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Bloodstream Infection in the Intensive Care Unit: Preventable Adverse Events and Cost Savings

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ABSTRACT

Objectives: Central line associated bloodstream infections (CLABSIs) impose a significant economic burden for patients admitted to the intensive care unit for adults (AICU). The objectives of the study were to evaluate the excess length of stay and extra costs attributable to CLABSIs diagnosed in the AICU. **Methods:** Cases were selected as patients admitted to AICU from 2006 through 2009, who developed a CLABSI episode. These were matched (1:1) with appropriate controls. Matching criteria were selected to exclude other factors that could influence cost and care practices. The length of stay and resources used between AICU admission and discharge and until hospital discharge or death were measured. Incremental costs and lengths of stay were calculated for each pair of patients. **Results:** Thirty cases and 30 controls were included in the study. A CLABSI episode resulted in an additional 10.5 days in the AICU and 9.1 days after AICU discharge, totaling an additional 19.6 days. The incremental cost associated with a CLABSI episode was US $65,993 in the AICU and US $23,893 after AICU discharge, totaling an incremental cost of US $89,886. **Conclusions:** By avoiding CLABSI events, cost offsets would be expected for payers with revenue losses to providers. An approach of sharing the gains resulting from preventive measures could be used to incentivize providers to maintain those investments, benefiting patients who will have a reduced risk of CLABSI development.

Keywords: bloodstream infection, cost, intensive care unit.

Introduction

Central venous lines are used extensively in intensive care units (ICUs) but may occasionally result in central line associated bloodstream infections (CLABSIs). In the United States, about 48,600 CLABSIs occur in ICUs each year [1]. These infections impose a significant economic burden, with additional estimated costs ranging from US $4,000 to US $36,000 per episode [2–4]. Critically ill patients with primary bloodstream infections are hospitalized for an average of 6.5 to 22 days longer than are patients without bloodstream infection [2–4]. Data from Latin America and other developing countries participating in the International Nosocomial Infection Control Consortium show that CLABSI rates in these countries are three to five times higher than rates in the United States [5].

Preventing CLABSI may improve patient care while reducing hospital stays, costs, and possibly also mortality. Central venous line bundles are fairly simple to perform with reproducible results. However, the implementation of these interventions requires a considerable investment in resources and manpower. Hospital Israelita Albert Einstein (HIAE) has implemented preventive measures in two phases, March 2005 to March 2007 phase 1 and April 2007 to April 2009 phase 2. Considering the study period we will report actions related to phase 2. Continuing the quality improvement measures, we implemented the Institute for Healthcare Improvement bundle (creation of a central catheter insertion cart; hand hygiene; maximal barrier precautions for insertion; chlorhexidine skin antisepsis; optimal site selection, with avoidance of the femoral vein for central venous access in adult patients; daily review of line necessity with prompt removal of unnecessary lines for all patients admitted to the ICU for adults [AICU]). This bundle was monitored every day by AICU nurses and doctors. The insertion process was interrupted at the same time that performance monitoring was occurring at the bedside if noncompliance with an element of the bundle was detected. Prior to the start of phase 2, we delivered a brief presentation to the AICU staff on CLABSI prevention, reviewed the study protocol, and encouraged participation in our "central line bundle – getting to zero" program. Monthly, we sent an e-mail to the team with feedback on compliance with the bundle and provided posters in the AICU with bar graphs displaying compliance measures and the CLABSI rate. A group of physicians was implemented to remove the unnecessary catheters every day. Compliance with all process measures while inserting the

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central venous catheter (CVC) was evaluated for all CVCs that were placed in the AICU [6]. In respect of the implantation costs, all materials required for the bundle were already standardized in our hospital and were already used in the insertion process, but not organized in the bundle form. The jointly further measures were just behavioral actions without the addition of direct costs. The training time spent was already included in the preexisting program of quality care in the AICU.

Between 2008 and 2010, the rate of CLABSI per 1000 catheter-days was reduced from 5.7 to 1.5 events per 1000 catheter-days. This reduction resulted in an estimated 85 avoided CLABSI events.

The lack of data on the economic burden of CLABSI in Brazil motivated us to measure the impact of reduction in CLABSI, evaluating the excess length of stay (LOS) both in the ICU and in the hospital and the extra costs attributable to these infections [7].

The objectives of the study were to evaluate the excess LOS in the AICU and in the hospital and extra costs attributable to CLABSI diagnosed in the AICU in a single institutional setting. This information will allow for discussion with leaderships and provide objective data for decision making.

Methods

Setting

This study was conducted at HIAE, which is a tertiary care, private hospital with 577 single-bed rooms, located in São Paulo, Brazil. The AICU has 40 beds. The rooms are configured in seven 4-room and two 6-room suites or "pods." The AICU has an open staffing model and approximately 2800 patients are admitted annually. The average LOS in the AICU is 3.96 days. The AICU receives patients from all clinical specialties, including bone marrow transplant and surgical specialties such as solid organ transplant and bariatric surgery.

Study Design

The study was developed as a pair-wise matched (1:1) case-control study.

Cases were identified through prospective active surveillance conducted by HIAE Infection Control and Prevention Team by using the Centers for Disease Control and Prevention definitions for CLABSI [8]. Case patients were defined as those admitted to medical-surgical AICU from January 1, 2006, through December 31, 2009, who had a CVC and who developed a CLABSI. We excluded from the analysis patients with more than one admission to the AICU, with more than one episode of bloodstream infection, or episodes of hospital-acquired infection other than CLABSI.

There is a great concern in the literature about the methodology used for cost analysis, because of the risk of biasing the results by not choosing the appropriate controls. The matching criteria used in the study were carefully chosen so as to exclude other confounding factors that could influence cost and care practices, such as the date of AICU admission.

Matching criteria were applied in the following order for the selection of controls: no documented episode of CLABSI, use of CVC, type of patient outcome (death or hospital discharge), diagnosis on hospital discharge (*International Statistical Classification of Diseases, 10th Revision*), Acute Physiology and Chronic Health Evaluation II (APACHE II) category based on mortality risk [9], LOS in the AICU of controls equivalent to time from AICU admission until CLABSI diagnosis for cases (±2 days), hepatic disease (defined as the presence of cirrhosis, acute gastrointestinal bleeding, portal hypertension, hepatic failure, or liver encephalopathy), dialysis-dependent renal failure, use of mechanical ventilation, date of AICU admission (±1 year), prior solid organ transplantation, age (±5 years), gender, New York Heart Association functional classification IV [10] in patients with heart disease, diagnosis of metastatic cancer, and immunodeficiency (defined as the use of chemotherapy, radiotherapy, or high-dose corticosteroids; diagnosis of leukemia, lymphoma, multiple myeloma, or acquired immunodeficiency syndrome). Criteria were presented in the priority order considered for matching and were defined to account for characteristics that could influence costs, irrespective of the occurrence of CLABSI [10].

The AICU maintains a prospective collection of epidemiological, clinical, laboratory, and outcomes data for all patients admitted to AICU, generating a database from which controls were selected. A linear mathematical model was used to maximize the matching criteria in the priority sequence presented above.

Study Definitions

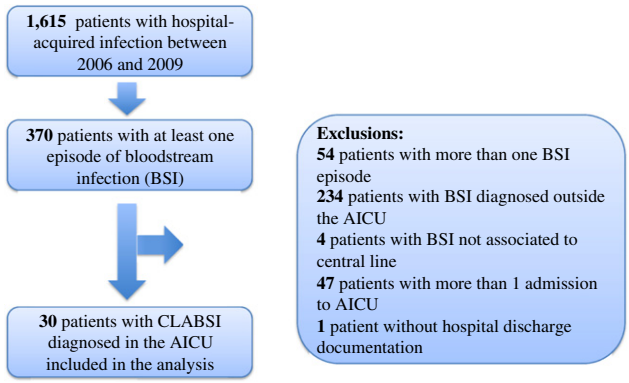
The LOS between AICU admission and AICU discharge or death and between AICU admission and hospital discharge or death were measured for cases and controls and the incremental lengths of stay were calculated for each pair of patients.

In the Brazilian private health care system, costs associated with CLABSI events usually impact third-party payers, mainly private insurers, because fee for service is the predominant reimbursement structure for providers. Therefore, the perspective of private health plans was chosen for this cost analysis.

All resource use was documented from the AICU admission until hospital discharge. The resource use included hospital stay, drugs, materials, exams, and procedures. Unit costs were defined from the perspective of private payers (unit revenues from the hospital perspective) and obtained from the HIAE billing system to reflect the expected hospital revenue per item. All costing information was adjusted to 2010 values, considering unit revenues based on the latest hospital price table at the time of the analysis. Costs were obtained in Reais and converted to US dollars considering the exchange rate of R $1.87 per US dollar. The number of units used by each patient was multiplied by its unit cost to estimate average total costs per patient for two periods: between AICU admission and AICU discharge or death and between AICU admission and hospital discharge or death. Incremental costs were calculated for each pair of patients.

Statistical Analysis

The analyses were performed by using KNIME software [11]. Differences between matched pairs were used as the primary



* BSI = Bloodstream infection; CLABSI = Central line associated bloodstream infection; AICU = adult intensive care unit.

Fig. 1 – Patient selection. AICU, intensive care unit for adults; BSI, bloodstream infection; CLABSI, central line associated bloodstream infection.