ONLINE FIRST

Decreased Antibiotic Utilization After Implementation of a Guideline for Inpatient Cellulitis and Cutaneous Abscess

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Background: Cellulitis and cutaneous abscess are among the most common infections leading to hospitalization, yet optimal management strategies have not been adequately studied. We hypothesized that implementation of an institutional guideline to standardize and streamline the evaluation and treatment of inpatient cellulitis and abscess would decrease antibiotic and health care resource utilization.

Methods: A retrospective preintervention-postintervention study was performed to compare management before and after implementation of the guideline (January 1, 2007–December 31, 2007, and July 9, 2009–July 8, 2010).

Results: A total of 169 patients (66 with cellulitis, 103 with abscess) were included in the baseline cohort, and 175 (82 with cellulitis, 93 with abscess) were included in the intervention cohort. The intervention led to a significant decrease in use of microbiological cultures (80% vs 66%; $P=.003$) and fewer requests for inpatient consultations (46% vs 30%; $P=.004$). The median duration of antibiotic therapy decreased from 13 days (interquartile range [IQR], 10-15 days) to 10 days (IQR, 9-12 days) ($P<.001$). Fewer patients received antimicrobial agents with broad aerobic gram-negative activity (66% vs 36%; $P<.001$), antipseudomonal activity (28% vs 18%; $P=.02$), or broad anaerobic activity (76% vs 49%; $P<.001$). Clinical failure occurred in 7.7% and 7.4% of cases ($P=.93$), respectively.

Conclusion: Implementation of a guideline for the management of inpatient cellulitis and cutaneous abscess led to shorter durations of more targeted antibiotic therapy and decreased use of resources without adversely affecting clinical outcomes.

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CELLULITIS AND CUTANEOUS abscess are the second most common infections leading to hospitalization in the United States, causing nearly 600 000 admissions annually.[1] This represents a 65% relative increase since 1999.[1,2] Although the management

See Invited Commentary at end of article

of these infections in the ambulatory care setting has garnered much attention recently, evaluation and treatment strategies for severe cases warranting hospitalization have not been well studied. Given their substantial impact, it is imperative that evidence-based strategies be developed to optimize outcomes, antibiotic use, and use of health care resources.

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The predominant pathogens causing cellulitis and cutaneous abscesses are aerobic gram-positive organisms, primarily *Staphylococcus aureus* and streptococcal species.[3-6] Despite this, we and others have

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described frequent treatment with antibiotics that have activity against aerobic gram-negative bacilli or anaerobic species.[7-9] In addition, industry-sponsored clinical trials of new antimicrobial agents involving cellulitis and abscess have utilized treatment regimens with a spectrum of activity beyond typical gram-positive organisms.[10-13] The optimal duration of therapy for these infections in

the hospital setting is not known, but evidence suggests that treatment for more than 7 to 14 days is not necessary.[3,8,14-18] However, long courses of up to 2 weeks or more are commonly prescribed.[7,9] Exposing patients to unnecessarily prolonged therapy or treatment regimens with an unnecessarily broad spectrum of activity is unacceptable in an era of progressive antimicrobial resistance[19-21] and increasing incidence and severity of *Clostridium difficile* infection.[22-24]

Clinical practice guidelines, or algorithms, have been shown to be effective tools to improve the use of antibiotics and health care resources for pneumonia in the hospital setting.[25-29] We hypothesized that implementation of a clinical practice guideline for inpatient cellulitis and cutaneous abscess would decrease unnecessary antibiotic exposure through shorter durations of narrower-spectrum antimicrobial therapy—as well as decrease the use of laboratory, microbiological, and radiographic resources—without adversely affecting clinical outcomes.

METHODS

STUDY SETTING AND POPULATION

Denver Health, Denver, Colorado, is a vertically integrated, public safety net health care system. Patients can access care at multiple sites, including a 477-bed hospital, emergency department, urgent care center, community health centers, subspecialty clinics, and the public health department.[30] These sites are linked by a computerized health information system.

INTERVENTION

Review of the evaluation and treatment of inpatient cellulitis and cutaneous abscess at Denver Health revealed substantial opportunity to improve antibiotic and institutional resource utilization.[9] We therefore assembled a multidisciplinary working group to develop a clinical practice guideline to standardize and streamline management (eFigure, http://www.archinternmed.com). For the diagnostic evaluation, we recommended selective, rather than routine, use of serum C-reactive protein (CRP) levels,[31] plain film radiographs,[32,33] and blood cultures.[15,33] Use of serum erythrocyte sedimentation rate (ESR), superficial wound cultures, computed tomographic (CT) imaging, and magnetic resonance imaging (MRI) were specifically discouraged. Parenteral vancomycin was suggested for empirical therapy[15,33] in addition to adjunctive use of a nonsteroidal anti-inflammatory agent,[34] unless contraindicated, and elevation of the affected area.[15,33] Use of antimicrobial agents with broad aerobic gram-negative or anaerobic activity was specifically discouraged. On clinical improvement in cases in which culture data were not available, transition to oral doxycycline, clindamycin, or trimethoprim-sulfamethoxazole was recommended.[15] A total course of therapy of 7 days was suggested, with longer courses reserved for cases of severe or poorly responsive disease.[8,15,33] To promote knowledge of, and adherence to, the guideline, we performed a multifaceted implementation strategy consisting of 4 components.

1. *Dissemination of the Guideline*: The clinical practice guideline was distributed to all clinicians via electronic mail, along with relevant background information, and made available via our institutional intranet. Hard copies of the guideline were posted in health care provider work areas and nursing stations.

2. *Development of an Electronic Admission Order Set*: To facilitate use of the guideline, we created a standardized computerized provider order entry (CPOE) admission order set for cellulitis and abscess. Only diagnostic tests, antimicrobial agents, and adjunctive therapies recommended in the guideline were available via the order set. Use of the CPOE order set was quantified by our *e*Health Services department at periodic intervals during the intervention period.

3. *Educational Campaign*: We undertook an educational campaign to improve knowledge of treatment of cellulitis and abscess and increase awareness of the guideline among faculty and housestaff. To provide this education, we designated key attending physician peer champions, representatives from the 5 departments that routinely manage patients with cellulitis and abscess: (1) emergency medicine, (2) adult urgent care, (3) internal medicine, (4) general surgery, and (5) orthopedic surgery. The designated peer champions were also members of the multidisciplinary group that developed the guideline.

4. *Audit and Feedback to Peer Champions*: During the 12-month intervention period, we performed quarterly review of cases to evaluate key indicators of antibiotic prescribing practices and resource utilization. Data on department-specific indicators were provided to the peer champions, who were asked to share the data with their faculty and housestaff and reinforce management concepts.

STUDY DESIGN

We performed a retrospective preintervention-postintervention study comparing the treatment of patients during 1-year periods before and after implementation of the guideline. The baseline and intervention period cohorts consisted of patients with a principal discharge diagnosis of cellulitis or cutaneous abscess from January 1, 2007, through December 31, 2007, and July 9, 2009, through July 8, 2010, respectively.

DATA COLLECTION

Identical case-finding methods and data collection procedures, as previously described,[9] were used for both time periods. Patients with a principal discharge diagnosis of cellulitis or cutaneous abscess, identified by *International Classification of Diseases, Ninth Revision* (*ICD-9*), coding and confirmed by medical chart review, were eligible for inclusion, regardless of whether the clinical practice guideline was followed during the intervention period. The *ICD-9* search codes relevant to the present study included cellulitis and cutaneous abscess of finger and toe (681.%), other cellulitis and abscess (682.%), erysipelas (035), acute lymphadenitis (683), and other infections of skin and subcutaneous tissue (686.%) (the percent sign [%] indicates a wild card that can match any sequence of characters). For patients with more than 1 hospitalization for cellulitis or abscess in a given time period, only the initial episode was included. Demographics, select comorbid conditions, and inpatient antibiotic administration were extracted electronically via our health care data warehouse. Data elements not available electronically were collected via medical chart review using a standardized data collection instrument (T.C.J. and E.E.S.).

Patients were excluded for age younger than19 years, transfer from an outside hospital, leaving against medical advice, odontogenic or other infections not including the skin, or an alternative diagnosis accounting for the clinical presentation. Because the clinical practice guideline was focused to the treatment of cellulitis or abscess requiring hospitalization without additional complicating factors, cases involving deep tissue infection, bacteremia, intensive care unit admission, diabetic ulcer or other chronic ulcer, peripheral arterial disease, recur-

Table 1. Demographic and Clinical Characteristics

Characteristic	All Cases[a] Baseline (n=169)	All Cases[a] Intervention (n=175)
Age, median (IQR), y	46 (36-52)	47 (37-54)
Male sex	126 (75)	115 (66)
Comorbidity		
Injection drug use	49 (29)	42 (24)
Diabetes mellitus	26 (15)	35 (20)
HIV infection	9 (5)	8 (5)
Hemodialysis	1 (1)	1 (1)
Alcohol abuse	27 (16)	22 (13)
Cirrhosis	1 (1)	6 (3)
Prior MRSA infection or colonization	11 (7)	7 (4)
Prior skin and soft-tissue infection	23 (14)	29 (17)
Primary location		
Lower extremity	75 (49)	84 (53)
Upper extremity	54 (36)	52 (33)
Groin or buttock	18 (11)	8 (5)
Trunk	8 (5)	16 (9)
Face, head, or neck	8 (5)	11 (6)
Multiple locations	6 (4)	4 (3)
Duration of symptoms, median days (IQR)	4 (2-7)	4 (3-7)
Failed outpatient therapy	43 (25)	53 (30)
Fever at presentation, ≥38.0°C	18 (11)	20 (11)
Leukocytosis, >10 000 white blood cells/mm^3	105 (62)	99 (57)
C-reactive protein, median (IQR)[b]	50.1 (23.6-91.9)	62.5 (17.0-120.0)

Abbreviations: HIV, human immunodeficiency virus; IQR, interquartile range; MRSA, methicillin-resistant *Staphylococcus aureus*.
[a] Data are presented as number (percentage) unless otherwise noted.
[b] Normal range, 0.08-3.1mg/L (0.76-28.5 nmol/L).

rent cellulitis within 90 days, human or animal bite, severe cellulitis necessitating surgical debridement or fascial biopsy, necrotizing fasciitis, periorbital or perirectal involvement, and hospitalization, surgery, or long-term care facility residence within 90 days were excluded. The study was approved by the Colorado Multiple Institutional Review Board.

All end points were specified prior to the study. The primary outcome was change in antimicrobial exposure as measured by duration of therapy and use of agents with a broad spectrum of aerobic gram-negative activity and anaerobic activity. Duration of therapy was defined as the number of calendar days that a patient received antibiotic treatment. Because this metric does not take into account administration of multiple agents on a given day, we also calculated days of antibiotic therapy administered, defined as the sum of the calendar days of each antibiotic administered (eg, vancomycin and piperacillin-tazobactam administered on the same day equates to 2 days of therapy).[35]

Secondary end points included changes in the incidence of clinical failure, use of serum ESR and CRP, microbiological cultures, plain film radiographs, CT imaging, MRI, and length of hospital stay. Clinical failure was a composite end point of treatment failure, recurrence, or rehospitalization for skin and soft-tissue infection within 30 days of discharge.[9] Treatment failure was defined as a change in antimicrobial therapy or need for additional drainage more than 7 days after the initiation of therapy due to inadequate clinical response. Recurrence was defined as evidence of worsening infection requiring reinitiation of antibiotic therapy after completion of the initial treatment course.

STATISTICAL ANALYSIS

Differences between the baseline and intervention cohorts in clinical characteristics, diagnostic testing, microbiological etiology of infection, antimicrobial therapy, and clinical outcomes were assessed using the Pearson χ^2, Fisher exact, or Wilcoxon rank-sum test where appropriate. $P < .05$ was considered significant. We used SAS statistical software (version 9.1; SAS Institute Inc, Cary, North Carolina) for data analysis.

RESULTS

Four hundred four and 376 patients with a principal discharge diagnosis of skin and soft-tissue infection during the baseline and intervention periods, respectively, were initially identified by *ICD-9* codes. After medical chart review, 235 and 201 patients, respectively, were excluded from analysis owing to the presence of additional complicating factors (153 [38%] and 137 [36%], respectively); age younger than 19 years; (39 [10%] and 28 [7%], respectively); odontogenic infection (21 [5%] and 13 [3%]); leaving against medical advice (9 [2%] and 14 [4%]); infection not involving the skin (6 [1%] and 3 [1%]); alternative etiology of clinical presentation (5 [1%] and 3 [1%]); and transfer from an outside hospital (2 [0.5%] and 3 [1%]). The final baseline cohort included 169 patients (66 with cellulitis and 103 with abscess), and the intervention cohort included 175 patients (82 with cellulitis and 93 with abscess). Overall, patients in the 2 time periods had similar demographic and clinical characteristics (**Table 1**). The lower or upper extremities were the predominant sites of infection. Markers of severity of illness—fever at presentation, failure of outpatient treatment, leukocytosis, and need for operative drainage in cases of abscess—were similar in each cohort and similar when stratified by classification of cellulitis or abscess (data not shown).

Overall use of serum ESR was similar, whereas use of serum CRP increased during the intervention period (**Table 2**). Microbiological culture specimens were obtained less frequently during the intervention period (80% vs 66%; $P = .003$). This was predominantly driven by decreased use of blood cultures (51% vs 38%; $P = .02$). The use of imaging studies significantly decreased in cases of cellulitis (94% vs 80%; $P = .03$) but increased somewhat in cases of abscess (69% vs 80%; $P = .09$). Overall, significantly fewer advanced imaging studies were used; use of MRI decreased from 5% to 1% ($P = .02$), whereas use of CT or MRI in cases not involving the head or neck was less frequent (15% vs 7%; $P = .03$). Requests for consultations also significantly decreased during the intervention period (46% vs 30%; $P = .004$), particularly requests for general surgery (28% vs 16%; $P = .006$) and infectious diseases (15% vs 5%; $P = .003$) consultations. The CPOE admission order set was used in only 9 of 175 cases (5%) during the intervention period.

Of the 196 total cases of cutaneous abscess, incision and drainage was performed in all but 2 cases in the baseline period and 1 case in the intervention period. There were no significant differences between the periods in the need for repeated drainage procedures or in microorganisms cultured (data not shown). *Staphylococcus aureus*

Table 2. Health Care Resource Utilization[a]

Characteristic	All Cases			Cellulitis			Cutaneous Abscess		
	Baseline (n=169)	Intervention (n=175)	*P* Value	Baseline (n=66)	Intervention (n=82)	*P* Value	Baseline (n=103)	Intervention (n=93)	*P* Value
Inflammatory marker measured	104 (62)	132 (75)	.006	46 (70)	59 (72)	.76	58 (56)	73 (78)	.001
Erythrocyte sedimentation rate	90 (53)	102 (58)		39 (59)	42 (51)		51 (50)	60 (65)	
C-reactive protein	102 (60)	130 (74)		45 (68)	57 (70)		57 (55)	73 (78)	
Microbiological culture obtained	136 (80)	116 (66)	.003	42 (64)	38 (46)	.04	94 (91)	78 (84)	.12
Superficial wound swab	10 (6)	5 (3)		9 (14)	5 (6)		1 (1)	0	
Abscess	NA	NA		NA	NA		79 (77)	71 (76)	
Blood	86 (51)	67 (38)		38 (58)	34 (41)		48 (47)	33 (35)	
Imaging of affected area	133 (79)	140 (80)	.77	62 (94)	66 (80)	.03	71 (69)	74 (80)	.09
Plain film radiograph	97 (57)	94 (54)		47 (71)	38 (47)		50 (49)	56 (60)	
Ultrasonography	42 (25)	50 (29)		28 (42)	30 (37)		14 (14)	20 (22)	
CT scan	21 (12)	22 (13)		6 (9)	8 (10)		15 (15)	14 (15)	
Excluding face, head, or neck	17 (11)	11 (7)		5 (8)	1 (1)		12 (13)	10 (11)	
MRI	8 (5)	1 (1)		5 (8)	1 (1)		3 (3)	0	
CT scan or MRI	28 (17)	23 (13)		11 (17)	9 (11)		17 (17)	14 (15)	
Excluding face, head, or neck	24 (15)	12 (7)		10 (15)	2 (3)		14 (15)	10 (11)	
Consultation requested	77 (46)	53 (30)	.004	37 (56)	25 (30)	.002	40 (39)	28 (30)	.20
General surgery	48 (28)	28 (16)		27 (41)	11 (13)		21 (20)	17 (18)	
Orthopedic surgery	11 (7)	9 (5)		7 (11)	4 (5)		4 (4)	5 (5)	
Internal medicine	6 (4)	6 (3)		1 (2)	4 (5)		5 (5)	2 (2)	
Infectious diseases	25 (15)	9 (5)		7 (11)	3 (4)		18 (17)	6 (6)	
Podiatry	4 (2)	6 (3)		3 (5)	4 (5)		1 (1)	2 (2)	
Other surgical specialty[b]	2 (1)	1 (1)		1 (2)	0		1 (1)	1 (1)	

Abbreviations: CT, computed tomography; MRI, magnetic resonance imaging; NA, not applicable.
[a] Data are presented as number (percentage) of patients except where noted.
[b] Otolaryngology–head and neck surgery or plastic surgery.

or streptococcal species were identified in 97% and 94% of cases with positive cultures ($P=.42$); methicillin-resistant *S aureus* (MRSA) was identified in 44% and 51% of cases ($P=.38$), respectively.

Use of vancomycin increased significantly (75% vs 93% of cases; $P<.001$), whereas use of parenteral β-lactam/β-lactamase inhibitor combinations decreased (60% vs 28%; $P<.001$) (**Table 3**). On discharge, doxycycline was prescribed more commonly (5% vs 27%), whereas amoxicillin-clavulanate was prescribed less commonly (21% vs 9%). Overall, significantly fewer patients were exposed to antimicrobial therapy with a broad spectrum of aerobic gram-negative activity (66% vs 36%; $P<.001$), antipseudomonal activity (28% vs 18%; $P=.02$), and anaerobic activity (76% vs 49%; $P<.001$) during the intervention period (**Figure 1**A). These trends were similar when stratified by classification of cellulitis or cutaneous abscess (Figure 1B and C).

The median duration of therapy decreased by 3 days during the intervention period (13 vs 10; $P<.001$) (Table 3). Significantly more patients received less than 10 days of therapy (14% vs 38%; $P<.001$), and fewer patients received more than 14 days (33% vs 12%; $P<.001$) (**Figure 2**A). Similar trends were noted when stratified by cellulitis or cutaneous abscess (Figure 2B and C). Antimicrobial exposure, as measured by days of antibiotic therapy, was reduced in both the inpatient and outpatient settings.

The frequency of adverse clinical outcomes was similar between the baseline and intervention cohorts (**Table 4**). Clinical failure occurred in 7.7% and 7.4% of cases during the 2 periods, respectively ($P=.93$). There were no significant differences in the incidence of clinical failure when cases were stratified by duration of therapy (data not shown).

COMMENT

Cellulitis and cutaneous abscess are among the most common infections leading to hospitalization, but optimal management strategies are not well defined. Implementation of a clinical practice guideline to standardize and streamline the management of these infections decreased use of certain health care resources, including blood cultures, advanced imaging studies, and inpatient consultations. In addition, the intervention led to considerable decreases in antimicrobial exposure through shorter durations of therapy and less frequent use of agents with an unnecessarily broad spectrum of activity. Despite use of fewer resources and more focused antibiotic therapy, adverse clinical outcomes were not increased.

A substantial amount of health care resources are allocated to the evaluation and treatment of cellulitis and abscess.[9] In our guideline, we discouraged the use of diagnostic studies without well-defined roles in the evaluation of these infections.[15,31-33,36] This part of the intervention had variable success. For example, we did not observe an expected decrease in use of serum ESR. In contrast, we saw more judicious use of blood cultures, MRI, and CT or MRI in cases not involving the head or neck (such cases were excluded because advanced imaging is often indicated in this clinical scenario), and

Table 3. Antimicrobial Therapy[a]

Characteristic	All Cases			Cellulitis			Cutaneous Abscess		
	Baseline (n=169)	Intervention (n=175)	*P* Value	Baseline (n=66)	Intervention (n=82)	*P* Value	Baseline (n=103)	Intervention (n=93)	*P* Value
Inpatient therapy (received at ≥1 dose)									
Vancomycin	127 (75)	162 (93)		52 (79)	77 (94)		75 (73)	85 (91)	
Parenteral β-lactam/β-lactamase inhibitor[b]	102 (60)	49 (28)		35 (53)	23 (28)		67 (65)	26 (28)	
Cefazolin	34 (20)	25 (14)		13 (20)	10 (12)		21 (20)	15 (16)	
Trimethoprim-sulfamethoxazole	44 (26)	42 (24)		18 (27)	20 (24)		26 (25)	22 (24)	
Clindamycin	36 (21)	30 (17)		17 (26)	9 (11)		19 (18)	21 (23)	
Doxycycline	3 (2)	26 (15)		3 (5)	21 (26)		0	5 (5)	
Levofloxacin	12 (7)	5 (3)		7 (11)	2 (2)		5 (5)	3 (3)	
Amoxicillin-clavulanate	12 (7)	6 (3)		6 (9)	1 (1)		6 (6)	5 (5)	
Nafcillin	9 (5)	0		5 (8)	0		4 (4)	0	
Other[c]	18 (11)	3 (2)		10 (15)	1 (1)		8 (8)	2 (2)	
≥3 Inpatient antibiotics	75 (44)	46 (26)	<.001	34 (52)	23 (28)	.004	41 (40)	23 (25)	.02
Use of NSAID	56 (33)	82 (47)	.009	22 (33)	48 (59)	.002	34 (33)	34 (37)	.60
Discharge therapy									
Trimethoprim-sulfamethoxazole	81 (48)	81 (46)		32 (48)	34 (41)		49 (48)	47 (51)	
Amoxicillin/clavulanate	35 (21)	15 (9)		12 (18)	9 (11)		23 (22)	6 (6)	
Clindamycin	19 (11)	22 (13)		6 (9)	8 (10)		13 (13)	14 (15)	
Doxycycline	9 (5)	47 (27)		5 (8)	30 (37)		4 (4)	17 (18)	
Dicloxacillin	8 (5)	1 (1)		2 (3)	0		6 (6)	1 (1)	
Cephalexin	9 (5)	3 (2)		4 (6)	1 (1)		5 (5)	2 (2)	
Levofloxacin[d]	7 (4)	3 (2)		3 (5)	2 (2)		4 (4)	1 (1)	
Other	3 (2)	1 (1)		2 (3)	0		1 (1)	1 (1)	
None	7 (4)	7 (4)		4 (6)	2 (2)		3 (3)	5 (5)	
Total duration of therapy, median (IQR), d[e]	13 (10-15)	10 (9-12)	<.001[f]	13 (10-14)	10 (9-13)	.002[f]	14 (11-16)	11 (9-12)	<.001[f]
Total days of antibiotic therapy, median (IQR)[e]	15 (12-19)	11 (10-14)	<.001[f]	15 (12-18)	11 (10-15)	<.001[f]	15 (12-19)	11 (10-14)	<.001[f]
Days of inpatient therapy, median (IQR)	5 (4-9)	5 (3-7)		6 (4-10)	4 (3-7)		5 (3-8)	5 (3-6)	
Days of outpatient therapy, median (IQR),[e]	9 (7-10)	7 (5-9)		7 (7-10)	7 (5-9)		10 (7-12)	7 (5-9)	

Abbreviations; IQR, interquartile range; NSAID, nonsteroidal anti-inflammatory drug.
[a] Data are presented as number (percentage) of patients unless otherwise noted.
[b] Piperacillin-tazobactam, ampicillin-sulbactam, or ticarcillin-clavulanate.
[c] Imipenem-cilastatin, linezolid, ceftriaxone, penicillin G, dicloxacillin, cephalexin.
[d] One patient during the intervention period received ciprofloxacin.
[e] Excludes 7 and 3 cases during the baseline and intervention periods, respectively, for which the duration of discharge antibiotic therapy was not known.
[f] Wilcoxon rank-sum test.

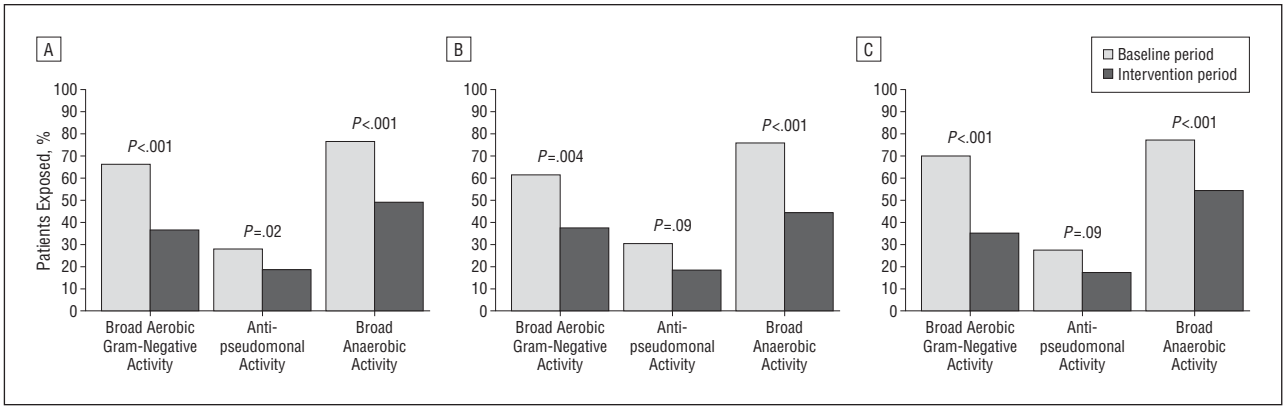

Figure 1. Exposure to antimicrobial classes by time period. Broad aerobic gram-negative activity: β-lactam/β-lactamase inhibitor combinations, fluoroquinolones, ceftriaxone, or imipenem-cilastatin. Antipseudomonal activity: piperacillin-tazobactam, ticarcillin-clavulanate, levofloxacin, ciprofloxacin, or imipenem-cilastatin. Broad anaerobic activity: β-lactam/β-lactamase inhibitor combinations, clindamycin, or imipenem-cilastatin. A, All cases; B, patients with cellulitis; C, patients with cutaneous abscess.

overall use of imaging studies for cellulitis. The reason for the trend in increased use of imaging studies in cases of abscess is not clear. Because of the burden of skin and soft-tissue infections in hospitals, more rigorous evaluation of the role of diagnostic studies for these infections should be pursued. A somewhat unexpected benefit of our intervention was the marked decrease in the number of requested inpatient consultations, which may

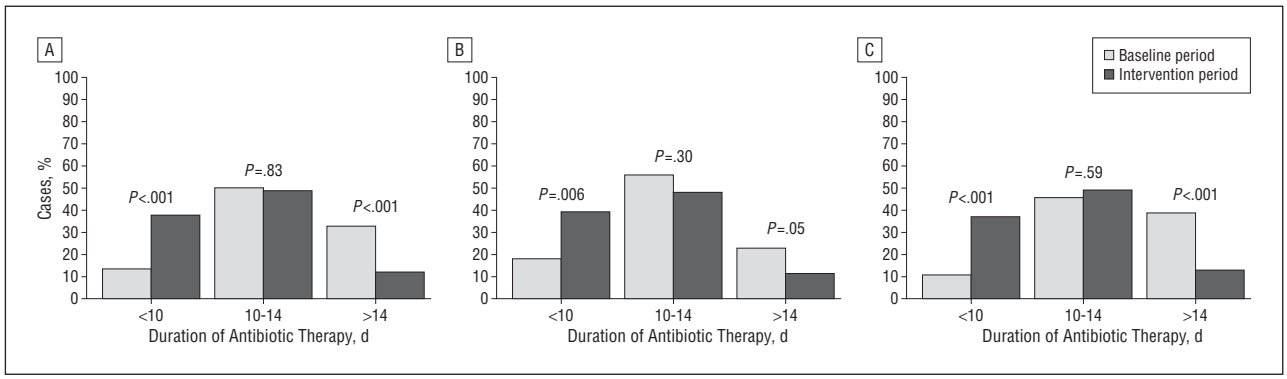

Figure 2. Duration of antibiotic therapy by time period. A, All cases; B, patients with cellulitis; C, patients with cutaneous abscess.

Table 4. Clinical Outcomes[a]

	All Cases			Cellulitis			Cutaneous Abscess		
Outcome	Baseline (n=169)	Intervention (n=175)	*P* Value	Baseline (n=66)	Intervention (n=82)	*P* Value	Baseline (n=103)	Intervention (n=93)	*P* Value
Outpatient follow-up[b]	82 (49)	98 (56)		31 (47)	39 (48)		51 (50)	59 (63)	
Clinical failure	13 (7.7)	13 (7.4)	.93	8 (12.1)	8 (9.8)	.65	5 (4.9)	5 (5.4)	>.99[b]
Treatment failure	4 (2.4)	3 (1.7)		3 (4.6)	2 (2.4)		1 (1.0)	1 (1.1)	
Recurrence[b]	5 (3.0)	8 (4.6)		4 (6.1)	5 (6.1)		1 (1.0)	3 (3.2)	
Rehospitalization due to SSTI[b]	8 (4.7)	8 (4.6)		4 (6.1)	4 (4.9)		4 (3.9)	4 (4.3)	
Rehospitalization[b]	13 (7.7)	9 (5.1)	.33	5 (7.6)	4 (4.9)	.51[c]	8 (7.8)	5 (5.4)	.50
In-hospital mortality	0	0		0	0		0	0	
Length of hospital stay, median (IQR), d	4 (3-5)	4 (3-5)	.43[d]	4 (3-5)	3 (3-4)	.65[d]	4 (3-5)	4 (3-5)	.58[d]

Abbreviations: IQR, interquartile range; SSTI, skin and soft-tissue infection.
[a] Data are presented as number (percentage) of patients unless otherwise noted.
[b] Within 30 days of hospital discharge.
[c] Fisher exact test.
[d] Wilcoxon rank-sum test.

lead to time savings for health care providers, increased efficiency for the hospital, and lower health care costs. We suspect this reflects greater confidence on the part of health care providers because of the availability of the management algorithm and the educational aspects of the intervention.

Although cellulitis and cutaneous abscess are predominantly caused by gram-positive pathogens, use of treatment regimens with a broad spectrum of gram-negative and anaerobic activity is common.[7-13] In our guideline, we promoted the use of a single gram-positive agent, vancomycin, as empirical treatment for both cellulitis and cutaneous abscess. We chose vancomycin for the sake of simplicity in the guideline, the unclear role of community-associated MRSA in cases of cellulitis, and the frequent isolation of MRSA from abscess culture samples. At the same time, we actively discouraged the use of agents with broad gram-negative and anaerobic activity. This treatment strategy led to marked decreases in exposure to broad spectrum therapy. We observed 45%, 36%, and 36% relative declines in the use of broad aerobic gram-negative agents, antipseudomonal agents, and broad anaerobic agents, respectively. These improvements were observed in cases of both cellulitis and abscess. It is noteworthy that most patients with cellulitis during the intervention period were discharged with trimethoprim-sulfamethoxazole or doxycycline, agents that may not have reliable in vitro activity against streptococci.[37-39] Since 94% of patients with cellulitis received vancomycin for a median of 3 days (IQR, 2-4 days) prior to discharge, the clinical relevance of in vitro trimethoprim-sulfamethoxazole or doxycycline resistance in a subset of cases is not clear. We did not observe an increase in adverse clinical outcomes in such cases during the intervention period despite the more frequent use of doxycycline.

Although the optimal duration of antimicrobial therapy for patients hospitalized with cellulitis or cutaneous abscess is not known, the limited available evidence and extrapolation of data from the outpatient setting suggest that treatment durations of more than 7 to 14 days are not necessary.[3,8,14,16-18] Similar to other institutions,[7] we demonstrated a median treatment duration of nearly 2 weeks in the baseline period. Implementation of the guideline promoting 7 days of therapy decreased the median duration of therapy by nearly 25%. Moreover, patients were less likely to receive prolonged durations of therapy (>14 days) and more likely to receive a short course of therapy (<10 days). Of importance, patients who received a short course of therapy were not more likely to experience clinical failure than those who re-

ceived a long course of therapy. Our data suggest that short durations of therapy targeted to gram-positive pathogens decreases unnecessary antibiotic exposure without adversely affecting outcomes; however, clinical trials in this area are needed.

This study has several important limitations. First, the retrospective preintervention-postintervention study design is subject to reviewer bias. Medical chart reviewers were not blinded; however, we attempted to lessen the potential for bias via electronic capture of data and use of objective end points when possible. In addition, all patients who met prespecified study criteria were included in the intervention cohort, regardless of whether the clinical practice guideline was used. Second, this study design is also subject to period effect. We are not aware of any changes in hospital practice over the study period that would have accounted for our results. Notably, the marked increase in community-acquired MRSA in our community occurred well before the baseline period,[40] and the prevalence of MRSA was stable over the time period of this study. Third, since the optimal diagnostic workup and antimicrobial therapy for skin and soft-tissue infections in the hospital setting are not known, our algorithm reflects only a single potential management strategy. We believe this underscores the need for comparative-effectiveness research involving the evaluation and treatment of complicated skin and skin structure infections. Fourth, 2 factors potentially limit the generalizability of our results: (1) the study was performed at a single institution, although similar patterns of broad-spectrum or prolonged antibiotic therapy for skin and soft-tissue infection have been described elsewhere,[7,8] and (2) the algorithm addresses the management of only a subset of patients hospitalized with skin and soft-tissue infection. Further study in patients with additional complicating factors is necessary. A strength of the study is that the intervention itself is broadly applicable across hospitals and that it did not require a substantial dedication of financial resources. Although not all hospitals have CPOE systems, the electronic order set was used in only 5% of cases, suggesting this was not a critical component for success of the intervention.

We believe this study represents a paradigm of how the management of common infections in the hospital setting can be improved via a process that includes review of relevant literature, rigorous evaluation of current practices, assembly of key personnel (peer champions), development of an intervention to promote change in health care provider behavior, and multifaceted implementation of that intervention, facilitated by medical informatics technology when possible, with audit and feedback. Given the success of this intervention for skin and soft-tissue infections, this process may be effectively used for other common inpatient infections.

Although clinical practice guidelines can improve the management of infections, barriers to health care provider uptake and adherence must be addressed. Multifaceted interventions to change health care provider behavior are more effective than single interventions.[41,42] In combination, the multiple approaches we undertook to promote use of the guideline were successful; however, additional room for improvement exists. We encountered 2 important challenges that may have prevented more consistent adherence to the guideline. First, multiple hospital services are involved in the management of patients with cellulitis and abscess. Second, because ours is a teaching hospital, rotation of housestaff among affiliated hospitals leads to frequent turnover of health care providers responsible for the day-to-day care of patients. Therefore, ensuring knowledge of and adherence to the guideline by all relevant health care providers was difficult. Involvement of peer champions who reinforced key management concepts helped meet this challenge.

In summary, implementation of a clinical practice guideline for inpatient cellulitis and cutaneous abscess led to shorter durations of more targeted antibiotic therapy and decreased use of health care resources without adversely affecting clinical outcomes. This broadly applicable intervention should be considered by hospitals and antibiotic stewardship programs to improve patient safety and decrease use of finite health care resources.

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