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Original Article

Effectiveness of an electronic health system–based best-practice advisory to enhance the time to de-escalation of vancomycin for respiratory indications

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Abstract

Objective: Methicillin-resistant *Staphylococcus aureus* (MRSA) infection is highly unlikely when nasal-swab results are negative. We evaluated the impact of an electronic prompt regarding MRSA nasal screening on the length of vancomycin therapy for respiratory indications.

Design: Retrospective, single-center cohort study.

Setting: Tertiary-care academic medical center (Mayo Clinic) in Jacksonville, Florida.

Patients: Eligible patients received empiric treatment with vancomycin for suspected or confirmed respiratory infections from January through April 2019 (preimplementation cohort) and from October 2019 through January 2020 (postimplementation cohort).

Intervention: The electronic health system software was modified to provide a best-practice advisory (BPA) prompt to the pharmacist upon order verification of vancomycin for patients with suspected or confirmed respiratory indications. Pharmacists were prompted to order a MRSA nasal swab if it was not already ordered by the provider.

Methods: We reviewed patient records to determine the time from vancomycin prescription to de-escalation. The secondary end point was incidence of acute kidney injury.

Results: The study included 120 patients (preimplementation, n = 61; postimplementation, n = 59). Median time to de-escalation was significantly shorter for the postimplementation cohort: 76 hours (interquartile range [IQR], 52–109) versus 42 hours (IQR, 37–61; $P = .002$). Acute kidney injury occurred in 11 patients (18%) in the preimplementation cohort and in 3 patients (5%) in the postimplementation cohort ($P = .01$; number needed to treat, 8).

Conclusions: Implementation of a BPA notification for MRSA nasal screening helped decrease the time to de-escalation of vancomycin.

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Lower respiratory tract infection is one of the most common infectious processes and can be a severe complication of hospital admission.[1–3] According to guidelines for the management of adults with hospital-acquired pneumonia and ventilator-associated pneumonia, vancomycin is recommended only if a patient has risk factors for antimicrobial resistance, is being treated in an intensive care unit where >10%–20% of *Staphylococcus aureus* isolates are methicillin resistant, or is in a unit where the prevalence of methicillin-resistant *S aureus* (MRSA) is unknown.[4] Respiratory tract infections are less commonly caused by MRSA,[1–3] but many patients with confirmed or suspected respiratory tract infections are empirically prescribed vancomycin.

Prolonged, unnecessary vancomycin therapy increases the risk of adverse events and increases the use of resources (eg, product, nursing administration, therapeutic drug monitoring).[5,6] Vancomycin costs ~$20 per day for treatment (1 gram intravenously every 12 hours), not including laboratory monitoring. Narrowing the spectrum of antibiotic coverage in a timely manner can be challenging with respiratory infections. Adequate sputum samples often cannot be collected and can take several days to

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finalize. Nasal swab cultures also can be used to aid in the de-escalation of anti-MRSA agents. Multiple studies have reported that nasal swab–based screening has a high negative predictive value (>95%) for MRSA pneumonia.[7–11] Thus, when MRSA nasal swab results are negative, MRSA pneumonia is highly unlikely and vancomycin use can be de-escalated. MRSA nasal swabs can offer guidance in de-escalation practices because they have a turnaround time of ~24 hours.[7–11]

Protocols have been implemented at Mayo Clinic to provide healthcare practitioners with clinical decision support. This protocol supports de-escalation of vancomycin treatment for respiratory indications upon receipt of negative results from a MRSA nasal swab. The electronic health system (EHS) is programmed to provide a prompt, based on a best-practice advisory (BPA) regarding vancomycin therapy, when a pharmacist verifies an order of vancomycin for a patient with suspected or confirmed respiratory indications. This prompt reminds the pharmacist to order a MRSA nasal swab if it has not been previously ordered by the provider. If the swab results are negative, the system will alert the pharmacist to the negative result and prompt them to discuss vancomycin de-escalation with the primary service if the indication for use is solely for respiratory infection. In this study, we assessed whether the electronic BPA prompt decreased the time to de-escalation of vancomycin therapy for patients with respiratory indications.

Methods

We conducted a single-center, retrospective, before-and-after cohort study at Mayo Clinic, a tertiary-care academic medical center in Jacksonville, Florida. The Mayo Clinic Institutional Review Board considered this study to be a quality assurance initiative, and it was exempted from further review. Informed consent was waived for patients authorizing use of their health records for research. The reporting of this study follows the SQUIRE (Standards for Quality Improvement Reporting Excellence) 2.0 publication guidelines.[12]

Patient selection and study period

EHS reports were used to identify patients for inclusion in the study. Eligible patients were adults (aged ≥18 years) who were empirically prescribed vancomycin for suspected or confirmed respiratory indications. We excluded patients who were already receiving vancomycin at the time of hospital admission or at another time outside the designated study periods; patients with extrapulmonary indications; patients with lung transplants or cystic fibrosis; pregnant patients, patients who used nasal mupirocin or nasal povidone iodine; patients who received only 1 dose of vancomycin; and patients who died or were transitioned to hospice care during treatment. These exclusion criteria were applied to reduce bias by ensuring that we evaluated only patients receiving vancomycin for pulmonary indications. The patient location at time of swab collection was used to determine whether the patient was in the ICU or non-ICU.

The BPA notification served to remind the pharmacist to follow the protocol of ordering a MRSA nasal swab when completing a vancomycin consult for a respiratory indication if a swab order had not already been placed by the provider. The automatic BPA notification was implemented in our EHS in September 2019, and we assessed 4-month periods before and after implementation. The BPA notification appeared as designed. The preimplementation group included patients hospitalized from January 1 through April 30, 2019, and the postimplementation group included patients hospitalized from October 1, 2019, through January 31, 2020.

Outcomes

Clinical outcomes and demographic data were abstracted from EHS records. The primary end point of this study was time from prescribing to de-escalation of vancomycin (measured in hours). We selected this end point because it would indicate whether the BPA helped expedite the de-escalation of vancomycin for pulmonary indications. The secondary end point was incidence of new acute kidney injury during treatment (defined according to RIFLE criteria[13] as a doubling of serum creatinine or increase in serum creatinine of 0.5 mg/dL). Presentation of the BPA notification trigger was chosen to validate the accuracy of the BPA alert when completing order verification of vancomycin for pulmonary indications. The incidence of acute kidney injury was evaluated to determine whether the duration of vancomycin therapy influenced kidney function.

An initial in-service and continued efforts to educate the providers and pharmacy staff contributed to the success of vancomycin MRSA nasal screens being ordered and the potential discontinuation of vancomycin if MRSA nasal swab cultures were negative. The antimicrobial stewardship team also reviewed inpatient records daily (Monday–Friday) to ensure that MRSA nasal screens were ordered for all patients receiving vancomycin for pulmonary indications.

Statistical analysis

Continuous variables are summarized as mean (standard deviation [SD]) or median (interquartile range [IQR]). Categorical variables are summarized as frequency (%). All tests were 2-sided, with the overall α level set at 0.05 for statistical significance. JMP software (SAS Institute, Cary, NC) and Excel spreadsheet software (Microsoft, Redmond, WA) were used for the statistical analysis.

Results

Patient characteristics

The EHS report identified 433 patients who received empiric vancomycin treatment for suspected or confirmed respiratory tract infections. Of the 230 patients who were treated before implementation of the BPA prompt, 61 patients met eligibility criteria for inclusion in the analysis. Of the 213 patients who were treated after implementation of the prompt, 59 patients were included in the final analysis. The primary reasons for exclusion were extrapulmonary infection, death, or transition to hospice care during the course of treatment, and receipt of only 1 dose of vancomycin (Fig. 1).

The baseline patient characteristics are shown in Table 1. Study groups appeared reasonably well matched, with no significant differences in age, sex, origin of respiratory tract infection, or in patients in the ICU or non-ICU upon obtaining nasal swab.

Outcomes

We compared time to de-escalation between the preimplementation and postimplementation groups, with groups defined by the launch of the EHS BPA alert in September 2019. The median time

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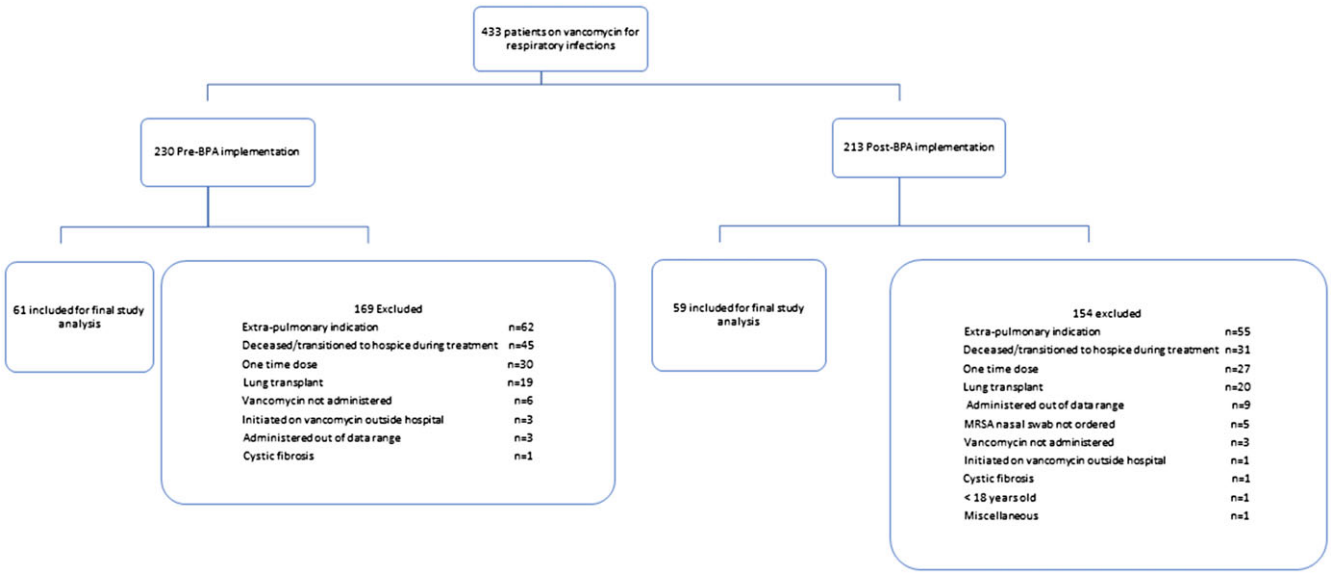

Fig. 1. Inclusion and exclusion criteria.

Table 1. Baseline Characteristics (N=120)

Characteristic	Pre-BPA implementation (n=61)	Post-BPA implementation (n=59)	*P* value
Age, mean (SD), y	64 (18)	64 (14)	.88
Male sex, No. (%)	32 (52)	35 (59)	.23
Health care–associated infection, No. (%)	33 (54)	31 (53)	.43
Community-acquired infection, No. (%)	28 (46)	28 (47)	.50
Admitted to the intensive care unit, No. (%)	25 (41)	30 (51)	.14

Table 2. Primary and Secondary Outcomes

Outcome	Pre-BPA implementation (n=61)	Post-BPA implementation (n=59)	*P* value
Time to de-escalation of vancomycin therapy, median (IQR), h	76 (52-109)	42 (37-61)	.002
Acute kidney injury, No. (%)	11 (18)	3 (5)	.01

to vancomycin de-escalation was 76 hours (IQR, 52–109) for the preimplementation group and 42 hours (IQR, 37–61) for the post-implementation group ($P = .002$). Primary outcomes are summarized in Table 2.

Acute kidney injury occurred in 18% of the preimplementation cohort and 5% of the postimplementation cohort ($P = .01$; number needed to treat, 8). Secondary outcomes are summarized in Table 2.

Discussion

Although MRSA has a low prevalence in pulmonary infections, it is associated with a significant risk of death.[14,15] Consequently, vancomycin may be empirically prescribed and potentially continued for the duration of the pulmonary infection. In this study, we evaluated the number of hours between the prescription and de-escalation of vancomycin therapy before and after implementation of a BPA prompt to the pharmacist. Vancomycin therapy for pulmonary indications usually is discontinued if the results of MRSA nasal swabs are negative, owing to the high negative predictive value of these tests.[7] Our results showed that the BPA prompt was associated with a significant decrease in time to de-escalation and also a lower incidence of acute kidney injury. This process was performed Monday through Friday by decentralized pharmacist on the floor. These findings build on the results reported by Willis et al[16] by creating an automatic process that prompted the pharmacist to order the test when vancomycin was prescribed.

Strengths of this study include the significantly shorter time to de-escalation with the use of the MRSA nasal cultures. Any benefits associated with nasal cultures for MRSA screening will only improve when using polymerase chain reaction assays for detection. With institutions now moving toward the use of rapid molecular assays, an automatic BPA prompt may further decrease the time to de-escalation of vancomycin therapy.

This study had several limitations. The BPA relied on the providers to accurately document a respiratory tract infection as the indication for vancomycin therapy. The study was conducted retrospectively at a single center.

In conclusion, this study showed that implementation of a MRSA nasal screen BPA helped decrease the time to de-escalation of vancomycin therapy for pulmonary indications. These findings suggest that an automatic BPA prompt potentially could decrease the incidence of adverse events, lower costs, and reduce the clinical monitoring associated with vancomycin. Future considerations include more widespread use of rapid molecular assays to further decrease the time to de-escalation and to expand the screening process to patients with other (nonpulmonary) indications.

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