A predictive model for diagnosis of lower extremity cellulitis: A cross-sectional study

Adam B. Raff, MD, PhD,[a] Qing Yu Weng, MD,[a] Jeffrey M. Cohen, MD,[b] Nicole Gunasekera, BS,[b] Jean-Phillip Okhovat, MD, MPH,[b] Priyanka Vedak, MD,[a] Cara Joyce, PhD,[c] Daniela Kroshinsky, MD, MPH,[a] and Arash Mostaghimi, MD, MPA, MPH[b]

Boston, Massachusetts; and Chicago, Illinois

Background: Cellulitis has many clinical mimickers (pseudocellulitis), which leads to frequent misdiagnosis.

Objective: To create a model for predicting the likelihood of lower extremity cellulitis.

Methods: A cross-sectional review was performed of all patients admitted with a diagnosis of lower extremity cellulitis through the emergency department at a large hospital between 2010 and 2012. Patients discharged with diagnosis of cellulitis were categorized as having cellulitis, while those given an alternative diagnosis were considered to have pseudocellulitis. Bivariate associations between predictor variables and final diagnosis were assessed to develop a 4-variable model.

Results: In total, 79 (30.5%) of 259 patients were misdiagnosed with lower extremity cellulitis. Of the variables associated with true cellulitis, the 4 in the final model were asymmetry (unilateral involvement), leukocytosis (white blood cell count ≥10,000/uL), tachycardia (heart rate ≥90 bpm), and age ≥70 years. We converted these variables into a points system to create the ALT-70 cellulitis score as follows: Asymmetry (3 points), Leukocytosis (1 point), Tachycardia (1 point), and age ≥70 (2 points). With this score, 0-2 points indicate ≥83.3% likelihood of pseudocellulitis, and ≥5 points indicate ≥82.2% likelihood of true cellulitis.

Limitations: Prospective validation of this model is needed before widespread clinical use.

Conclusion: Asymmetry, leukocytosis, tachycardia, and age ≥70 are predictive of lower extremity cellulitis. This model might facilitate more accurate diagnosis and improve patient care. (J Am Acad Dermatol 2017;76:618-25.)

Key words: cellulitis; diagnosis; diagnostic model; lower extremity cellulitis; misdiagnosis; predictive model; pseudocellulitis.

Cellulitis is the most common skin and soft tissue infection (SSTI), accounting for 10% of infectious disease–related hospitalizations in the United States.[1] In 2010, the incidence of SSTI in the United States was 48.46 per 1000 person-years, tenfold the incidence of pneumonia.[2] An estimated 2.3 million emergency department (ED) visits for cellulitis occur annually,[3] with 13.9%-17% of patients ultimately admitted.[3-5]

Although the clinical features of cellulitis include erythema, edema, warmth, and tenderness, these signs and symptoms are common to many skin

From the Department of Dermatology, Massachusetts General Hospital, Boston[a]; Department of Dermatology, Brigham and Women's Hospital, Boston[b]; and Department of Public Health Sciences, Loyola University, Chicago.[c]

Dr Raff and Dr Weng contributed to this work equally.

Funding sources: None.

Conflicts of interest: None declared.

Accepted for publication December 23, 2016.

Reprints not available from the authors.

Correspondence to: Arash Mostaghimi, MD, MPA, MPH, Department of Dermatology, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, 15 Francis St, PBB-B 421, Boston, MA 02115. E-mail: Amostaghimi@bwh.harvard.edu.

Published online February 16, 2017.

0190-9622/$36.00

http://dx.doi.org/10.1016/j.jaad.2016.12.044

conditions. The lower extremities are involved in 70%-80% of patients,[6] and the infection is most often unilateral.[7] No accurate or reliable diagnostic studies for cellulitis are currently available, and clinical diagnosis based on history and physical exam is the current gold standard. Unfortunately, it has been demonstrated that over 30% of patients given a diagnosis of cellulitis actually have an alternative condition known as pseudocellulitis, which mimics cellulitis.[8,9] Previous studies have shown that this misdiagnosis results in delay of effective care, unnecessary exposure to antibiotics, and inappropriate hospitalization, which carry risks for *Clostridium difficile* colitis, anaphylaxis, and nosocomial infections, among others.[9-12]

CAPSULE SUMMARY

- Misdiagnosis of cellulitis is a common and expensive problem.
- We present a 4-variable predictive model for assessing the likelihood of cellulitis in patients presenting to the emergency department.
- This model might facilitate early identification of patients at risk for cellulitis misdiagnosis and improve patient care while decreasing cost.

Cellulitis ambulatory care costs in the United States in 2006 were $3.7 billion,[13] and the inpatient cost of misdiagnosed lower extremity cellulitis alone is estimated to be $195-$515 million annually.[9] Early identification of patients at risk for misdiagnosis of cellulitis might enable clinicians to consider alternative diagnoses, improve diagnostic accuracy, and decrease health care costs. We sought to create a model for predicting the likelihood of cellulitis versus pseudocellulitis among patients being admitted to the hospital through the ED for cellulitis to reduce diagnostic error.

METHODS

Selection criteria

This study used the same cohort of patients used in our previous work, in which we performed a retrospective cross-sectional chart review of all patients presenting to and admitted through the ED of a large urban hospital with a diagnosis of lower extremity cellulitis between June 2010 and December 2012.[9] Patients were identified by using the Research Patient Data Registry (RPDR), a clinical data registry of all patients within the Partners Healthcare system. Information stored within the RPDR includes patient demographics, medications, laboratory reports, and visit notes. We queried the RPDR using International Classification of Diseases, Ninth Revision, codes for lower extremity cellulitis (681.10, 682.6, 682.7, 682.8, 682.9), location of service (ED), and age (≥18 years) to identify eligible patients. The Partners Healthcare institutional review board approved this study.

Patients ≥18 years who were diagnosed with cellulitis by the ED physician or admitting team, presented directly to the ED, and were subsequently admitted were eligible for inclusion in the study. Exclusion criteria included cellulitis in areas other than the lower extremities, intravenous antibiotic use within 48 hours before ED visit, surgery within past 30 days, abscess, penetrating trauma, burn, known history of osteomyelitis, diabetic ulcer, or indwelling hardware at site. Patients who were discharged with a diagnosis of cellulitis were considered to have true cellulitis, and those who were given an alternative diagnosis during the hospital course, upon discharge, or within 30 days of discharge were considered to have pseudocellulitis. For diagnoses that were changed within 30 days, only those that specifically changed the diagnosis of the initial cellulitis hospitalization were considered.

Data collection and chart review protocol

Each patient chart was individually reviewed to document patient history, presentation, and hospital course. If a patient was admitted more than once for cellulitis within the specified period, the earliest presentation that fulfilled all inclusion criteria was used. Each patient's past medical and dermatologic history was recorded.

Variables collected on initial ED presentation included vital signs (temperature and heart rate), general appearance, pain scale, subjective characteristics of the lesion (presence of pain, itch, or burning), and physical exam of the lesion (color, warmth to touch, tenderness, unilateral vs bilateral involvement of lower extremities, presence of lymphadenopathy or edema, and demarcation of the lesion). White blood cell count with differential diagnosis on ED presentation was also recorded.

Data collected over the course of hospitalization might have included wound or skin culture, blood culture, and skin biopsies, and the findings from these studies were documented for the cases in which they occurred.

A formal chart review protocol was developed, and eligible patients were selected per the inclusion and exclusion criteria described previously. Data were recorded by using Research Electronic Data Capture.[14] Each reviewer was trained by ABR and