The Journal of Emergency Medicine, Vol. 72, No. C, pp. 121–128, 2025

0736-4679/$ - see front matter

https://doi.org/10.1016/j.jemermed.2024.11.012

Evidence Based Medicine

What is the Utility of Point-of-Care Ultrasound for Diagnosis of Soft Tissue Abscess vs. Cellulitis?

Kristine Jeffers, MD,* Samuel M. Keim, MD, MS,† Brit Long, MD,* Michael Gottlieb, MD,‡ and Srikar R. Adhikari, MD, MS†

*Department of Emergency Medicine, Brooke Army Medical Center, Fort Sam Houston, Texas, †Department of Emergency Medicine, The University of Arizona, Tucson, Arizona, and ‡Department of Emergency Medicine, Rush University Medical Center, Chicago, Illinois

Reprint Address: Samuel M. Keim, MD, Department of Emergency Medicine, The University of Arizona College of Medicine Tucson, P.O. Box 245057, Tucson, AZ 85724-5057

□ **Abstract—Background: Skin and soft tissue infections (SSTIs) including cellulitis and abscess are common conditions managed in the emergency department, but differentiating these on history and physical examination alone can be challenging. Point-of-care ultrasound (POCUS) has been proposed as a tool to distinguish abscess from cellulitis. Clinical Question: What is the utility of POCUS for diagnosing soft tissue abscess vs. cellulitis? Evidence Review: Studies retrieved included four systematic reviews and meta-analyses evaluating the use of POCUS for diagnosing abscess. These studies provide estimates of the potential utility of POCUS in differentiating abscess and cellulitis. Conclusion: Based upon the available literature, POCUS can reliably differentiate abscess and cellulitis and assist with management of SSTIs.**

This manuscript did not utilize any grants, and it has not been presented in abstract form. This clinical review has not been published, it is not under consideration for publication elsewhere, its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. This review does not reflect the views or opinions of the U.S. government, Department of Defense, Defense Health Agency, U.S. Army, U.S. Air Force, or SAUSHEC EM Residency Program.

□ **Keywords—soft tissue infection; infectious disease; cellulitis; abscess; POCUS; point-of-care ultrasound; point-of-care ultrasonography; ultrasound; ultrasonography**

Case Report

A 43-year-old man with no significant past medical history presents to the Emergency Department (ED) with redness and pain along the forearm. He denies recent trauma, fevers, chills, rigors, and fatigue, but he has noted increased pain and warmth along the site that has been worsening over 3 days. On physical examination, his vital signs are normal. He is neurovascularly intact, and you find an area of induration, warmth, and erythema that is 5 cm in diameter. You suspect cellulitis, but question whether an abscess is present.

Clinical Question

What is the utility of point-of-care ultrasound (POCUS) for diagnosing soft tissue abscess vs. cellulitis?

Context

Cellulitis and abscess are common skin and soft tissue infections (SSTIs) managed in the ED. There are approximately six million ED visits annually for cellulitis

Received: 6 November 2024; Accepted: 16 November 2024

and abscess, with < 10% of these patients' requiring admission (1–4). However, the need for hospitalization increases in those of older age and significant comorbidities (2,5,6).

Cellulitis is defined as a localized, superficial infection of the dermis and subcutaneous layers of the skin (1,7,8). This most commonly presents with erythema, warmth, pain, tenderness, and induration. Systemic symptoms such as fevers, chills, and rigors may be present. Several bacterial pathogens may result in cellulitis, with the most common cause of nonpurulent cellulitis beta-hemolytic streptococci (e.g., *Streptococcus pyogenes*), followed by *Staphylococcus aureus* (1,7–17).

An abscess is defined as a localized collection of neutrophils, liquefactive necrosis, and edema surrounded by a fibrous capsule that may be associated with overlying cellulitis. This typically presents as a pyogenic, fluctuant focus with surrounding erythema, and spontaneous drainage of material may occur. *Staphylococcus aureus* is the predominant causative microbe in abscesses, up to 70% of which are methicillin resistant (1,3,7,18–25).

Treatment of cellulitis includes antibiotics, whereas for abscess it includes drainage with or without antibiotics (8,26). However, history and physical examination are not 100% accurate in differentiating cellulitis and abscess, which can impact management (1,5,8,27,28). POCUS has emerged as a potential tool in the diagnosis of cellulitis and abscess (8,29–34).

Evidence Search

To address the clinical question, you search for systematic reviews and meta-analyses evaluating the use of POCUS for differentiating soft tissue abscess from cellulitis. The patient population in whom you are interested are ED patients with concern for soft tissue abscess. You restrict your search results to systematic reviews and meta-analyses. Utilizing the search terms "abscess" or "soft tissue" and "meta-analysis" and "point-of-care ultrasound" or "point-of-care ultrasonography" yields eight citations. From these citations, you pull the following four resources from the literature.

Evidence Review

Point-of-Care Ultrasound for Diagnosis of Abscess in Skin and Soft Tissue Infections (31)

Population

Study authors included studies comparing clinical examination and POCUS for detection of abscess in patients of any age. Studies also had to include the criterion for abscess diagnosis of purulent drainage either on incision or at follow-up. Absence of an abscess was defined as no purulent drainage on incision or resolution. Six trials (four pediatric, two adult) with a total of 800 patients were included.

Exclusion criteria

Authors excluded studies not conducted in the ED or by emergency physicians. Trials were also excluded if they included intraoral abscesses or abscesses that required operative drainage.

Study design

The authors searched MEDLINE, Web of Science, CINAHL, EMBASE, and Cochrane Libraries from inception through May 21, 2015, using the keywords abscess, ultrasonography, cellulitis, and SSTI. They also searched clinicaltrials.gov, and on January 1, 2016, they searched EBSCO and Google Scholar. All abstracts and articles were initially screened by two authors, and a third reviewer was involved for any disputes on study inclusion. Two authors abstracted the data. Heterogeneity was tested using DerSimonian and Laird's Q test. Calculations were based on the diagnostic odds ratios (ORs) for each test, using log scale. A hierarchical summary receiver operator characteristic (HSROC) model was created to report summary diagnostic accuracy of POCUS.

Outcomes

Outcomes of interest were sensitivity and specificity of POCUS and clinical examination for diagnosis of abscess.

Main results

The sensitivity of POCUS ranged from 90% to 98%, and specificity ranged from 67–88%. The sensitivity of clinical examination ranged from 75% to 95%, and specificity ranged from 60% to 84%. There was significant heterogeneity in the six studies (χ^2[5] 33.11, $p < 0.0001$). One study by Marin et al. was excluded on a repeat heterogeneity test due to its major differences, with no statistically significant heterogeneity found in the remaining five studies (χ^2[4] 3.34, $p = 0.50$) (35). Overall, pooled sensitivity and specificity for POCUS (using data from all trials except for Marin et al.) were 97% (95% confidence interval [CI] 94–98%) and 83% (95% CI 75–88%), respectively. Positive likelihood ratio (LR+) was 5.5 (95% CI 3.7–8.2), and negative likelihood ratio (LR−) was 0.04 (95% CI 0.02–0.08). Description of POCUS training for study physicians was explained, but background experience of POCUS among study physicians was not routinely described. The description ranged from novice to POCUS credentialed physicians or was not described.

In Patients Presenting to the Emergency Department with Skin and Soft Tissue Infections What is the Diagnostic Accuracy of Point-of-Care Ultrasonography for the Diagnosis of Abscess Compared to the Current Standard of Care? A Systematic Review and Meta-Analysis (32)

Population

Authors included prospective cohort and case-control studies evaluating the diagnostic accuracy of POCUS for abscess in ED patients. Patients were required to have an SSTI with diagnostic uncertainty regarding abscess or cellulitis. The index test was the use of POCUS in diagnosis of abscess in ED patients. Final diagnosis was made using a reference standard of purulent discharge from an incision and drainage, radiologist opinion on computed tomography imaging, or final diagnosis from clinical follow-up.

Exclusion criteria

Authors excluded case reports, retrospective studies, and other types of case-control studies. They also excluded studies that did not report sensitivity or specificity, if data could not be extracted to construct a 2 × 2 table, and studies of patients in the primary care or inpatient setting.

Study design

Authors searched Ovid MEDLINE, Ovid EMBASE, and Cochrane Library from inception to March 31, 2016. Two authors reviewed articles for inclusion. Disagreement was resolved by consensus, and if needed, a third reviewer was involved. Two reviewers independently extracted the data into a prepared data sheet. Data extracted included author, title, journal name, year of publication, study design (prospective cohort, case-control), study setting, POCUS protocol, reference standard, QUADAS-2 items, and data on sensitivity and specificity or data for 2 × 2 table. Methodological quality and risk of bias of each article was assessed using the QUADAS-list. Heterogeneity was assessed using a forest plot as well as an HSROC, which can control for the lack of an ideal reference standard. Data were combined for meta-analysis using the HSROC model to obtain summary estimates of the pairs of sensitivity and specificity. Data analysis was conducted using Stata software (StataCorp LLC, College Station, TX).

Outcomes

The primary outcome was to determine the sensitivity and specificity of POCUS in diagnosing abscess in ED patients with SSTIs. The secondary objective was accuracy of POCUS in a subgroup analysis of pediatric patients. A post hoc secondary outcome was the reported change in management due to POCUS, as this was thought to be clinically important.

Main results

Eight studies were included in the final systematic review and meta-analysis, with a total of 747 patients. Three studies included adults, and five studies were from pediatric ED settings. All but one study was conducted in the United States. Using the QUADAS tool, most studies were found to be of moderate to high quality. Meta-analysis yielded a sensitivity of 95.5% (95% CI 88.9–98.3) and specificity of 80.3% (95% CI 56.4–92.7%). LR+ was 5.6 (95% CI 2.2–14.6), and LR− was 0.05 (95% CI 0.02–0.11). Subgroup analysis of POCUS in pediatric patients found a point estimate of sensitivity 93.9% (95% CI 84.8–97.7%) and specificity 82.9% (95% CI 34.2–97.9%). LR+ for pediatric patients was 5.5 (95% CI 0.9–33.9), and LR− was 0.07 (95% CI 0.03–0.15). Data to support a change in management after POCUS were available in 5 of 7 studies. In studies of pediatric patients, the rate of management change ranged from 14% to 27%. Patients who ultimately did not require drainage ranged from 12% to 29%, and patients requiring drainage after POCUS ranged from 13% to 18%. Studies of adults had higher rates of management change, with a range of 17–56%. Patients who were found to need drainage after POCUS ranged from 23% to 40%, and those who did not require drainage ranged from 12% to 36%.

Point-of-Care Ultrasonography for the Diagnosis of Skin and Soft Tissue Abscesses: A Systematic Review and Meta-analysis (33)

Population

Authors included prospective or randomized controlled trials assessing the use of POCUS for skin and soft tissue abscess. They included 14 studies, comprising 2656 total patients, for final analysis.

Exclusion criteria

Authors excluded case reports, case series, retrospective studies, and review articles.

Study design

Authors searched PubMed, Scopus, the Latin American and Caribbean Health Sciences Literature database, the Cumulative Index of Nursing and Systematic Reviews, and the Cochrane Central Register of Controlled Trials to include citations from inception to July 26, 2019. They also performed a search of clinicaltrials.gov. Authors included all prospective or randomized controlled trials assessing the use of POCUS for skin and soft tissue abscesses. Two authors independently extracted data from all included studies into a predesigned data collection form. Any discrepancies were resolved by consensus,

with the addition of a third reviewer if needed. Calculations were completed with a bivariate random-effects model. To assess heterogeneity, a χ^2 statistic $p < 0.10$ or an I^2 statistic $> 50\%$ was considered significant for heterogeneity. A receiver operating curve was used to evaluate the primary outcome with a 95% confidence region. A funnel plot was used to assess publication bias. A fixed-effects analysis was used for subgroup analysis of diagnostic accuracy in adults. Statistical analysis was completed using the MIDAS module for Stata/MP to perform analysis, including bivariate random-effects analyses, summary receiver operating curve analysis, and assessment of publication bias. DIAGT module was used for fixed-effects analyses. Forest plots were constructed with RevMan (The Cochrane Collaboration).

Outcomes

The outcome of interest was the diagnostic accuracy of POCUS for identifying skin and soft tissue abscesses. Secondary outcomes included whether POCUS resulted in a change in management, the percentage of correct vs. incorrect changes in management, and differences in treatment failure rates between POCUS and non-POCUS groups.

Main results

Thirteen studies were performed in the ED, and one was performed in an outpatient clinic. POCUS was 94.6% sensitive (95% CI 89.4–97.4%) and 85.4% specific (95% CI 78.9–90.2%), with an LR+ of 6.5 (95% CI 4.4–9.6) and LR− of 0.06 (95% CI 0.03–0.13) for diagnosing abscess. Among cases that were clinically unclear, POCUS was 91.9% sensitive (95% CI 77.5–97.4%) and 76.9% specific (95% CI 65.3–85.5%), with a LR+ of 4.0 (95% CI 2.5–6.3) and LR− of 0.11 (95% CI 0.03–0.32). Overall, POCUS resulted in a change in management in 301 of 2107 patients (14.3%). Among the remaining 6 studies (n = 1715 cases), POCUS led to a correct change in management in 177 cases (10.3%; 95% CI 8.9–11.8%) and led to an incorrect change in management in 12 cases (0.7%; 95% CI 0.3–1.1%). There was evidence of statistical heterogeneity but no evidence of publication bias.

Role of Point-of-Care Ultrasound (POCUS) in the Diagnosis of an Abscess in Paediatric Skin and Soft Tissue Infections: A Systematic Review and Meta-Analysis (34)

Population

Authors included all relevant studies that met the following criteria: a diagnostic study, must evaluate POCUS for differentiating abscess from cellulitis in pediatric patients, and must have a reference standard to confirm abscess such as incision and drainage. Seven studies were included, with a total of 870 patients and 917 lesions. Six studies were conducted in a pediatric ED and one included children seen in a general ED.

Exclusion criteria

The authors excluded case reports, consensus statements, and unpublished articles, non-English articles, and studies with insufficient data to construct diagnostic 2×2 tables.

Study design

The authors searched PubMed, EMBASE, and the Cochrane Library from inception to November 2020 to identify studies on POCUS for differentiating abscess and cellulitis in pediatric patients with SSTIs. Two investigators independently reviewed the studies for inclusion, and discrepancies were resolved through discussion. Data were extracted into a standardized form. Quality of each study was assessed using the QUADAS-2 tool. A bivariate effect model was used to calculate pooled sensitivity, specificity, LR+, LR−, and diagnostic OR for the diagnostic accuracy of POCUS in differentiating cellulitis from abscess in pediatric patients with SSTIs. Heterogeneity was evaluated using the inconsistency index (I^2) and the Cochran Q test, and the Deeks funnel plot asymmetry test was used to evaluate publication bias.

Outcomes

The primary outcome of this meta-analysis was to compare the diagnostic accuracy of POCUS with physical examination for the diagnosis of abscess in pediatric patients.

Main results

The pooled sensitivity of POCUS was 0.90 (95% CI 0.82–0.95), and sensitivity was 0.80 (95% CI 0.72–0.86). The pooled LR+, LR−, and diagnostic OR of POCUS were 4.5 (95% CI 3.1–6.4), 0.13 (95% CI 0.07–0.23), and 36 (95% CI 17–75), respectively. Four studies were included on an analysis of physical examination for diagnosis of abscess with a pooled sensitivity of 0.84 (95% CI 0.80–0.88), specificity of 0.69 (95% CI 0.62–0.76), and area under the curve of 0.85 (95% CI 0.81–0.88). There was significant evidence of heterogeneity, but authors found no evidence of publication bias. Abscess prevalence, sample size, and year of publication were associated with the heterogeneity. Sensitivities remained similar but specificity was lower in studies conducted prior to 2013, when abscess prevalence was $> 60\%$, and when sample size was > 100.

Conclusions

SSTIs are a common diagnosis in the ED setting and present along a spectrum, including cellulitis and abscess. The management of cellulitis includes antibiotics, whereas abscess requires drainage of the purulent material (8,9). POCUS has emerged as an integral tool in the diagnosis of many conditions, including SSTIs, as it may assist in determining the presence of an abscess.

The studies evaluated in this review found that POCUS demonstrated over 90% sensitivity and 80% specificity for diagnosis of abscess, which seemed to be better than physical examination (31–34). However, there are several important considerations. First, patients with cellulitis and a negative POCUS initially may develop abscess later, which can confound the results. Second, there were various gold standards used for diagnosis of abscess among the included studies with no definitive criterion, and the individual studies included convenience samples with contamination between the sonographers and clinician for diagnosis and management decisions. These potentially can inflate any estimates of sensitivity and specificity (33–37). A study published in 2019 with 1216 patients found that ultrasound (US) demonstrated a sensitivity and specificity of 94.0% and 94.1%, respectively, whereas for clinical evaluation they were 90.3% and 97.7%, respectively (37). If the diagnosis was uncertain, US demonstrated a sensitivity and specificity of 95.7% and 96.2%, respectively, and for clinical evaluation, 96.6% and 97.3%, respectively. US changed management in 1.2% of certain cases (13/1111), of which 76.9% were appropriate changes and 23.1% inappropriate. In uncertain cases, US changed management in 23.8% (25/105), of which 84.0% were appropriate and 16.0% inappropriate (37). The meta-analysis by Gottlieb et al. found that POCUS led to a correct change in management in 10.3% of cases, with a number needed to treat of 10 patients, and an inappropriate change in 0.7% of cases, with a number needed to harm of 142 patients (33).

We believe POCUS has utility in managing patients with SSTI, though the accuracy of POCUS for diagnosis of abscess depends on the pretest probability and operator skill. If abscess is clinically apparent, POCUS may not be necessary for diagnosis, though if the diagnosis is unclear, POCUS has utility in differentiating cellulitis and abscess. Even in clinically apparent cases of abscess, POCUS can be helpful in determining the appropriate site for drainage, as well as avoiding an incision of a pseudoaneurysm or lymph node (8).

Commentary by Dr. Srikar Adhikari

Soft tissue infections are commonly encountered in the ED. POCUS has emerged as a valuable tool in managing these infections, offering tailored management strategies. POCUS has grown in importance for managing soft tissue infections, particularly in cases where there is uncertainty about the presence of an abscess and whether a drainage procedure is necessary. In pediatric cases, where assessing abscesses is challenging due to limited patient cooperation, smaller body size, and parental concerns, POCUS offers a rapid, noninvasive diagnostic option. This method spares children from the trauma of unnecessary procedures and, when needed, allows for more precise intervention. Although POCUS is known for its high sensitivity in differentiating abscesses from cellulitis, there are other, less-explored yet equally valuable aspects of its clinical utility. One notable advantage of POCUS is its ability to provide real-time guidance for procedures like incision and drainage. US-guided drainage of soft tissue abscesses has been shown to be more effective and safer than unguided approaches. This is especially valuable in cases involving deep abscesses or those located adjacent to neurovascular structures, where POCUS precision helps clinicians avoid complications associated with blind drainage. Another advantage of POCUS is its ability to identify conditions that may mimic an abscess, such as hematoma, lymphadenitis, septic thrombophlebitis, pyomyositis, and presence of a foreign body. By detecting these conditions, POCUS helps clinicians avoid unnecessary procedures and enables appropriate consultations and interventions.

A remarkable aspect of POCUS in abscess management is its capacity to democratize care by making advanced imaging accessible in nontraditional settings. In resource-limited environments, where access to formal imaging modalities like computed tomography or magnetic resonance imaging is restricted, POCUS provides a portable, cost-effective alternative. The unique features of soft tissue US, such as ease of learning, quick execution in clinical settings, and significant impact on patient care, make it highly attractive for clinical practice. However, clinicians must receive proper training and be aware of limitations, including conditions that may mimic abscesses on US, as well as the possibility of isoechoic abscess appearances that can complicate detection.

Future research should investigate the test characteristics of US for detecting abscesses of various sizes and in different locations, and focus on patient-centered outcomes like antibiotic use, return visits, and hospital admissions. Integration with artificial intelligence (AI) is also on the horizon, with early studies showing AI's potential to assist in interpreting US images, thus improving

diagnostic accuracy even for novice users. By integrating real-time US with AI interpretation, clinicians with limited POCUS expertise can access expert-level support for abscess diagnosis, reducing operator variability that can sometimes affect outcomes.

In conclusion, POCUS can significantly impact the diagnosis and management of abscesses, improving precision, accessibility, and safety in patient care. By reducing diagnostic uncertainty, guiding interventions, and expanding access to advanced imaging in diverse settings, POCUS is an invaluable tool for managing soft tissue infections. Looking ahead, advancements in US technology and AI integration will continue to strengthen its role, establishing it as an essential tool in clinical practice.

Declaration of competing interest

None.

CRediT authorship contribution statement

Kristine Jeffers: Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Samuel M. Keim:** Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Visualization, Writing – original draft, Writing – review & editing. **Brit Long:** Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Michael Gottlieb:** Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Srikar R. Adhikari:** Conceptualization, Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing.

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Article Summary

1. Why is this topic important?

Differentiating abscess and cellulitis with history and physical examination can be challenging.

2. What is the Clinical Question?

What is the utility of point-of-care ultrasound for diagnosis of abscess vs. cellulitis?

3. Search strategy.

PubMed search using combined keywords "abscess" and "meta-analysis" and "point-of-care ultrasound" or "point-of-care ultrasonography."

4. Citations appraised.

"Point-of-Care Ultrasound for Diagnosis of Abscess in Skin and Soft Tissue Infections" (31).

"In Patients Presenting to the Emergency Department with Skin and Soft Tissue Infections, What is the Diagnostic Accuracy of Point-of-Care Ultrasonography for the Diagnosis of Abscess Compared to the Current Standard of Care? A Systematic Review and Meta-Analysis" (32).

"Point-of-Care Ultrasonography for the Diagnosis of Skin and Soft Tissue Abscesses: A Systematic Review and Meta-analysis" (33)

"Role of Point-of-Care Ultrasound (POCUS) in the Diagnosis of an Abscess in Paediatric Skin and Soft Tissue Infections: A Systematic Review and Meta-Analysis" (34)

5. Are the results valid?

Yes—for emergency department patients with soft tissue infection.

6. What are the results?

Based upon the available literature, POCUS can reliably differentiate abscess and cellulitis.

7. Can I apply the results to my practice?

Yes.