Effect of Initial Bedside Ultrasonography on Emergency Department Skin and Soft Tissue Infection Management

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Study objective: We examine the utility of emergency department (ED) ultrasonography in treatment of skin and soft tissue infections.

Methods: We enrolled ED patients with skin and soft tissue infections and surveyed clinicians in regard to their pre-ultrasonography certainty about the presence or absence of an abscess, their planned management, post-ultrasonography findings, and actual management. We determined sensitivity and specificity of ultrasonography and clinical evaluation, and assessed appropriateness of management changes based on initial clinical assessment and outcomes through 1-week follow-up.

Results: Among 1,216 patients, clinicians were uncertain of abscess presence in 105 cases (8.6%) and certain for 1,111 cases (91.4%). Based on surgical exploration and follow-up through 1 week, sensitivity and specificity for abscess detection by clinical evaluation were 90.3% and 97.7%, and by ultrasonography were 94.0% and 94.1%, respectively. Among 1,111 cases for which the clinician was certain, sensitivity and specificity of clinical evaluation were 96.6% and 97.3% compared with ultrasonographic evaluation sensitivity and specificity of 95.7% and 96.2%, respectively. Of 105 uncertain cases, sensitivity and specificity of ultrasonography were 68.5% and 80.4%. Ultrasonography changed management in 13 of 1,111 certain cases (1.2%), appropriately in 10 of 13 (76.9%) and inappropriately in 3 of 13 (23.1%). Of 105 uncertain cases, ultrasonography changed management in 25 (23.8%), appropriately in 21 of 25 (84.0%) and inappropriately in 4 of 25 (16.0%).

Conclusion: Ultrasonography rarely changed management when clinicians were certain about the presence or absence of an abscess. When they were uncertain, ultrasonography changed drainage decisions in approximately one quarter of cases, of which most (84%) were appropriate. [Ann Emerg Med. 2019;74:372-380.]

Please see page 373 for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background

Between 1993 and 2005, annual emergency department (ED) visits for skin and soft tissue infections in the United States increased from 1.2 million to 3.4 million.[1,2] A substantial proportion of these infections present as abscesses, and community-associated methicillin-resistant *Staphylococcus aureus* has been recognized as the most frequently identified cause of purulent skin and soft tissue infections in many parts of the world.[3]

Incision and drainage is the primary treatment for skin abscess,[4] producing cure rates of 80% to 90%; adjunctive antibiotics have been shown to increase initial cure rates and decrease risk of recurrences.[5,6] The decision to perform surgical drainage is typically straightforward, but can be complicated by difficulties in determining whether an abscess is present.

Point-of-care ultrasonography is able to visualize most abscesses.[7] The American College of Emergency Physicians' (ACEP's) 2016 clinical ultrasonographic guidelines list skin and soft tissue ultrasonography as a core application.[8] However, expert opinion and limited data indicate that large, fluctuant abscesses are easily identified and ultrasonography provides little benefit in managing most cases.[9-15] Abscesses that are small or those deep in skin structures may be less apparent on clinical examination. Several small studies suggest that point-of-care ultrasonography may be useful in evaluating the presence or absence of drainable fluid in difficult cases, and

Editor's Capsule Summary

What is already known on this topic

Ultrasonography can detect presence or absence of cutaneous abscess in emergency department patients, potentially guiding treatment and avoiding unnecessary surgical drainage.

What question this study addressed

How accurate is ultrasonography compared with clinical evaluation, and how frequently does it change management?

What this study adds to our knowledge

In this study of 1,216 patients, ultrasonography accurately identified abscesses (>90% sensitivity and specificity). When clinicians were certain of their clinical assessment, ultrasonography rarely changed management (1.2% of cases). Among uncertain cases, however, management changes occurred in 23.8% and were predominantly appropriate.

How this is relevant to clinical practice

Ultrasonography provides little benefit when there is confidence in the clinical evaluation, but can provide useful guidance when this is not the case.

could change management for up to 73% of patients with suspected but not clinically obvious abscesses.[9-11]

Importance

Accurate ED assessment of the presence or absence of an abscess can inform drainage decisions and enhance patient outcomes by targeting effective treatment and avoiding unnecessary surgical exploration. Bedside ultrasonography can provide additional information that may improve diagnostic decisions. However, to our knowledge no large prospective study has assessed its accuracy or the frequency and appropriateness with which its use might change management compared with clinical evaluation alone.

Goals of This Investigation

We sought to evaluate the ability of point-of-care ultrasonography to accurately detect the presence or absence of an abscess and to inform drainage decisions in patients with skin and soft tissue infections. As part of a multicenter clinical trial that enrolled ED patients with an acute skin and soft tissue infection, including cellulitis, wound infection, or abscess, we surveyed treating clinicians in regard to their pre-ultrasonography certainty of the presence or absence of an abscess, their planned management, their bedside ultrasonographic findings, and subsequent management of the skin and soft tissue infections. We calculated the sensitivity and specificity of clinical examination and ultrasonography, and then evaluated the frequency and appropriateness of changes in drainage plans based on ultrasonographic findings.

Our specific goals were to appraise the overall ability of clinical evaluation to detect or exclude an abscess among patients with skin and soft tissue infections, and to assess the overall ability of point-of-care ultrasonography to detect and exclude an abscess, as well as to inform drainage decisions among cases in which providers expressed either certainty or uncertainty about the presence or absence of an abscess.

MATERIALS AND METHODS

Study Design and Setting

We conducted an independent evaluation of the use of point-of-care ultrasonography in conjunction with our investigation on Strategies Using Off-Patent Antibiotics for Methicillin-Resistant *Staphylococcus aureus* (STOP MRSA). This prospective observational multicenter study enrolled emergency physicians and also ED patients undergoing evaluation and treatment of skin and soft tissue infections from February 2010 to April 2013. We conducted the study at 5 centers (Olive View–UCLA Medical Center [Los Angeles, CA], Maricopa Medical Center [Phoenix, AZ], Johns Hopkins University Medical Center [Baltimore, MD], University of Missouri Kansas City/Truman Medical Center [Kansas City, MO], and Temple University Medical Center [Philadelphia, PA]). The study was reviewed and approved by the institutional review boards at each center.

Selection of Participants

The STOP MRSA study enrolled patients older than 12 years with an acute skin and soft tissue infection who could be discharged from the ED and treated as outpatients, including those receiving a diagnosis of an abscess, infected wound, or cellulitis. The protocol dictated that centers enroll consecutive patients 24 hours a day, 7 days a week. Details of the STOP MRSA trials have been published elsewhere.[5,16,17] Patients with a suspected abscess were treated with standardized incision and exploration.

We asked all clinicians who provided verbal consent to participate in the study and to conduct bedside soft tissue ultrasonography on all participants as part of their STOP MRSA evaluation. We required all site investigators to undergo training in incision and drainage techniques and to adhere to a standardized ultrasonographic protocol. We

also asked clinicians to provide us with their current training level (postgraduate year for residents and years since graduating from residency for other providers), as well as the number of previous soft tissue point-of-care ultrasonographic studies they had completed.

Methods of Measurement

We asked treating clinicians to complete short surveys before and after performing ultrasonography. Before imaging, we asked clinicians to record measurements of maximal length and width of erythema and induration (if present) and, based on clinical evaluation alone, to indicate their initial assessment from among the following 3 options: certain an abscess was present, certain no abscess was present, or uncertain about the presence or absence of an abscess. Clinicians then indicated their intended management: perform incision and exploration (and drainage if fluid were found), needle aspiration (and incision and drainage if fluid were found), or no incision and exploration or needle aspiration (for patients thought to have no abscess). The STOP MRSA protocol mandated incision and drainage for all suspected abscesses.[5]

After clinicians had completed ultrasonography, we asked them to complete a second survey and to indicate the following: whether fluid appeared present on ultrasonography (and, if present, the single largest measurement of the extent of fluid collection); their final management (incision and exploration, needle aspiration followed by incision and exploration if an abscess was found, or no drainage); and what material (purulent, blood, or other fluid) was obtained if an incision or aspiration was performed.

Under the STOP MRSA protocol, at 1 week after enrollment, we examined patients in person or contacted them by telephone. During follow-up, we collected data on whether patients required subsequent ultrasonography, required incision and drainage, and whether that drainage was purulent.

We assigned each clinician a blinded unique identifier and collected information on their training level (resident, fellow, faculty, or other) and overall number of previous point-of-care ultrasonographic evaluations performed (of any type, not specifically for skin and soft tissue infections).

Outcome Measures

We defined an abscess as being present if a collection of purulent material was detected through incision and exploration or needle aspiration during the initial visit or through 1-week follow-up. We designated all other cases as having no abscess.

Primary Data Analysis

For each case, we recorded whether clinicians were initially certain or uncertain in their assessment of the presence or absence of an abscess. Using these tabulations, we determined individual case classifications for 5 separate assessments: initial clinical assessment of all cases; initial ultrasonographic evaluation for all cases; clinical assessment among cases in which clinicians were certain of the presence or absence of an abscess; ultrasonographic evaluations among cases in which clinicians were certain of the presence or absence of an abscess; and ultrasonographic evaluations in which clinicians were uncertain about the presence or absence of an abscess. In assessing the diagnostic accuracy of initial clinical evaluation among all cases, we categorized evaluations as positive when the clinician was certain an abscess was present and negative otherwise (when the clinician was certain an abscess was absent or uncertain about the presence or absence of an abscess).

We classified a case as truly positive if the assessment and final clinical outcome both indicated an abscess was present. We classified a case as falsely positive when the assessment indicated an abscess was present, but the participant was not found to have an abscess. We assigned a true-negative classification when the assessment indicated no abscess and the patient was not found to have an abscess. We classified a case as falsely negative when the assessment indicated no abscess but the patient was found to have an abscess. Using these classifications, we calculated point measures and 95% confidence intervals (CIs) for the operator characteristics (sensitivity, specificity, positive predictive value, and negative predictive value) and positive and negative likelihood ratios for each of the 5 separate assessments.

Before the ultrasonographic evaluation, we recorded the clinician's planned management for each case (incision/exploration, needle aspiration followed by incision and exploration if an abscess were found, or no drainage), and recorded the actual management after ultrasonography. We then determined the frequency with which final management differed from the initial planned management. We also determined the appropriateness or inappropriateness of changes in management based on the final determination of whether an abscess was present or absent. We classified changes as appropriate when the clinician, after obtaining ultrasonographic imaging results, either (1) performed incision and exploration or needle aspiration that yielded purulent material for cases in which these procedures were not initially planned or (2) avoided incision and exploration or needle aspiration for cases in which these

procedures were previously planned and the participant was classified as having no abscess on 1-week follow-up. We classified change in management as inappropriate when the clinician, after obtaining ultrasonographic imaging results, either (1) performed an incision and exploration or needle aspiration for cases in which these procedures were not initially planned and the intervention did not yield purulent material and an abscess was not diagnosed within 1 week or (2) did not incise and explore or needle aspirate for cases in which these procedures were planned and an abscess was diagnosed within 1-week follow-up.

We completed all calculations with SAS (version 9.4; SAS Institute, Inc., Cary, NC).

RESULTS

Clinicians completed ultrasonographic surveys on 1,234 patients (Figure 1). We excluded 18 of these cases, leaving 1,216 patients in our study population, including 264 (21.7%) in the cellulitis subtrial, 286 (23.5%) in the infected wound subtrial, and 666 (54.8%) in the abscesses subtrial. Before ultrasonography, clinicians were certain of the presence of abscess in 756 cases (62.2%), certain of the absence of abscess in 355 cases (29.2%), and uncertain of the presence or absence of abscess in 105 cases (8.6%). We identified 22 patients (1.8%) who did not have an abscess on their initial visit and who failed to complete follow-up evaluations and definitive outcome assessments for the presence or absence of abscess.

Characteristics of Study Subjects

Table 1 presents characteristics of our study population. The median length and width of erythema of the various skin and soft tissue infections were 7.0 and 5.0 cm, respectively. The median length and width of induration (measured in 1,149 cases) were 4.0 and 3.5 cm, respectively. The dimensions of erythema and induration among cases for which the clinician was certain or uncertain of the presence or absence of an abscess were similar. Of 1,216 skin and soft tissue infections evaluated, the presence of purulent material after incision and exploration or needle aspiration was found among 796 (65.5%) at the enrollment visit and 31 (2.5%) during 1-week follow-up, yielding a total of 827 cases involving abscesses. Figure 2 presents the ultrasonographic findings and management of the 1,216 patients enrolled in the study.

Main Results

Using clinical evaluation alone, clinicians identified 747 of the 827 cases in which abscess was ultimately diagnosed (sensitivity 90.3%), and identified that an abscess was absent in 380 of 389 cases in which no abscess was diagnosed (specificity 97.7%). Ultrasonography identified 777 of the 827 cases in which abscess was diagnosed (sensitivity 94.0%), and identified absence of an abscess in 366 of the 389 cases in which no abscess was diagnosed (specificity 94.1%).

Among 1,111 cases in which clinicians were certain on their clinical assessments, abscesses were ultimately diagnosed in 773 cases, and 338 were found to have no

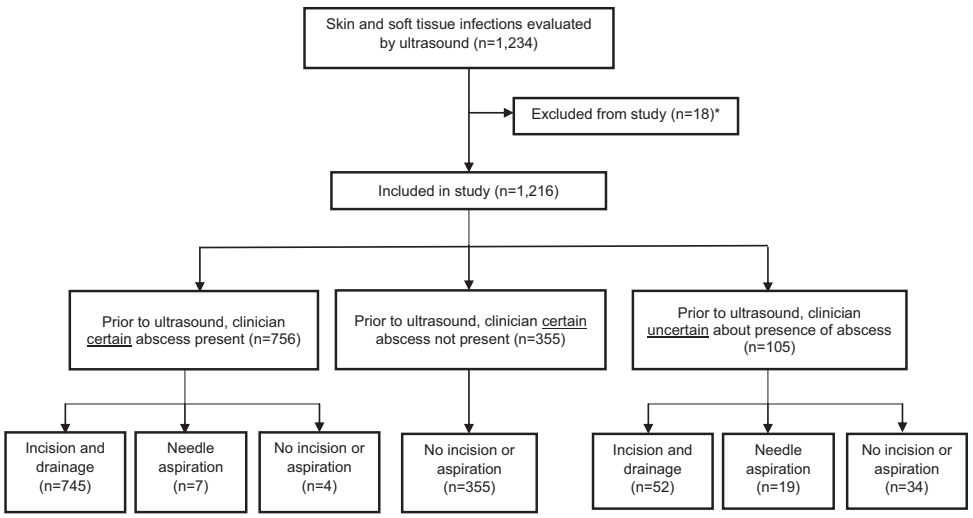

Figure 1. ED patients presenting with skin and soft tissue infections to be evaluated with bedside ultrasonography: clinician certainty about presence of an abscess and planned treatment. *Of the 18 patients who were excluded, 5 did not meet eligibility criteria and were not enrolled in the STOP MRSA study, 4 were missing data on what the physician would do before ultrasonography, 7 were missing data on the clinician's interpretation of ultrasonographic findings, and 2 could not be linked to the STOP MRSA data because their study identification number was incorrectly entered.

Table 1. ED patients with skin and soft tissue infections evaluated with ultrasonography by clinicians who were certain and uncertain about the presence or absence of an abscess before performing the ultrasonography.

Characteristic	Total (n=1,216)	Clinician Was Certain About the Presence or Absence of an Abscess (n=1,111)	Clinician Was Uncertain About the Presence or Absence of an Abscess (n=105)
Median age (IQR), y	36 (26–48)	36 (26–448)	35 (25–48)
Sex, No. (%)			
Female	508 (41.8)	469 (42.2)	39 (37.1)
Male	708 (58.2)	642 (57.8)	66 (62.9)
Race, No. (%)			
White	650 (53.5)	605 (54.5)	45 (42.9)
Black	461 (37.9)	416 (37.4)	45 (42.9)
Asian	4 (0.3)	3 (0.3)	1 (1.0)
Native American	6 (0.5)	4 (0.4)	2 (1.9)
Other	51 (4.2)	45 (4.1)	6 (5.7)
Multirace	44 (3.6)	38 (3.4)	6 (5.7)
Ethnicity, No. (%)			
Hispanic	455 (37.4)	425 (38.3)	30 (28.6)
Not Hispanic	760 (62.5)	686 (61.8)	74 (70.5)
Unknown	1 (0.1)	0 (0.0)	1 (1.0)
Erythema length, median (IQR; range), cm	7.0 (4.0–12; 0.5–56)	6.5 (4.0–12.0; 0.5–56)	7.4 (5.0–12.0; 1.2–27)
Erythema width, median (IQR; range), cm	5.0 (3.0–8.5; 0.3–56)	5.0 (3.0–9.0; 0.3–56)	6.0 (4.0–8.0; 1.2–19)
Distinct border of induration present, No. (%)	912 (75.0)	830 (74.7)	82 (78.1)
Induration length, median (IQR; range), cm (n=1,149)	4.0 (3.0–6.5; 0.0–56)	4.0 (3.0–6.5; 0.0–56)	4.0 (3.0–6.0; 0.0–12)
Induration width, median (IQR; range), cm (n=1,149)	3.5 (2.5–5.0; 0.0–44)	3.5 (2.5–5.0; 0.0–44)	3.5 (2.5–5.0; 0.0–15)
Dark fluid present on ultrasonography, No. (%)			
Yes	800 (65.8)	753 (67.8)	47 (44.8)
No	414 (34.0)	356 (32.0)	58 (55.2)
Unsure	2 (0.2)	2 (0.2)	0
Treatment after ultrasonography, No. (%)			
Incision and drainage	795 (65.4)	753 (67.8)	42 (40.0)
Needle aspiration	13 (1.1)	8 (0.7)	5 (4.8)
None of the above	408 (33.6)	350 (31.5)	58 (55.2)
If incision and drainage or needle aspiration performed (n=808), purulent material present, No. (%)			
Yes	796 (98.5)	751/761 (98.7)	45/47 (95.7)
No	4 (0.5)	5/761 (0.7)	0/47
No purulent and nonpurulent material drained	8 (1.0)	5/761 (0.7)	2/47 (4.3)
At 1-wk follow-up, incision and drainage performed and purulent material present, No. (%)	31 (2.5)	22 (2.0)	9 (8.6)

IQR, Interquartile range.

abscess. Clinicians correctly identified 747 abscesses (sensitivity 96.6%) and correctly identified absence of an abscess in 319 cases (specificity 94.4%). Ultrasonography identified 740 of the 773 abscesses (sensitivity 95.7%) and demonstrated absence of an abscess in 325 of the 338 cases without abscess (specificity 96.2%).

Among 105 cases in which clinicians were uncertain in their clinical assessments, ultrasonography identified

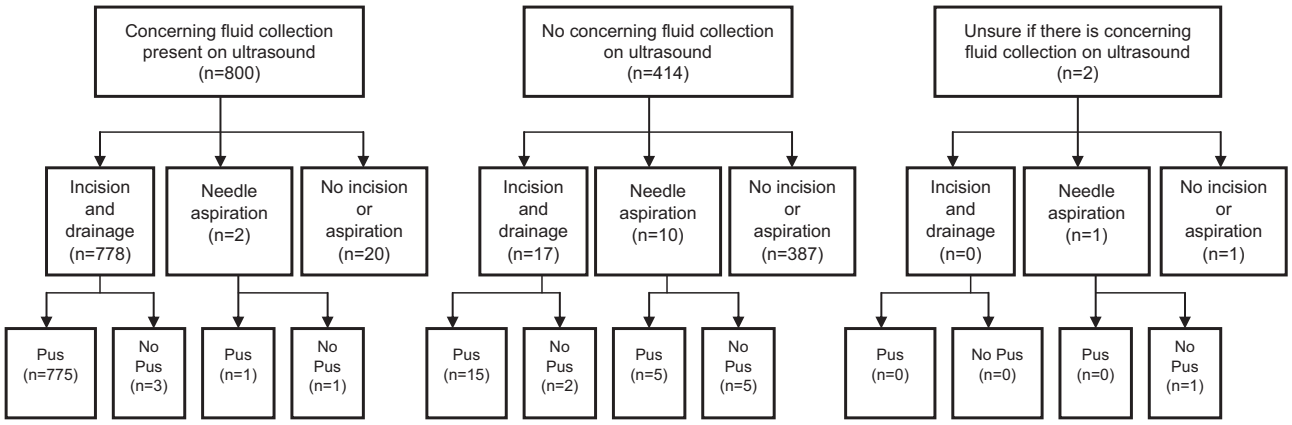

Figure 2. Ultrasonographic findings and subsequent management and findings of ED patients with skin and soft tissue infections.

abscess in 37 of the 54 cases ultimately found to have an abscess (sensitivity 68.5%) and revealed absence of an abscess in 41 cases without an abscess (specificity 80.4%). Table 2 presents outcome classifications, operator characteristics, and positive and negative likelihood ratios for clinical and ultrasonographic evaluations.

Overall, ultrasonography changed initial planned management in 38 cases (3.1%). Among 1,111 certain cases, ultrasonography changed management in 13 cases (1.2%), 10 appropriately (76.9%) and 3 inappropriately (23.1%). Among 105 uncertain cases, point-of-care ultrasonography changed management in 25 cases (23.8%; 95% CI 16.0% to 33.1%), with appropriate changes in 21 (84.0%; 95% CI 63.9% to 95.5%) and inappropriate changes in 4 (16.0%; 95% CI 4.5% to 36.1%).

The 1,216 point-of-care ultrasonographic evaluations were performed by 319 clinicians, including 664 (54.6%) by emergency medicine residents, 462 (38.0%) by attending emergency physicians, 84 (6.9%) by physician extenders (nurse practitioners and physician assistants), 4 (0.3%) by emergency medicine fellows, and 2 (0.2%) by medical students. Individual clinicians evaluated a median of 2 patients with skin and soft tissue infections (interquartile range 1 to 4; range 1 to 135). More than 75% of the clinicians had performed greater than 25 previous bedside ultrasonographic examinations, 21.3% had performed between 5 and 24, and 3.6% had performed fewer than 5. The clinician outlier who performed 135 ultrasonographic examinations (11%) exhibited a sensitivity of 90.4% and specificity of 100%. Table 3 summarizes the degree of certainty in regard to the presence or absence of an abscess, based on clinician training and experience.

LIMITATIONS

Our results may have limited application to patients who do not have characteristics of our study population. In particular, patients in our trial had less severe infections that were amenable to outpatient treatment. This population is likely to exhibit greater diagnostic uncertainty based on clinical examination and perhaps a greater utility of ultrasonography compared with populations who exhibit more significant disease. In addition, enrollment in the STOP MRSA abscess study was limited to patients who had abscesses and erythema greater than 2 cm in diameter, which means that we were unable to assess the discriminating ability of clinical evaluation or point-of-care ultrasonography on smaller lesions.

We enrolled patients with all 3 types of skin infections (cellulitis, infected wounds, and abscesses), but our sample size targets dictated that we enroll specific numbers of patients with each type of infection (1,265 in the abscess arm and 500 each in the cellulitis and infected wound arms). Consequently, by study design, we had more patients with suspected abscesses and a consequently higher probability of having abscesses. However, it is less clear what effect these enrollments had on the proportion of cases in which clinicians were uncertain about the presence or absence of abscess. The prevalence of uncertainty is likely to differ among the separate infection types.

Our survey may provide an inaccurate proxy for what clinicians thought and ultimately chose. For example, a clinician may have indicated certainty on a survey that no abscess existed, but in actual practice might have surgically explored the lesion.

Our study may be subject to operator bias in the use of point-of-care ultrasonography. Performance of point-of-care ultrasonography may vary with clinician experience. It is likely that clinicians with more extensive experience have greater sensitivity and specificity in detecting and excluding abscesses than observed by our study. Conversely,

Table 2. Outcome classifications, operator characteristics, and positive and negative predictive values for the clinical and ultrasonographic evaluations performed in the study.

	True Positive	False Positive	True Negative	False Negative	Sensitivity (95% CI), %	Specificity (95% CI), %	PPV (95% CI), %	NPV (95% CI), %	Positive Likelihood Ratio (95% CI)	Negative Likelihood Ratio (95% CI)
Clinical evaluation, all cases (N=1,216)	747	9	380	80	90.3 (88.1–92.3)	97.7 (95.7–98.9)	98.8 (97.8–99.5)	82.6 (78.8–86.0)	39.0 (20.5–74.5)	0.10 (0.08–0.12)
Ultrasonographic evaluation, all cases (N=1,216)	777	23	366	50	94.0 (92.1–95.4)	94.1 (91.3–96.2)	97.1 (95.7–98.2)	88.0 (84.5–90.9)	15.9 (10.7–23.6)	0.06 (0.05–0.08)
Clinical evaluation, certain cases (N=1,111)	747	19	319	26	96.6 (95.1–97.8)	94.4 (91.4–96.6)	97.5 (96.2–98.5)	92.5 (89.2–95.0)	17.2 (11.1–26.6)	0.04 (0.02–0.05)
Ultrasonographic evaluations, certain cases (N=1,111)	740	13	325	33	95.7 (94.1–97.0)	96.2 (93.5–97.9)	98.3 (97.1–99.1)	90.8 (87.3–93.6)	24.9 (14.6–42.4)	0.04 (0.03–0.06)
Ultrasonographic evaluations, uncertain cases (N=105)	37	10	41	17	68.5 (54.4–80.5)	80.4 (66.9–90.2)	78.7 (64.3–89.3)	70.7 (64.8–82.3)	3.49 (1.95–6.27)	0.39 (0.26–0.59)

PPV, Positive predictive value; *NPV*, negative predictive value.

individuals with less experience are likely to have less accurate outcomes.

It is possible that our criterion standard outcome overestimated the number of abscesses. We assumed that an abscess later detected within 1 week of follow-up represented a missed abscess, yet some of these lesions could have developed after the initial evaluation. This is likely to result in a small underestimate for the sensitivity of point-of-care ultrasonography.

It is also important to carefully interpret the positive and negative predictive values obtained in this study. These values do not apply to the overall population of patients with skin and soft tissue infections, but rather to the subpopulations who clinicians thought might have an abscess. In particular, these values do not apply to the general population of patients with infected wounds, or those with cellulitis.

Although our study focuses on using point-of-care ultrasonography to detect abscesses, it may have additional benefits such as determining abscess location and dimensions, and ascertaining the effectiveness of drainage. An assessment of its utility in these additional applications is beyond the scope of this study.

DISCUSSION

For patients presenting with skin and soft tissue infections, accurate assessment of the presence or absence of an abscess leads to management that optimizes outcomes while avoiding unnecessary invasive procedures. In this study of the utility of bedside soft tissue ultrasonography among 1,216 participants in a clinical trial who had suspected abscess, cellulitis, or wound infection, we found that overall, ultrasonography rarely informed clinical decisionmaking, but when it did, it generally improved appropriateness of management. In approximately 90% of cases, clinicians were certain of the presence or absence of an abscess; their clinical assessment was accurate and ultrasonography rarely changed management. In the approximately 10% of cases in which they had uncertainty, ultrasonography changed management in approximately one quarter of cases. Among all cases in which ultrasonographic findings led to changed management, these changes were 3 to 5 times more likely to be appropriate than inappropriate. These findings support the use of point-of-care ultrasonography for cases in which providers are uncertain of the presence or absence of abscess after their clinical evaluation.

Our results stand in contrast to those of a similar study involving 126 adults with cellulitis without obvious abscess on physical examination, in which the authors reported that ultrasonography changed projected management in 56% of

Table 3. Abscess evaluations by previous ultrasonographic experience level.

Clinician Experience	Total Abscess Evaluations	Certain on Presence or Absence of Abscess	Uncertain on Presence or Absence of Abscess
Training level, No. (%)			
Faculty	462 (38.0)	418 (90.5)	44 (9.5)
Fellow	4 (0.3)	4 (100.0)	0
Resident	664 (54.6)	608 (91.6)	56 (8.4)
Other*	86 (7.1)	81 (94.2)	5 (5.8)
Previous examinations, No. (%)			
<5	44	40 (90.9)	4 (9.1)
5–24	259	232 (89.6)	27 (10.4)
≥25	913	839 (91.9)	74 (8.1)
Total	1,216	1,111 (91.4)	105 (8.6)

*Other: Nurse practitioners, physician assistants, medical students.

cases.[11] An abscess was ultimately found in 46% of these patients, which suggests higher threshold for certainty (or what would be considered "obvious") in regard to the presence or absence of an abscess than in our study. A few single-site studies involving small numbers of clinicians, as well as studies involving children, have also suggested that bedside ultrasonography may improve accuracy and aid in diagnosis of a drainable abscess.[1,2,18,19] A recent meta-analysis reported similar sensitivity but somewhat lower specificity (83% versus 94%) of ultrasonography for abscess detection than we observed, which may reflect a different spectrum of patients with more advanced cellulitis and early fluid collections that are not borne out to be true abscesses on exploration.[13] Because our work focused on populations treated as outpatients, we likely encountered fewer of these advanced cases.

Despite the acknowledged limitations, our results probably provide a good representation of the outcomes and operator characteristics that are likely to exist among the general population of clinicians who use bedside ultrasonography. Our examining clinicians had a broad range of experience, including postgraduate years 1 to 4 in the specialties of emergency medicine, family medicine, internal medicine, general surgery, and other surgical subspecialties, as well as some fourth-year rotating medical students, emergency medicine fellows, attending emergency physicians, and physician extenders. The total group of diverse sonographers also had various experience with point-of-care ultrasonography, ranging from fewer than 5 to greater than 25 previous ultrasonographic examinations.

When clinicians are certain an abscess is present or absent according to clinical evaluation alone, they should proceed with appropriate management on the basis of their judgment; ultrasonography provides little benefit in these situations. Alternatively, when clinicians are uncertain about the presence or absence of an abscess according to physical examination, ultrasonography can provide useful information to better target need for surgical exploration and drainage. Although ultrasonography was less accurate among cases in which the clinician was uncertain of the presence or absence of an abscess, its use led to a change in management in approximately one quarter of cases, and these changes were approximately 5 times more likely to be appropriate than inappropriate.

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All authors attest to meeting the four ICMJE.org authorship criteria: (1) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (2) Drafting the work or revising it critically for important intellectual content; AND (3) Final approval of the version to be published; AND (4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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