Journal of Microbiology, Immunology and Infection (2016) xx, 1–9

Available online at www.sciencedirect.com

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journal homepage: www.e-jmii.com

ORIGINAL ARTICLE

Effects of implementation of an online comprehensive antimicrobial-stewardship program in ICUs: A longitudinal study

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Received 15 April 2016; received in revised form 26 May 2016; accepted 13 June 2016
Available online ■ ■ ■

KEYWORDS
antimicrobial stewardship program;
ICU;
patient outcomes;
quality improvement

Abstract *Background/purpose:* The long-term effects of antimicrobial-stewardship programs in the intensive care units (ICUs) have not been adequately examined. We evaluated the impact of an online comprehensive antimicrobial stewardship program (OCASP) on the outcomes of patients in 200-bed medical/surgical ICUs over the course of 11 years.
Methods: We analyzed the records of adult patients admitted to ICUs during the 5 years before (n = 27,499) and the 6 years after (n = 33,834) implementation of an OCASP. Antimicrobial consumption, expenditures, duration of treatment, incidence of healthcare-associated infections (HAIs), prevalence of HAIs caused by antimicrobial-resistant strains, and crude or sepsis-related mortality of patients were analyzed. Segmented regression analyses of interrupted time series were used to assess the significance of changes in antimicrobial use.
Results: Compared to the patients in the pre-OCASP period, the patients in the post-OCASP period were older, had greater disease severity, longer ICU stays, and were more likely to receive antimicrobials, but had lower antimicrobial expenditures and crude and sepsis-related mortality. The trend of overall antimicrobial use [slope of defined daily dose/1000 patient-days vs. time) increased significantly before OCASP implementation ($p < 0.001$), but decreased significantly after implementation ($p < 0.01$). The administration duration of all classes of antibiotics were significantly shorter ($p < 0.001$) and the incidences of HAIs were significantly lower ($p < 0.001$) after implementation. However, there was an increase in the proportion of HAIs caused by carbapenem-resistant *Acinetobacter baumannii* relative to all *A. baumannii* infections.

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http://dx.doi.org/10.1016/j.jmii.2016.06.007

Please cite this article in press as: Chen I-L, et al., Effects of implementation of an online comprehensive antimicrobial-stewardship program in ICUs: A longitudinal study, Journal of Microbiology, Immunology and Infection (2016), http://dx.doi.org/10.1016/j.jmii.2016.06.007

Conclusion: Implementation of an OCASP in the ICUs reduced antimicrobial consumption and expenditures, but did not compromise healthcare quality.

Introduction

The problem of increasing antimicrobial resistance is especially critical for patients in the intensive care unit (ICU), because they are more susceptible to healthcare-associated infections (HAIs).[1,2] Antibiotic resistance may be particularly severe in ICUs, because the patients are critically ill and often severely immunocompromised, have undergone medical or surgical procedures or instrumentation, or receive multiple antimicrobials conferring selection pressure of antimicrobial-resistant pathogens. Furthermore, effective infection-control programs may not be in place.[3] Previous research indicated that ICU patients are five to 10 times more likely to acquire HAIs than patients in general wards.[4] Moreover, HAIs caused by antimicrobial-resistant isolates are associated with increases of medical costs, prolongation of ICU stays, and greater morbidity and mortality.[5] Several approaches may potentially reduce antimicrobial resistance. For example, use of shorter courses of broad-spectrum antimicrobials may reduce selection pressure on bacterial flora and prevent the emergence of resistance.[6] In general, antimicrobial-stewardship programs may help combat the emergence of antimicrobial resistance, improve clinical outcomes, and reduce medical costs by limiting the inappropriate use of antimicrobials.[7,8]

Previous research indicated that 30—50% of antimicrobial use in hospitals is unnecessary or inappropriate[9] and that, among all hospital departments, ICUs have the greatest use of antimicrobials.[1] Therefore, antimicrobial stewardship is particularly important for ICU settings. Previous research examining the impact of antimicrobial stewardship in ICUs indicated that changes in antimicrobial use were associated with decreased antimicrobial resistance.[3,8,10] While implementation of an antibiotic stewardship program requires considerable human resources, especially in large institutions, the increased computerization of hospitals in recent years provided new opportunities for development of such programs. A recent study in a large hospital setting examined the impacts of an online, comprehensive, facility-wide antimicrobial-control system on healthcare quality and economic burden.[11] However, the long-term effects of computerized programs for implementation of antimicrobial review in ICU patients have not been adequately explored.

This longitudinal study reported the results of an online, comprehensive, antimicrobial-stewardship program (OCASP) implemented in 2005 that was developed to guide the use of antimicrobial agents in the ICUs of a 2700-bed medical center in southern Taiwan. The specific objectives were to examine the long-term effects of OCASP on antimicrobial use and expenditures, duration of antimicrobial treatment, incidence of HAIs, prevalence of HAIs caused by antimicrobial-resistant pathogens, and outcomes of patients admitted to the ICUs.

Methods

Study design and setting

The Kaohsiung Chung Gang Memorial Hospital (KSCGMH) is a medical center in southern Taiwan, with 2700 beds, 43 non-critical wards, and 18 ICUs that included nine medical and six surgical ICUs (a total of 200 beds) for adults. This retrospective study was conducted with a waiver of the need for informed consent of participants, and was approved by the Institutional Review Board (Ethics Committee) of Chang Gung Memorial Hospital, Kaohsiung, Taiwan (Document no. 97-1694B).

All data for patients aged 18 years or older who were admitted to any medical or surgical ICU from January 2000 to December 2010 were retrospectively reviewed. The data included age, sex, duration of ICU stay, use of parenteral antimicrobials, and duration of antimicrobial treatment. Disease severity was evaluated by Acute Physiology and Chronic Health Evaluation (APACHE) II score[12] or Glasgow Coma Scale (GCS)[13] upon ICU admission. All patients readmitted to an ICU after discharge were classified as new patients.

OCASP in ICUs

The OCASP was implemented in the ICUs of the KSCGMH in January 2005, wherein all antimicrobial agents prescribed to ICU patients required approval from infectious diseases (ID) physicians. The OCASP is built into the Health Information System and is linked to comprehensive electronic medical records. All inpatient settings were allocated and preassigned to 10 ID physicians practicing in the hospital. Each ID physician was notified when the antimicrobial was prescribed to patients admitted to his or her preassigned ICU or ward. All of the above information was entered into OCASP automatically, and a remind message was sent to the ID physician by mobile phone if the prescription was not reviewed within 48 hours. The prescribing physicians were required to provide necessary supporting clinical data that included clinical history, laboratory reports, culture results, and images for online review by the ID physicians. After review, the ID physicians would briefly discuss the case with the intensivists prior to rendering a decision. If a prescription was disapproved, the antimicrobial would be discontinued by the pharmacy unit-dose delivery system within 48 hours, and the prescriber would be immediately notified to modify the regimen. When necessary, the ID

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