheath, which drained pus when excised. After drainage, irrigation, and closure, the patient did well post-operatively and was discharged with antibiotics. Cultures eventually grew *Pasteurella multocida*. At a follow-up clinic visit, she was healing well and had full active and passive range of motion without discomfort.

Case 4

A 46-year-old woman presented to the ED for a cat bite on her right index finger that had occurred the previous day. She complained of significant swelling, pain, and redness to the entire finger that made any movement impossible. She was afebrile and had four small puncture wounds on the dorsal and volar side of the proximal interphalangeal (PIP) joint of the index finger. The finger was symmetrically swollen and erythematous, especially

along the volar surface, and the patient was unable to perform any active or passive range of motion due to pain. The physician had clinical suspicion for flexor tenosynovitis, so placed a surgical consult and began treatment with intravenous antibiotics.

In agreement with the clinical examination, a water bath ultrasound examination (Figure 5) did show anechoic fluid along the flexor tendon, but also a fluid collection in the joint space of the PIP joint. Although initially doubtful of the diagnosis of septic arthritis, in the OR the orthopedic surgeon identified pus located in both the flexor tendon sheath and the joint capsule. Cultures identified *P. multocida*. She was uneventfully discharged after a short hospital stay, and at a follow-up visit 1 month later she was healing well and working to improve range of motion with physical therapy.

DISCUSSION

Infections occur within the hand more frequently than in other parts of the body and are most prominent in patient populations exhibiting certain risk factors: peripheral vascular disease, diabetes mellitus, and end-stage renal failure (3). *Staphylococcus* and *streptococcus* are common offending pathogens, but given the more unique routes of entry in the hand, a broader infectious spectrum must be considered. For example, bites involving human saliva have been noted to have a median of four concomitant pathogens, often including Gram-negative rods and anaerobes. Similarly, dog bites are usually polymicrobial, often containing *Capnocytophaga canimorsus*, a Gram-negative rod that can cause overwhelming sepsis. *P. multocida* is a highly virulent Gram-negative rod commonly complicating both dog and cat bites, however, due to the

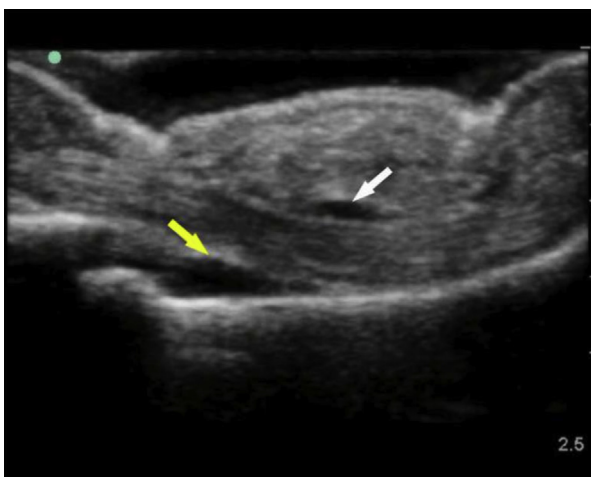


Figure 5. Longitudinal view of the index finger under water bath ultrasound showing fluid around the flexor tendon (white arrow) as well as inside the joint capsule of the proximal interphalangeal joint (yellow arrow).

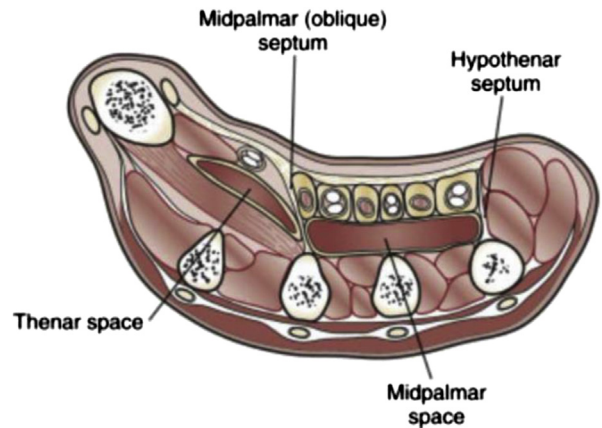


Figure 6. Normal anatomy of the hand showing thenar and midpalmar potential spaces. This figure was published in: Marx J, Hockberger R, Walls R. *Rosen's Emergency Medicine Concepts and Clinical Practice*, 7th edn., Hand, page 522, Maryland Heights, MO: Mosby Elsevier; 2009.

puncture-like nature of cat bites, these wounds often develop into deep-space infections (4).

The anatomy of the hand is complex, containing deep spaces and tendon sheaths that can harbor infection. The deep palmar spaces of the hand include the midpalmar space, the hypothenar space, and the thenar space (Figure 6). Three additional superficial spaces on the dorsum of the hand are the dorsal subcutaneous space, the dorsal subaponeurotic space, and the interdigital web space. Although not technically deep spaces owing to their lack of well-defined anatomic borders, infections in the superficial spaces present similarly to deep space infections (5). In the normal hand, all of these spaces are potential rather than actual spaces.

On the flexor surface of the hand, the flexor tendons are surrounded by synovial sheaths. The tendon sheath of the thumb is continuous with the radial bursa of the palm, and the small finger sheath is continuous with the ulnar palmar bursa. The ulnar bursa surrounds the superficial and deep flexor tendons, and the radial bursa surrounds the flexor pollicis longus. These two bursae communicate in 80% of people. In most instances the tendon sheaths of the index, middle, and ring finger do not communicate. On the extensor surface, tendons are briefly covered by synovial sheaths to reduce friction as they pass over the dorsum of the wrist, but are uncovered as they pass through the dorsal subaponeurotic space (5).

When assessing patients with hand infections, the EP must be able to distinguish between relatively benign superficial infections and possibly devastating deep space or tendon sheath infections. Traditionally, this is accomplished only by physical examination, with the examiner attempting to elicit induration, fluctuance, and the clinical signs of suppurative flexor tenosynovitis: fusiform swelling, pain with passive extension, pain with palpation

along the tendon sheath, and a finger held in slight flexion. The distinction between cellulitis, abscess, and flexor tenosynovitis, however, can still be difficult by physical examination alone, and little support for Kanavel's clinical signs are found in the literature because they were originally published over 100 years ago (6). A delay in diagnosis, or worse, a misdiagnosis, is known to result in increased morbidity to the patient (7). For example, amputation rates may approach 17% in misdiagnosed cases of pyogenic flexor tenosynovitis (3).

Ultrasound is an excellent imaging modality for superficial infections. It can also often spare the patient the radiation exposure associated with traditional imaging methods while lessening the diagnostic financial burden. Ultrasound is known to be more sensitive than computed tomography (CT) for the detection of small cutaneous abscesses. In one recent study by Gaspari et al., ultrasound had a 96.7% sensitivity for abscess vs. 76.7% for CT (8). The authors attribute this difference to the ability of ultrasound to provide greater sub-millimeter detail combined with the ability for dynamic imaging (8). Tayal et al. demonstrated marked superiority of bedside ultrasound over physical examination in detecting or ruling out clinically significant abscesses, showing that ultrasound correctly changed management in 71/126 cases, as demonstrated by incisional findings or follow-up (9). Two studies also document the utility of ultrasound in diagnosing septic flexor tenosynovitis. Jeffrey et al. correctly identified 5 of 6 patients with surgically proven bacterial flexor tenosynovitis, missing only one with a very small amount of fluid in the tendon sheath (10). Schecter et al. also correctly identified 11 of 12 patients needing surgical drainage based on anechoic fluid in the tendon sheath (11).

The above cases demonstrate the potential value of bedside ultrasound in distinguishing different types of hand infections with similar physical examination findings. In the first case, ultrasound correctly identified uncomplicated cellulitis even though the patient complained of exquisite pain with passive range of motion, possibly saving her from an unnecessary surgery. In case 2, an abscess was found in the subaponeuritic space even though the physical examination seemed most consistent with cellulitis. Ultrasound was used in the third case to correctly identify suppurative flexor tenosynovitis when the physical examination was interpreted differently by the EP and the surgeon. In the final case, flexor tenosynovitis was suspected based on the clinical examination, but ultrasound also identified the concomitant joint space infection and allowed the surgeon to incise and drain both spaces.

Ultrasound imaging of the hand is best accomplished with a high-frequency linear array transducer. Skin is typically seen as a thin, hyperechoic superficial layer.

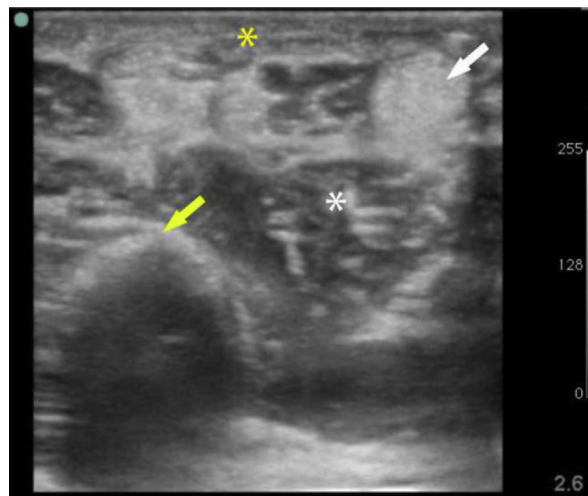


Figure 7. Normal transverse view of the hand showing subcutaneous tissue (yellow asterisk), tendons (white arrow), muscle (white asterisk), and bone (yellow arrow).

Subcutaneous tissue is hypoechoic, and skeletal muscle is easily identified by its characteristic hypoechoic texture with echogenic internal striations that appear feather-like in a long axis and speckled in a short axis. In a long axis, tendons are hyperechoic fibrillar structures that move when the corresponding joints are ranged. In a short axis, tendons are hyperechoic and typically round, ovoid, or flat. Bones are hyperechoic and cast a black shadow (Figure 7).

Image quality of the hand is generally enhanced by using a water bath technique. First described in the medical literature over 30 years ago, water bath technique is accomplished by immersing the patient's hand in a large basin filled with warm water (12). A linear array transducer is then placed into the bath and aimed at the desired imaging surface, but does not touch the skin (Figure 8).



Figure 8. Water bath ultrasound. The hand is immersed in a bath of warm water. The transducer is aligned over the finger but does not contact the skin.

The use of water bath in hand imaging has some particular benefits. The hand may be positioned several centimeters from the tip of the transducer, which improves imaging because the focal zone is usually in this area rather than directly adjacent to the transducer. Second, placing the transducer directly onto the skin is usually painful because it necessitates conforming the hand to the contours of the transducer. By using a water bath as a conducting medium, the entire surface area of the hand may be imaged with minimal patient movement.

Cellulitis displays a characteristic “cobblestone” appearance on ultrasound: thickened and abnormally hyperechoic skin and subcutaneous tissue with areas of hypoechoic edema that traverse it in a reticular pattern. A similar pattern is also seen in edema from noninfectious causes such as severe venous insufficiency. Abscess cavities are most often spherical or elliptical, with the liquefied contents demonstrating a range of echogenicity, and may also contain debris, septae, or gas. They are almost universally surrounded by a rim of hyperechoic soft tissue and display posterior acoustic enhancement. In suppurative flexor tenosynovitis, the ultrasound examination demonstrates a hypoechoic fluid collection within the tendon sheath and thickening of the tendon, as compared to the contralateral side (10). Gas-producing organisms can create unique challenges to image acquisition. Gas particles are not emendable to sound wave propagation and therefore, inhibit visualization of deeper structures. If the images are easily obtained in non-infected tissues and then have a “dirty” appearance over the area of infection, it would seem prudent to proceed to CT imaging for better disposition planning.

WHY SHOULD AN EMERGENCY PHYSICIAN BE AWARE OF THIS?

Future studies can be performed to compare time to appropriate disposition of hand infections using tradi-

tional assessment vs. ultrasound-augmented assessment. Until such a time, bedside ultrasound of the hand seems to be an extremely useful adjunct to the physical examination in distinguishing between cellulitis, deep space abscesses, and flexor tenosynovitis.

REFERENCES

1. National Hospital Ambulatory Medical Care Survey. 2010 Emergency department summary tables. Available at: http://www.cdc.gov/nchs/data/ahcd/nhamcs_emergency/2010_ed_web_tables.pdf. Accessed August 11, 2013.
2. Rosberg HE, Carlsson KS, Dahlin LB. Prospective study of patients with injuries to the hand and forearm: costs, function, and general health. *Scand J Plast Reconstr Surg Hand Surg* 2005;39:360–9.
3. Pang HN, Teoh LC, Yam AK, Lee JY, Puhaindran ME, Tan AB. Factors affecting the prognosis of pyogenic flexor tenosynovitis. *J Bone Joint Surg Am* 2007;89:1742–8.
4. Talan DA, Abrahamian FM, Moran GJ, et al. Clinical presentation and bacteriologic analysis of infected human bites in patients presenting to emergency departments. *Clin Infect Dis* 2003;37:1481–9.
5. Lyn E, Mailhot T. Hand. In: Marx J, ed. *Emergency medicine: concepts and clinical practice*. Philadelphia: Mosby Elsevier; 2010: 521–2.
6. Kanavel A. *Infections of the hand*. 1st edn. Philadelphia and New York: Lea and Febiger; 1912.
7. Draeger RW, Bynum DK Jr. Flexor tendon sheath infections of the hand. *J Am Acad Orthop Surg* 2012;20:373–82.
8. Gaspari R, Dayno M, Briones J, Blehar D. Comparison of computerized tomography and ultrasound for diagnosing soft tissue abscesses. *Crit Ultrasound J* 2012;4:5.
9. Tayal VS, Hasan N, Norton HJ, Tomaszewski CA. The effect of soft-tissue ultrasound on the management of cellulitis in the emergency department. *Acad Emerg Med* 2006;13:384–8.
10. Jeffrey RB Jr, Laing FC, Schechter WP, Markison RE, Barton RM. Acute suppurative tenosynovitis of the hand: diagnosis with US. *Radiology* 1987;162:741–2.
11. Schechter WP, Markison RE, Jeffrey RB, Barton RM, Laing F. Use of sonography in the early detection of suppurative flexor tenosynovitis. *J Hand Surg Am* 1989;14:307–10.
12. Berger LA, Lister A, Lilley AC. A water bath for thyroid scanning with ultrasound. *Br J Radiol* 1981;54:630–1.