

How automatic notification of infectious disease specialists impacted the management of *Staphylococcus aureus* bacteremia in a community hospital setting

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ABSTRACT

Objective: The objective of this study was to review the impact of an automatic email notification to infectious disease consultants.

Design: Cases were identified from a community hospital system microbiology database by at least one positive blood culture. Records were reviewed both before (2013 and 2014) and after (2015 and 2016) the implementation of the automated email system (intervention). Prior to this policy, consultation with the infectious disease (ID) specialist was at the discretion of the primary team.

Results: There were no significant differences in 30-day mortality between the two groups (18 vs 20%, $p = 0.10$). However, a trend of shorter hospital stays (12.2 vs 9.5 days, $p = 0.03$) and reduced 30 day readmissions (40% vs 19%, $p = 0.03$) was observed and antibiotics prescribed for complicated cases was more appropriate (57% vs 85%, $p = 0.004$).

Conclusions: In this study population, the implementation of an automatic email generator to ID specialists was associated with a shorter hospital length of stay, less 30-day readmissions and more appropriate length of antibiotics prescribed in complicated cases of SAB. The authors recommend future studies replicating the methodology employed here with larger sample sizes before consideration of employing a similar automatic email ID consult generation at other health systems.

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1. Introduction

Staphylococcus aureus is the leading cause of community and healthcare associated bacteremia with mortality ranging from 20–40% [1–3]. There is a growing body of evidence that suggests that infectious disease (ID) consultation improves mortality, adherence to the Infectious Disease Societies of America (IDSA) guidelines, reduces in-hospital mortality, and results in earlier discharge for patients with *Staphylococcal aureus* bacteremia (SAB) [4–13]. The IDSA clinical practice guidelines published in 2011 [14] state that repeat blood cultures should be collected 2–4 days after initial positive cultures to determine clearance of infection; an echocardiogram is recommended, most specifically a transesophageal echocardiogram (TEE); and an investigation into the source of the bacteremia should be conducted. For cases of uncomplicated bacteremia the minimum duration of appropriate IV antibiotics is two weeks, and for complicated cases the minimum duration is four to six weeks [14–17].

The purpose of this study is to review the impact of an administrative decision to generate an automatic email to infectious disease consultants when a patient has evidence of *Staphylococcus aureus* in a blood culture.

2. Methods

In December of 2014, a new policy was implemented at a community health system (Lakeland Health) to minimize mortality and increase ID consultation in the management of patients with SAB. An automatic email report is distributed daily with identification of patients with positive *staphylococcus aureus* blood cultures via secure email at 11:00 to all the ID physicians. Prior to this policy, consultation with the ID specialist was at the discretion of the primary medical team.

The primary outcome was to evaluate how this policy affected rates of mortality. Secondary outcomes included adherence to the IDSA guidelines, timeliness of de-escalation therapy after identification of methicillin sensitive *Staphylococcus aureus* (MSSA), duration of antibiotics prescribed, hospital length of stay, and 30-day readmission. The Lakeland Hospital system has three hospitals. Hospital 1 (Saint Joseph, MI) is a 254-bed hospital, hospital 2 (Niles, MI) is an 89 bed hospital and hospital 3 (Watervliet, MI) is a 49 bed acute care hospital. Bedside ID consultations are only available at hospital 1. Telephone consultations are available at the other locations. The infectious disease

consultants also periodically serve in the role as hospitalists. In this study, a telephone consultation was not considered an ID consult based on previous studies regarding the impact of ID consultation [18].

Patients were identified from a database from the microbiology laboratory. All patients with at least one positive blood culture for *Staphylococcus aureus* who were older than 18 years of age from 1 January 2013–5 September 2016 were included. Patients were excluded if they were younger than 18 years of age or if blood cultures were positive in the month of December of 2014, as this was the month the email notification system or intervention was initiated. Patients were extracted from the database with keywords 'SAUR,' 'MSSA' and 'MRSA.' The Vitek2 database [19] was utilized to access data from 2013 and 2014. Viewics [20] was the database that identified patients from 2015 and 2016. Cases of SAB were identified from 1 January 2013–30 November 2014 for the pre-intervention group. The post-intervention group included cases from 1 January 2015–5 September 2016.

Patient medical records were reviewed in the electronic medical record EPIC using patient identification numbers (MRNs) to obtain additional data. Data was entered into a password protected Excel document and patient identifiers were removed. The study was approved by the Lakeland Health hospital institutional review board.

2.1. Statistical analyses

Base descriptive analytics were first performed, including frequencies, means, and standard deviations for patient demographic variables. Independent t-test analyses were then performed to examine for statistically significant differences between paired variables (before and after the implementation of automatic email ID consult) for continuous data. All data analyses were performed using IBM SPSS Statistical Analysis Software Version 25 by the third author (SJW).

3. Results

A total of $n = 57$ cases were included in the pre-intervention group and $n = 60$ cases were included in the post intervention group. There was $n = 1$ patient in the pre-intervention group that was bacteremic twice and a total of $n = 3$ patients in the post intervention group that were bacteremic twice. There were $n = 4$ cases at hospital #2 and $n = 1$ case at hospital #3 in the pre-intervention group and $n = 6$ at hospital #2 in the post group with the remainder of cases treated at hospital #1. Table 1 displays the demographics of the patients included in the study. There were no significant differences in the demographics between the two groups. The average age of patients was 64

Table 1. Patient demographics.

	Pre Intervention (N = 57)	Post Intervention (N = 60)	p-value*
Average patient age (years)	64 (SD = 15.06)	62 (SD = 16.03)	0.53
Male (#, %)	N = 36, 63%	N = 38, 63%	0.93
Diabetes Mellitus (#, %)	N = 26, 46%	N = 30, 50%	0.70
End Stage Renal Disease on Dialysis (#, %)	N = 13, 23%	N = 16, 27%	0.67
Immunosuppressed (#, %)	N = 9, 16%	N = 8, 13%	0.68

SD = standard deviation

*Independent t test performed.

(pre) and 62 (post) years of age, the majority were male, about one quarter were on dialysis and less than 20% were immunosuppressed (≥ 10 mg chronic daily prednisone use, known malignancy). The 30-day mortality was also similar between both groups for pre (18%) and post (20%) ($p = 0.10$). Similar percentages of methacillin resistant *staphylococcus aureus* (MRSA) prevalence and complicated cases were found in both groups. Of the $n = 5$ patients who died during their hospital stay in the pre-intervention group, $n = 3$ did not have bedside ID consultation. Of the $n = 11$ patients who died during their hospital stay in the post group, $n = 5$ patients did not have bedside ID consultation due to family decisions regarding end of life care or the patient expired within 48 hours of admission.

Table 2 displays the primary and secondary outcomes in the study. Of those not receiving ID consultation in the pre-intervention group, $n = 1$ patient was transferred to a tertiary care facility, $n = 1$ died before being seen by ID, $n = 1$ patient died on inpatient hospice, $n = 1$ patient died as a DNR, $n = 1$ patient left against medical advice, $n = 1$ hospitalist felt that the positive blood culture was a contaminant, and $n = 1$ patient was notified after discharge about positive blood cultures however refused to return to the hospital. In the post intervention group, of those who did not receive ID consultation: $n = 3$ patients had blood cultures that resulted positive within 24 hours of their in-hospital death, $n = 1$ patient was made comfort care only, $n = 1$ patient left against medical advice, and $n = 1$ was transferred to a tertiary care facility.

Table 3 shows the compliance with the 2011 IDSA guidelines. In patients prescribed antibiotics for uncomplicated SAB, none of the patients in the pre or post intervention group were prescribed less than 14 days of antibiotics. In patients prescribed antibiotics for complicated bacteremia 43% were prescribed an inappropriately short duration of antibiotics of less than 28 days compared to 15% in the post intervention group ($p = 0.004$).

Table 4 represents the sources of bacteremia that were identified. Of the $n = 5$ patients who died during their hospitalization in the pre-intervention group, $n = 3$ did not have a source identified and the

Table 2. Primary and secondary outcomes.

	Pre-intervention (N = 57)	Post-intervention (N = 60)	p-value*
Inpatient Mortality (#, %)	N = 5 ^a , 9%	N = 11 ^b , 18%	0.09
30 day Mortality (#, %) (including in-patient mortality)	N = 10, 18%	N = 12, 20%	0.10
Bedside ID Consult (#, %)	N = 43 ^c , 75%	N = 47 ^d , 78%	0.15
MRSA Prevalence (#, %)	N = 31, 54%	N = 34, 57%	0.74
Complicated bacteremia (#, %)	N = 38/53 ^e , 70%	N = 37/54 ^f , 69%	0.08
Duration of hospitalization (days)	N = 12.2	N = 9.5	0.03
Readmitted within 30 days (#, %) (excluding 30 day mortality)	N = 19/47, 40%	N = 9/48, 19%	0.03

^a 3 patients did not have Infectious Disease involvement
^b 6 patients did not have Infectious Disease involvement. In 4 cases family elected withdrawal of care, 1 patient died with inpatient hospice.
^c 10 of these patients were under the care of an Infectious Disease physician in a Hospitalist role. Two patients had care that coordinated with Infectious Disease as a 'telephone consult' that are not considered as an ID consult in this number.
^d 1 of these patients was under the care of an Infectious Disease physician in a Hospitalist role. Three of these patients had care that was coordinated with Infectious Disease as a 'telephone consult.' that are not considered as an ID consult in this number.
^e 4 patients unable to be designated into a category due lack of data secondary to early mortality or hospital transfer.
^f 6 patients unable to be designated into a category due to lack of data secondary to early mortality or hospital transfer.
 * Independent t test performed.

Table 3. Compliance with IDSA guidelines.

	Pre-intervention (N = 57)	Post-intervention (N = 60)	p-value*
Blood cultures repeated (#, %)	N = 45, 79%	N = 53, 88.3%	0.62
Transesophageal echocardiogram (#, %) (TEE)	N = 28 ^a , 49%	N = 33, 55%	0.47
Source identified (#, %)	N = 43, 75%	N = 45, 75%	1.0
Duration of antibiotics prescribed for uncomplicated bacteremia (#, %)	14 days: N = 9/12, 75% >14 days: N = 3/12, 25%	14 days: N = 9/15, 60% >14 days: N = 6/15, 40%	0.55
Duration of antibiotics prescribed for complicated bacteremia (#, %) (prescribed antibiotics at discharge)	<28 days: N = 13/30, 43% ≥28 days: N = 17/30, 57%	< 28 days: N = 4/26, 15% ≥ 28 days: N = 22/26, 85%	0.004

^a 1 patient refused
 *Independent t test performed

remaining n = 2 were found to have endocarditis. Of the n = 11 patients who died during their hospitalization in the post-intervention group, n = 4 did not have a source identified, n = 3 had pneumonia, n = 3 had endocarditis and n = 1 had a skin and soft tissue infection.

Finally, Table 5 displays de-escalation of antibiotics within 24 hours of identification of methicillin sensitive *staphylococcus aureus* (MSSA) bacteremia. There was a significant difference in nafcillin or oxacillin in the pre intervention group compared to the post (p = 0.021) and a preference

Table 4. Source of bacteremia.

	Pre-intervention (N = 57)	Post-intervention (N = 60)
Skin and soft tissue	N = 9	N = 9
Osteoarticular	N = 7	N = 10
Endocarditis	N = 7	N = 9
Pneumonia	N = 5	N = 8
Central Venous catheter	N = 7 ^a	N = 2 ^b
Peripheral venous catheter	N = 5	N = 1
Other	N = 3 ^c	N = 3 ^d
Urinary tract	N = 0	N = 3
Focus not clearly identified	N = 14 ^e	N = 15 ^f

^a 6 were associated with permacatheters.
^b 1 was associated with a permacatheter.
^c 1 was related to a bypass graft, 1 was an automatic implantable cardioverter defibrillator device infection and 1 was an AV fistula infection.
^d 1 was a bypass graft, 1 was a pseudo-aneurysm infection, 1 was a pacemaker lead infection.
^e 3 patients died during hospitalization.
^f 4 patients died during hospitalization.

Table 5. Antibiotic prescribed within 24 hours of identification of MSSA bacteremia.

Antibiotic	Frequency Pre-intervention (N = 23 ^a)	Frequency Post-intervention (N = 26)	p-value *
Cefazolin	N = 7, 30%	N = 17, 65%	0.075
Ciprofloxacin	N = 2, 9%	N = 1, 4%	**
Ertapenem	N = 1, 4%	N = 2, 8%	**
Daptomycin	N = 1, 4%	N = 0	**
Nafcillin or oxacillin	N = 9, 39%	N = 2, 8%	0.021
Vancomycin	N = 3, 13%	N = 4, 15% ^b	**

^a 3 patients of the total of 26 cases of MSSA bacteremia were excluded due to missing data (1 died, 2 were transferred prior to cultures).
^b 3 patients had a documented penicillin or cephalosporin allergy.
 * Independent t test performed.
 ** Numbers too small to calculate p values.

for cefazolin in the post intervention group; however there were very few cases without appropriate de-escalation.

4. Discussion

Interestingly the overall percentage of bedside infectious disease consultations did not significantly increase after the implementation of the automatic email notification system (75% to 78%, p = 0.15). However, it is important to note that n = 10 of the patients in the pre-intervention group and n = 1 patient in the post group were under the care of an infectious disease physician serving in the role as a hospitalist, which is considered a bedside ID consult in our study. Conceivably the infectious disease physicians were more cognizant of 2011 IDSA guidelines after the automatic notification system was implemented for patients with SAB, and physicians may have become more familiarized of the guidelines throughout the more recent years which may have impacted the results of our study. There were n = 2 and n = 3 telephone ID consultations in the pre and post group that were not included in the bedside ID consultation.

The most notable changes when comparing the pre and post intervention groups were in hospital length of stay (12.2 vs 9.5 days, $p = 0.03$), 30-day readmissions (40% vs 19%, $p = 0.03$), and appropriate duration of antibiotics of at least 28 days in cases of complicated SAB (54% vs 85%, $p = 0.004$). While timely recollection of blood cultures did increase, (79% vs. 88%), the difference was not statistically significant ($p = 0.62$). Per IDSA guidelines, for cases of uncomplicated bacteremia (exclusion of endocarditis, no evidence of metastatic foci, negative follow up blood cultures 2–4 days after initial positive cultures and the patient becomes afebrile within 72 hours of starting appropriate antibiotics) the minimum duration of appropriate IV antibiotics is two weeks. For complicated cases (prosthetic joint infections, recurrence or persistence of SAB, does not meet criteria for uncomplicated) the minimum duration is 4–6 weeks [13,15,16,18]. In the pre-intervention group 43% were prescribed less than the recommended 4 weeks compared with only 15% in the post intervention group. The post-intervention group had a shorter average hospital stay by almost three days, which may lend an additional benefit in terms of healthcare cost savings. However, it is worth noting that there was a higher rate of inpatient mortality in the post intervention that may account for this shorter length of stay. It is not clear why such a large portion of patients in both groups did not have an identifiable source for their bacteremia (~25%), but this percentage is consistent with other studies as the source of SAB was not identified in 18.9% of cases in a prospective study that included $n = 3,395$ patients from five centers [1], and in a study of $n = 337$ patients, 42% did not have an identifiable source [3]. The three most common sources of bacteremia were similar in both groups and found to be related to skin and soft tissue infections, osteoarticular infections and endocarditis.

One limitation of our study is the retrospective design. There was also a total of $n = 10$ patients who were transferred to tertiary care facilities and thus not all information was obtainable. Another limitation is the size of our study. The number of cases in this study limited our ability to show statistical significance. The authors recognize that there is a minimum of two days between admission of a bacteremic patient and notification of the ID specialist. There are time delays between when the culture results become positive to when the email generates every morning to when the physician reads the culture results and evaluates the patient. This is also a chronologic study. During the course of this study, several publications emerged that may have influenced the management of patients, including articles that demonstrate that cefazolin is as good as nafcillin, but with fewer severe side effects and less expense

[21,22]. An additional limitation is the external generalizability of these results. Further studies replicating the methodology here with not only a larger sample size but with recruiting samples from multiple health systems and examining other possibly relevant demographics variables such as socioeconomic status (SES) and healthcare costs could expand the applicability of the results observed.

In summary, the addition of an automatic email generator to infectious disease specialists reporting patients with *Staphylococcus aureus* bacteremia led to improved compliance with the IDSA guidelines, shorter hospital length of stays, less 30 day readmissions and more appropriate use of antibiotics. Not all hospitals have access to inpatient infectious diseases consultations. Although phone consultations have been shown to be inferior to in-person consultation [18], this study implies that there is still value in encouraging a form of ID consultation in the presence of SAB. Additional studies at other health systems are needed to evaluate how employing a similar automatic email to ID consultations regarding positive blood cultures for *staphylococcus aureus* impacts patient care.

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