Effect of closed-loop order processing on the time to initial antimicrobial therapy

Nicole Panosh, Richard Drew, and Michelle Sharpe

For patients with severe infections, the time to initiation of appropriate antimicrobial therapy is critical. Several studies have demonstrated that delays in initiating appropriate antimicrobial therapy lead to adverse patient outcomes, including increased mortality.1,2 Conversely, in patients with community-acquired pneumonia, decreases in both mortality and hospital length of stay have been reported with the administration of antibiotics within four hours of arrival at the hospital.3 For patients with life-threatening infections such as sepsis and meningitis, timely antibiotic administration is particularly important; in 2008 the Surviving Sepsis Campaign published guidelines recommending that antimicrobials be initiated as soon as possible (and within one hour) after the recognition of sepsis symptoms.4

While failure to identify infection or initiate appropriate empirical treatment has often been implicated in delays, medication order-processing time itself may also contribute to such delays. The amount of time it takes to get an i.v. antimicrobial agent to a

Purpose. The results of a study comparing the average time to initiation of i.v. antimicrobial therapy with closed- versus open-loop order entry and processing are reported.

Methods. A retrospective cohort study was performed to compare order-to-administration times for initial doses of i.v. antimicrobials before and after a closed-loop order-processing system including computerized prescriber order entry (CPOE) was implemented at a large medical center. A total of 741 i.v. antimicrobial administrations to adult patients during designated five-month preimplementation and postimplementation study periods were assessed. Drug-use reports generated by the pharmacy database were used to identify order-entry times, and medication administration records were reviewed to determine times of i.v. antimicrobial administration.

Results. The mean ± S.D. order-to-administration times before and after the implementation of the CPOE system and closed-loop order processing were 3.18 ± 2.60 and 2.00 ± 1.89 hours, respectively, a reduction of 1.18 hours (p < 0.0001). Closed-loop order processing was associated with significant reductions in the average time to initiation of i.v. therapy in all patient care areas evaluated (cardiology, general medicine, and oncology). The study results suggest that CPOE-based closed-loop order processing can play an important role in achieving compliance with current practice guidelines calling for increased efforts to ensure the prompt initiation of i.v. antimicrobials for severe infections (e.g., sepsis, meningitis).

Conclusion. Implementation of a closed-loop order-processing system resulted in a significant decrease in order-to-administration times for i.v. antimicrobial therapy.

Am J Health-Syst Pharm. 2012; 69:1423-6

DOI 10.2146/ajhp100644
patient is affected by the way in which the order is processed. Advances in technology present potential opportunities for improved efficiency in order processing. Therefore, the utility of such advances should be considered when identifying ways to decrease medication order-processing time.

Before the implementation of new technology in 2009, the computerized prescriber-order-entry (CPOE) system in use at Duke University Hospital (DUH), the Horizon system (McKesson Corporation, San Francisco, CA), was not capable of direct communication with the pharmacy order-entry system. As a consequence, medication orders were printed from the CPOE system and reentered into the pharmacy system by a technician before order verification by a decentralized pharmacist (this is known as “open-loop” order processing).

In May 2009, DUH completed the installation and implementation of a system in which the CPOE system communicates directly with the pharmacy system (“closed-loop” processing), allowing orders entered by providers to flow directly into the pharmacy system for verification. However, at that time it was unknown whether such enhancements could significantly reduce delays in medication delivery attributable to the ordering process. To our knowledge, there are no published studies of order-processing time in relation to this type of upgrade.

The primary objective of the study described in this article was to determine whether a closed-loop CPOE processing system affected order-to-administration times for intravenously administered antimicrobials in adult patients at DUH. As a secondary objective, we examined differences in administration times during designated study periods before and after implementation of closed-loop processing within intensive and intermediate care units.

**Methods**

This single-site retrospective cohort trial was conducted at DUH. The study population consisted of adult patients admitted to cardiology, oncology, or general medicine services for whom a new order for i.v. antimicrobials was entered into the CPOE system; our definition of antimicrobials encompassed antifungals, antivirals, and antibiotics. Patients whose records were incomplete (i.e., administration times were not recorded on the medication administration record) were excluded from the study. The study was reviewed and approved by the DUH institutional review board.

Based on a pharmacy database query of potentially eligible administrations, the inclusion of cases in the study was sequential, by medical record number. Two study periods were analyzed. The baseline (open-loop) study period examined i.v. antimicrobial administrations from June through October 2008. The closed-loop study period examined eligible i.v. antimicrobial administrations from June through October 2009 (after the deployment of the new CPOE system).

Drug-use reports generated by the pharmacy order-entry system, Horizon Meds Manager (McKesson), were used to identify CPOE order-entry times, and medication administration records were used to determine antimicrobial administration times. During both study periods, the pharmacy department electronically generated and printed the medication administration records on each patient. Administration times were handwritten on the medication administration records by nurses during both study periods. The order-to-administration time was measured for each new i.v. antibiotic order meeting the inclusion criteria, and the mean time was determined for each study period. As a secondary endpoint, the mean differences in order-to-administration times in intermediate care areas and intensive care areas during each study period were compared.

It was calculated that a total sample of 700 i.v. antimicrobial drug administrations would be required in order to detect a one-hour mean difference in order-to-administration times between the two study periods with 80% power (assuming a S.D. of 4.7 hours and with the a priori level of significance set at 0.05). The Wilcoxon rank sum test was used to compare differences in the mean values between study periods.

**Results**

A total of 741 i.v. antimicrobial drug administrations were assessed (371 in the baseline period and 370 after the implementation of the closed-loop order-entry system). The mean ± S.D. order-to-administration time in the open-loop study period was 3.18 ± 2.60 hours, compared with 2.00 ± 1.89 hours in the closed-loop period; this was a reduction of 1.18 hours (p < 0.0001). When stratified by patient care area (i.e., cardiology, oncology, or general medicine), the order-to-administration time decreased after the implementation of the closed-loop system in all cases. The mean ± S.D. order-to-administration time in the cardiology patient care areas was 3.20 ± 2.38 hours during the open-loop study period, compared with 2.00 ± 1.49 hours during the closed-loop study period (p = 0.009), as illustrated in Figure 1. In the oncology patient care areas, the mean ± S.D. order-to-administration times during the open- and closed-loop study periods were 2.76 ± 2.28 and 1.60 ± 1.42 hours, respectively (p < 0.001), with a similar decrease (from 3.48 ± 2.74 hours to 2.58 ± 2.46 hours, p = 0.001) noted in the general medicine patient care areas.

Differences in the time to initiation of i.v. antimicrobial therapy in intermediate and intensive care units...
between study periods were not significant (Figure 2). In the open-loop study period, the mean ± S.D. order-to-administration time was 3.20 ± 2.54 hours in all intermediate care areas combined and 3.13 ± 2.85 hours in all intensive care areas combined. During the closed-loop study period, the mean ± S.D. order-to-administration time in the intermediate care areas was 2.09 ± 2.01 hours compared with 1.73 ± 1.42 hours in the intensive care areas. There was a trend of decreased mean order-to-administration times with closed-loop processing in the intensive care areas relative to the intermediate care areas, but the difference was not significant (p = 0.262).

**Discussion**

In the study described here, the implementation of a closed-loop ordering process involving direct communication between the CPOE and pharmacy order-entry systems resulted in a significant decrease in the average order-to-administration time for i.v. antimicrobial agents. The study findings have important implications, since prompt antimicrobial administration has been shown to decrease mortality and hospital length of stay in patients with serious infections.

The study results also illustrated the potential for enhanced order-processing technology to improve patient care in the hospital setting and increase efficiency within the hospital pharmacy. Such benefits are increasingly recognized, as evidenced by legislation such as the Health Information Technology for Economic and Clinical Health (HITECH) Act, which allows Medicare and Medicaid incentive payments to eligible hospitals that adopt certified electronic health records in order to achieve objectives specified by the HITECH program.

In our study, the amount of time required to process antimicrobial orders for intermediate and intensive care areas did not differ significantly with the use of closed- versus open-loop processing; however, due to the relatively small number of evaluated i.v. antimicrobial administrations to patients in intensive care units, the study was not adequately powered to detect such a difference. Since critically ill patients would benefit from shorter-than-average order-to-administration times, further research in this area is warranted.

This study had several limitations. First, antimicrobial administration times (handwritten by nurses on the paper administration record) were sometimes documented in broad terms (e.g., 8 a.m., 1 p.m.) rather...
than precisely (e.g., 8:15 a.m., 1:30 p.m.); furthermore, these handwritten administration times may not have coincided with the actual times of receipt of the antimicrobials from the pharmacy. However, these limitations applied to both study periods.

Second, we did not exclude from the analysis i.v. antimicrobial administrations to patients who received initial antimicrobial therapy in the emergency department or as preprocedure prophylaxis, as that would have entailed the evaluation of data from multiple computer systems and difficulty making definitive case-exclusion decisions. In such cases, the administration of subsequent antibiotic doses may not have been given the same priority as the first antimicrobial treatment doses.

Third, any delays in antimicrobial administration that might have been due to insufficient i.v. access could not be ascertained via the study methodology used.

Conclusion

Implementation of a closed-loop order-processing system resulted in a significant decrease in order-to-administration times for i.v. antimicrobial therapy.

References


2. Gaieski DF, Mikkelsen ME, Band RA et al. Impact of time to antibiotics on survival in patients with severe sepsis or septic shock in whom early goal-directed therapy was initiated in the emergency department. Crit Care Med. 2010; 38:1045-53


