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AD-41-25 REV 1

Use of Ultrasound Elastography for Skin and Subcutaneous Abscesses

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Objective. Elastography is a new adjunct to real-time ultrasound imaging that overlays traditional B-mode imaging with a color graphic representation of tissue elasticity. Soft tissue infections are common presenting conditions in the emergency department, and elastography has the potential to help in diagnosis and treatment of evolving soft tissue infections as they progress from induration to fluctuant abscesses, but to our knowledge, no studies of elastography in superficial soft tissue have been published. We hypothesized that elastography would provide increased information regarding skin abscesses. ***Methods.*** This was a prospective study of patients with suspected skin abscesses requiring surgical drainage in the emergency department of an urban tertiary care center. Abscesses were imaged with B-mode imaging and elastography in orthogonal planes. Ultrasound images were analyzed for characteristics of the elastographic images. ***Results.*** A total of 50 patients with suspected skin abscesses underwent B-mode imaging and elastography. Elastography accurately differentiated the induration surrounding the abscess from the surrounding healthy tissue, a differentiation that was not visible on B-mode imaging. The elastographic properties of the abscess cavity were variable and not always seen, even with purulence identified during incision and drainage. In some cases, elastography identified abscess cavities not seen on B-mode imaging. When seen, the abscess cavity could be characterized by elastographic color and speckle patterns. ***Conclusions.*** Elastography identified the tissue induration and some abscess cavities not seen on B-mode imaging. It offers a way to characterize abscesses that may be useful clinically, but more research is needed. ***Key words:*** abscess; elastography; infection; skin; soft tissue.

Soft tissue infections are common conditions and range from superficial cellulitis to deeper soft tissue infections with abscess collections requiring surgery. Inadequately treated superficial soft tissue infections can progress to deeper tissue infections requiring more invasive surgery or bacteremia requiring hospitalization and intravenous antibiotics. Increasingly prevalent antibiotic-resistant bacteria in soft tissue infections have changed current therapy,[1] but primary therapy for a skin abscess remains surgical drainage. Therefore, it is even more important now to accurately identify skin abscesses. Differentiation of superficial cellulitis from a soft tissue abscess can be challenging but relies mostly on physical examination, with additional imaging by computed tomography or ultrasound if needed.[2–5]

Ultrasound has been shown to be a useful adjunct to the physical examination in patients with suspected soft tissue fluid collections. A new adjunct to ultrasound imaging called elastography allows identification of tissue "stiffness." Elastography is dynamic adjunct to con-

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ventional ultrasound imaging that provides an estimate of tissue stiffness by measuring the degree of distortion under the application of external force provided by the ultrasound probe. Ultrasound elastography has been used to differentiate thyroid nodules[6] and to characterize liver cirrhosis[7] (among other applications). Practically speaking, ultrasound elastography provides a color overlay similar to a color Doppler display with a color range relating to the stiffness of a tissue (Figure 1).

The natural progression of an abscess from induration to fluid collection should provide a useful diagnostic signature when imaged with elastography, but to our knowledge, no studies to date have been performed using elastography on soft tissue infections. In this article, we present our experience with a series of suspected soft tissue abscesses.

Materials and Methods

This was a prospective study of patients with suspected skin abscesses requiring surgical drainage in the emergency department of an urban tertiary care center. Patients in this study included individuals with clinically apparent abscesses and those with suspected abscesses. Patients were enrolled 24 hours a day over a 6-month period with study personnel available by pager. Patients were eligible for enrollment if they had localized swelling, pain, induration, and warmth suspicious for a soft tissue abscess with the intention to incise and drain. Patients younger than 18 years and pregnant patients were excluded from the study. In addition, patients with symptoms in the gluteal cleft consistent with a pilonidal cyst and patients with symptoms isolated to the genitalia were also excluded.

Ultrasound examinations were performed at presentation with an Ultrasonix ultrasound machine (Ultrasonix Medical Corporation, Richmond, British Columbia, Canada). Standard images of suspected soft tissue abscess collections were obtained, including long-axis and transverse B-mode images of the abscess, long-axis and transverse elastographic images of the abscess, and B-mode images of a contralateral site for comparison. Ultrasound images were analyzed for characteristics of the elastographic images. Review of the ultrasound images was done in a blinded fashion with the reviewer unaware of any patient characteristics. Determining whether the abscess cavity was visualized by either B-mode imaging or elastography was accomplished by characterizing the B-mode image of the abscess cavity as isoechoic, hypoechoic, or hyperechoic and describing the elastographic image of the edge of the abscess cavity as well defined or not. Data analysis included descriptive statistics (mean ± SEM).

Figure 1. Elastographic color spectrum scale on the side of the machine monitor when elastography is activated.

Table 1. Patient Characteristics

Characteristic	Total
Sex, % Male	46
Age, y (SD)	37.7 (1.8)
Associated cellulitis, %	70
Time before presentation, d (SD)	4.41 (0.49)
Location, %	
Face	14
Upper extremity	10
Axilla	8
Neck	4
Torso	20
Groin	12
Buttock	16
Lower extremity	20

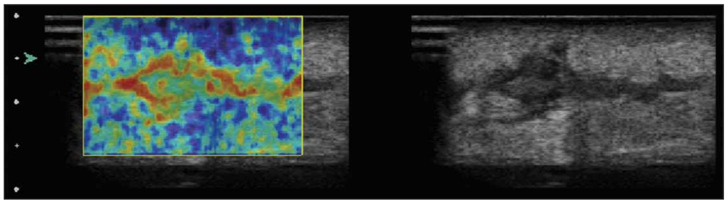
This study was approved by our Institutional Review Board with waiver of informed consent.

Results

A total of 50 patients were enrolled in the study with a documented abscess on ultrasound imaging and purulent material from incision and drainage. Patient characteristics are given in Table 1. Seventy percent of patients had associated cellulitis, and all patients in this study received at least 1 antibiotic in addition to incision and drainage. Fluid collections identified by ultrasound were an average of 0.2 ± 0.03 cm from the skin surface.

All of the abscesses were easily visualized with B-mode imaging, but only 58% (29 of 50) of the abscess cavities were visualized with elastography (Figure 2). Interestingly, some isoechoic abscesses that were difficult to identify by B-mode imaging were visible with elastography (Figure 3). The elastographic characteristics could be categorized by both the pattern of the elastographic signal and the color of the signal. Because of the heterogeneous nature of soft tissue abscesses, the elastographic characteristics ranged from confluent bands of color (27.6%) to large spotted signaling (38%) to small specked signaling (34.4%) (n = 29; Figure 4). The elastographic coloring showed a spectrum from mixed red (most soft) and yellow (soft) signaling (38%) to mixed yellow (soft) and green (medium stiffness) signaling (62%) (n = 29; Figure 5).

Although the surrounding tissue induration was not easily identifiable on B-mode imaging, it was identifiable on elastography in most patients in this study. In 98% (46 of 47) of the patients in this study, the limits of the induration were identifiable by elastographic imaging (Figure 6). In 3 of the patients, the induration extended beyond the boundaries of the ultrasound images, and the edge of the induration could not be assessed. The elastographic signals showed a similar range of patterning as in the abscess cavity, from solid (15%) to large spotted signaling (26%) to small specked signaling (59%) (n = 49; Figure 7). The color spectrum of the indurated tissue varied widely, all with some blue (firm) signaling surrounding the abscess and some (38%) with dark blue (stiffest) predominating (n = 49; Figure 8).



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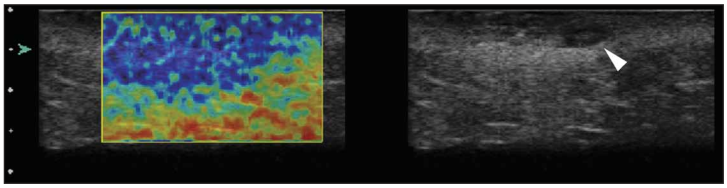

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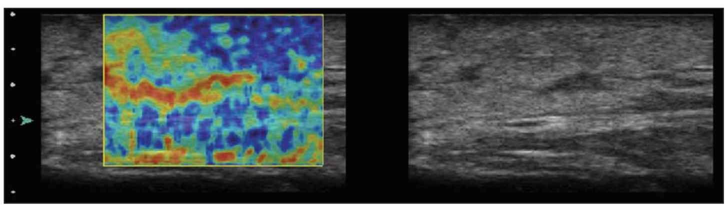
Figure 2. Abscess cavity visualized with B-mode imaging and elastography. **A**, The elastographic color overlies the gray scale image (left), with the abscess cavity visualized as a soft (red) rim on a less soft (yellow and aqua) background. The surrounding induration is visualized as stiff (deep blue on aqua). The image on the right is identical but without the elastographic overlay. **B**, The abscess cavity (arrowhead) is visualized with gray scale imaging (right image) but not with elastography. The surrounding induration is clearly visible as stiff (dark blue with aqua speckling).

Figure 3. Elastographic imaging of isoechoic abscesses. **A**, An isoechoic abscess that is difficult to visualize with gray scale imaging (left) is visible on elastography, with a soft (red) signal on a background of middle stiffness (aqua and green). **B**, An abscess with mixed isoechoic and hypoechoic signals shows additional extensions of the abscess cavity (arrowhead) on elastography (red on yellow) that is not visible on gray scale imaging.

A



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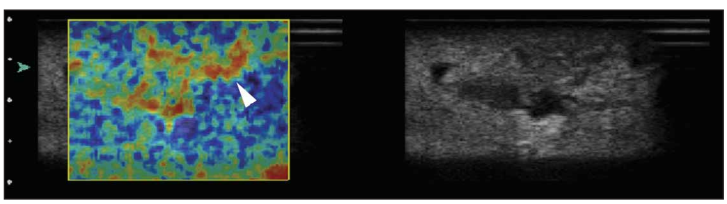

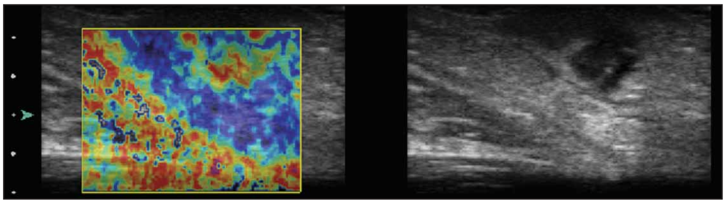

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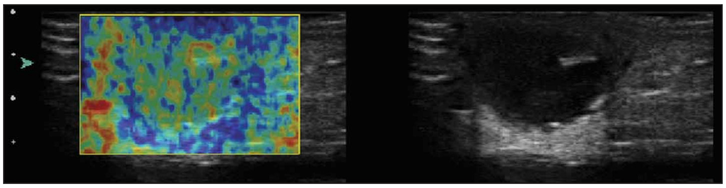

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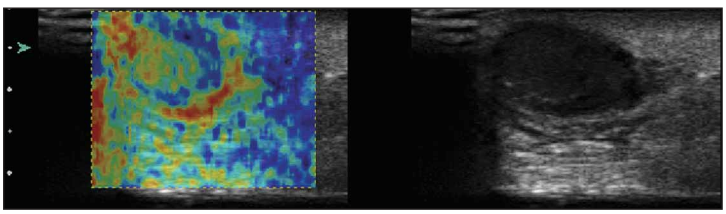
Figure 4. Elastographic color spectrum of skin abscesses. Softer abscess cavities with purulent material are visualized with elastography as larger spots of soft (**A**, red) on a less soft (**A**, yellow and green) background or smaller spots of soft (**B**, red and yellow) on a background of middle stiffness (**B**, green). The stiff blue of the surrounding induration accentuates the softer abscess cavity.

Figure 5. Elastographic color pattern of skin abscesses. The variable consistency of the abscess cavity is visualized with elastography as bands of color (**A**), larger spots of softer color on a background of medium stiffness (**B**, green and yellow), or smaller speckling of softer colors (**C**, red and yellow) surrounded by a range of stiffer colors.

A



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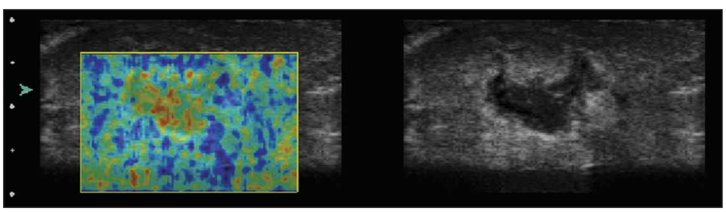

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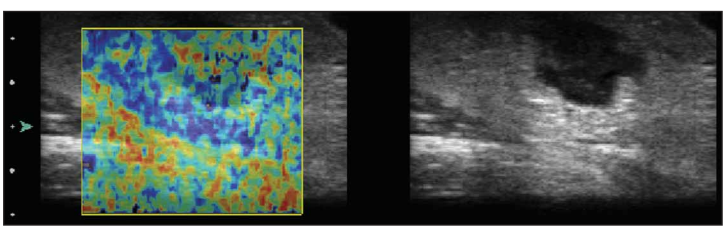


Delineation of the abscesses, induration, and normal tissue in patients with skin and soft tissue infections with differing levels of stiffness was variable. The elastographic color scheme of stiff tissue (blue) in some patients was sharply delineated from both the soft abscess core (red and yellow) and surrounding normal tissue (mixed color spectrum). The soft abscess center was sharply differentiated from the firm indurated tissue in 30.4% (14 of 46) of the patients in this study. The firm indurated tissue was sharply differentiated from the surrounding normal tissue in 72% (34 of 47) of the patients. Some images were unable to be included secondary to extension of the abscess or indurated tissue outside the image edge.

Discussion

Ultrasound imaging of soft tissue infections provides clear identification of the abscess fluid pocket in many cases, but some abscesses are isoechoic to the surrounding tissue and can be challenging to image. Elastography provides an advantage when combined with B-mode imaging in that it characterizes tissue by stiffness, which would theoretically result in easy visualization of abscess cavities containing pus. It was therefore surprising to note in this study that a relatively small number of abscess cavities were identified by elastography even though all of the abscesses produced purulent material at incision and drainage. Ultrasound elastography works on the principle of tissue deformation using pressure from the probe to measure tissue stiffness, and in many of the patients, the pain related to the abscess prevented more vigorous compression. Alternatively, the heterogeneous nature of the abscess cavity, with tissue debris mixed in with purulence, may result in a signal that is not accurately identified by elastography. Finally, future generations of elastography may improve imaging capabilities to better identify an abscess cavity.

One of the surprising benefits of elastography is related to its ability to identify surrounding tissue induration from localized edema. The delineation of induration from surrounding tissue was clearly identifiable on elastography but not on B-mode imaging. This imaging of tissue induration is not achievable with other imaging modalities and may represent a role for elastography in the future. We speculate that the size of the tissue induration may predict progression to bacteremia or the time to resolution. However, it is not clear whether identification of tissue induration will be of any clinical benefit because little attention has been paid to characterizing induration surrounding soft tissue infections. Future research will be needed to determine whether there is any prognostic value to characterizing tissue induration in soft tissue infection.

This study had a number of limitations. We studied a series of cases over 6 months and tried to enroll patients 24 hours a day, 7 days a week, but there were times when study personnel were unavailable, and we were unable to enroll patients. This could have caused a selection bias that could have affected our results. Another large limitation was the study size, with only a small number of patients enrolled, limiting the available conclusions. A larger, more comprehensive study of elastography in soft tissue infection is needed to identify any possible role in the clinical setting. A final limitation was the elastography package used in this study, which did not contain a feedback indicator for determining the accuracy of the probe pressure. It is possible that this feature, which is now available on some machines, would have improved the imaging quality. It was noted that the signal-to-noise ratio of the elastographic signal was worse with either too light or too heavy pressure.

In summary, ultrasound elastography accurately identifies induration surrounding soft tissue abscesses. In conjunction with B-mode imaging, elastography has the potential to provide valuable diagnostic information for soft tissue infections.

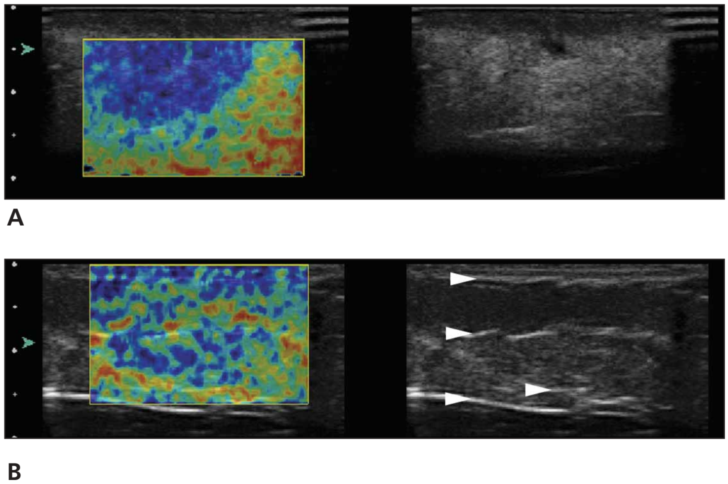
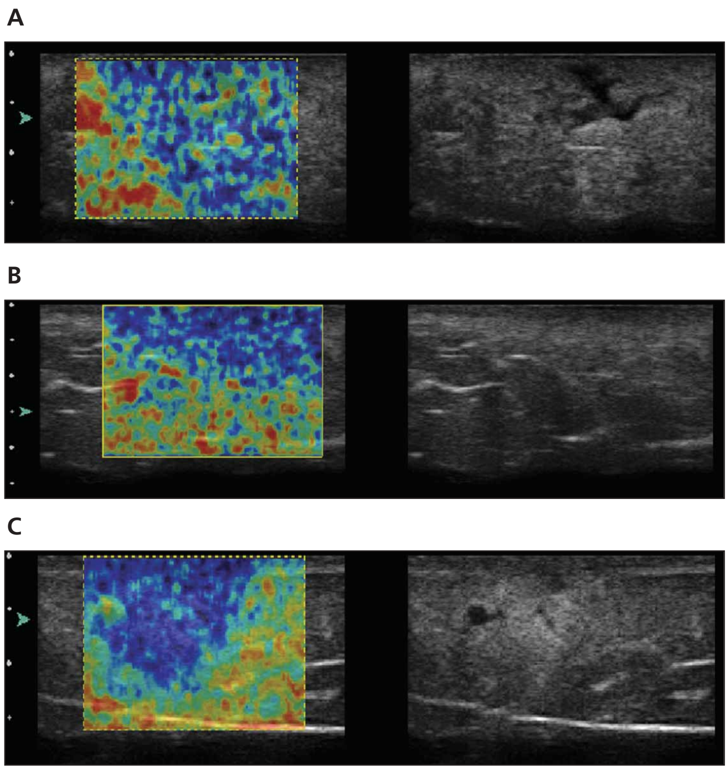
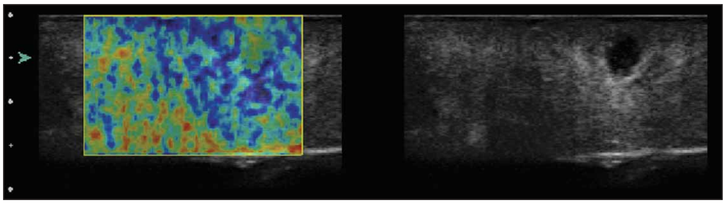


Figure 6. Elastographic imaging of soft tissue induration. **A**, Hard indurated tissue surrounding the abscess cavity is visualized with elastography as stiff regions (blue) surrounding the abscess cavity. **B**, A comparison view of the contralateral side without infection shows no localized stiff tissue (speckled mixed colors) and retention of the normal tissue planes (arrowheads).

Figure 7. Elastographic pattern of skin infection induration. Firm indurated tissue surrounding the soft abscess cavity is visualized with elastography as a range of patterns from speckled stiff coloring (**A**, blue) on a less soft (**A**, aqua) background to larger stiff spots (**B**, blue) on a background of middle stiffness (**B**, green and aqua) to almost solid stiff coloring (**C**, blue). The stiff induration (blue) is accentuated by the softer normal tissue (mixed colors).





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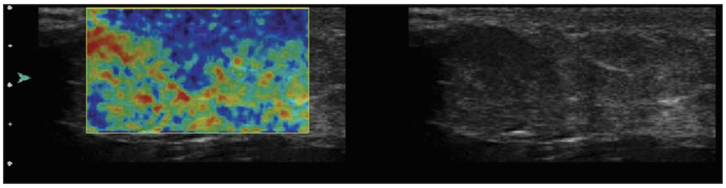

B

Figure 8. Elastographic color spectrum of skin infection induration. The surrounding induration is visualized with elastography as either speckled (**A**) or almost solid (**B**) stiff coloring (deep blue and aqua).

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