Preventing Healthcare-Associated Infections: Beyond Best Practice

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Abstract: The goal of this review is to evaluate best practices for preventing healthcare-associated infections (HAI) and to identify opportunities beyond best practice. Achieving an infection-free hospital stay for patients will require integration of infection prevention into routine bedside clinical care. The objectives are (1) to summarize the best practices for prevention of HAI; (2) to discuss the limitations of known best practices; and (3) to discuss potential approaches beyond best practice to prevent HAI. Rationale for comprehensive horizontal approaches with active caregiver participation is discussed.

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In the United States, approximately 1.7 million healthcare-associated infections (HAI) occur every year leading to 99,000 deaths[1] per estimates from the Centers for Disease Control and Prevention (CDC). These infections result in excess healthcare costs of $28 to $33 billion annually.[2] Twenty-five percent of these infections occurred in the intensive care units (ICUs), whereas the remaining 75% occurred outside of the ICUs.[1]

The CDC defines HAI as a localized or systemic condition resulting from an adverse reaction to the presence of an infectious agent(s) or its toxin(s).[3] There must be no evidence that the infection was present or incubating at the time of admission to the acute care setting. HAIs may be caused by infectious agents from endogenous or exogenous sources. Five infections, central line-associated bloodstream infection (CLABSI), catheter-associated urinary tract infection (CAUTI), surgical site infection (SSI), *Clostridium difficile* infection and pneumonia [hospital-acquired pneumonia, healthcare-associated pneumonia or ventilator-associated pneumonia (VAP)], constitute 85% of HAI.[4]

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The term HAI itself is pathogen nonspecific. Bacteria are the most common cause of HAI. Many other pathogens, including fungi, viruses and parasites, can cause these infections. Of particular interest are methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), multidrug-resistant Gram-negative bacilli, *C difficile* and *Candida* spp. Although there are multiple modes of transmission of pathogens in the hospital setting, the most common mode of transmission is via touch. The pathogenesis of HAI involves a complex interplay of multiple factors related to the patient, pathogen, caregivers, hospital environment, leadership structure and care processes.

BEST PRACTICES TO PREVENT HAI

Best Practice is a method or technique that has consistently shown results superior to those achieved with other means and that is used as a benchmark. The fundamental best practices recognized for preventing HAI are hand hygiene,[5,6] standard precautions, isolation precautions and prudent antimicrobial use. Evidence for their effectiveness originates primarily from biologic plausibility and experiences with HAI and outbreak control. Other best practices are the use of bundles and checklists to prevent specific HAI. The Institute for Healthcare Improvement defines a bundle as a set of 3 to 5 best practices that are effective in preventing a specific HAI. A checklist is a tool modeled after its successful use in the airline industry. It reduces mental workload and serves as a reminder to use bundled best practices during patient care. The surgical safety checklist[7] and the central line checklist[8] are excellent examples of checklists that have led to decreased rates of HAI. The components of any given bundle of best practices are evidence based and typically selected by experts and endorsed by professional organizations. The known best practices, including the bundles frequently used in the United States, are shown in Figure 1.

It is not necessary for the components of any given bundle to be constant. Hospital programs may modify the components of a given care bundle per institutional or regional needs. For example, the "European ventilator care bundle"[9] is different from the bundle commonly used in the United States. It consists of the following components: (1) no ventilator circuit

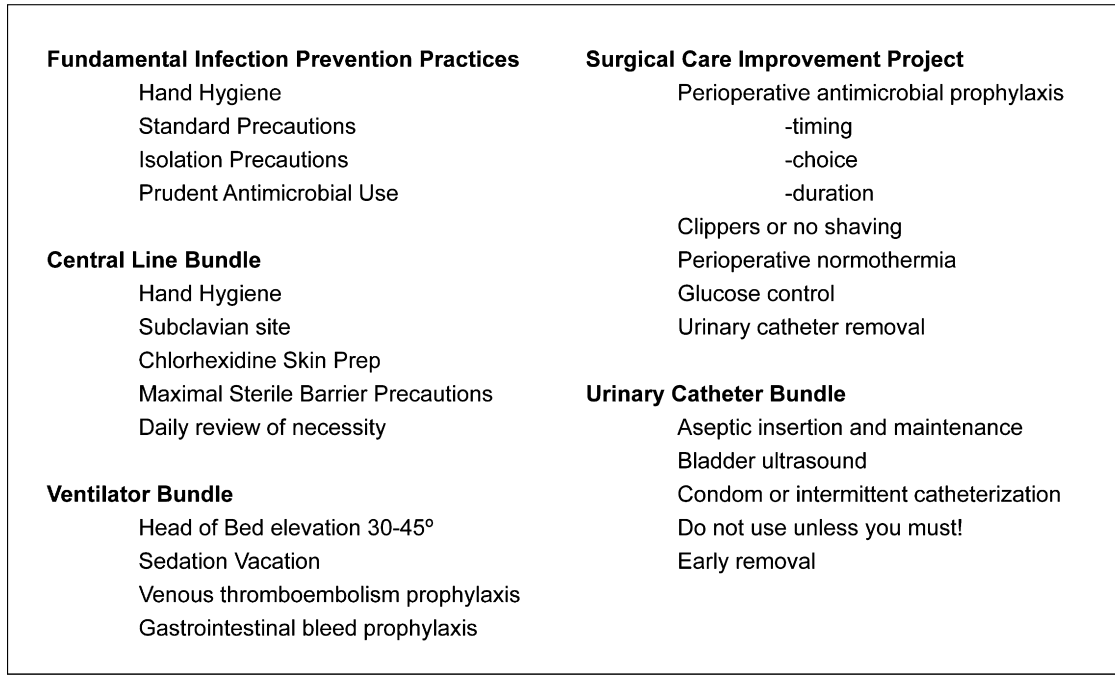

FIGURE 1. Best practices to prevent healthcare-associated infection.

tube changes unless specifically indicated; (2) strict hand hygiene practice with the use of alcohol-based hand rub; (3) appropriately educated and trained staff; (4) sedation vacation and weaning protocol; and (5) oral care with the use of chlorhexidine.

Implementation of the central line bundle has resulted in reduction of CLABSI in several hospitals. One of the most prominent examples is the Keystone study conducted by Pronovost et al[8] in more than a hundred ICUs in Michigan. With the implementation of central line bundle in these ICUs, the mean and median rates of CLABSI decreased from 7.7 and 2.7 (interquartile range, 0.6–4.8) at baseline to 1.3 and 0 (0–2.4) at 16 to 18 months and to 1.1 and 0 (0.0–1.2) at 34 to 36 months postimplementation. Another notable demonstration of the effectiveness of the central line bundle came from the Pittsburgh Regional Healthcare Initiative.[10] In this initiative, the pooled mean rate of CLABSI per 1000 central line days in participating ICUs decreased by 68%, from 4.31 to 1.36 ($P < 0.001$) over a 4-year period.

Berenholtz et al[11] conducted a collaborative study among 112 ICUs to reduce VAP using the ventilator bundle that is typically used in the United States (Table 1). They reported decrease of overall median VAP rate from 5.5 cases (mean, 6.9 cases) per 1000 ventilator days at baseline to 0 cases (mean, 3.4 cases) at 16 to 18 months after implementation ($P < 0.001$) and 0 cases (mean, 2.4 cases) at 28 to 30 months after implementation ($P < 0.001$). Several other studies reported similar results.[12,13]

In a national collaborative effort to prevent SSIs, the Surgical Care Improvement Project (SCIP)[14] was designed and implemented nationally in the United States. In a large study reported by Stulberg et al[15] including 405,720 hospital discharges after surgery demonstrated adherence to SCIP was associated with a decreased likelihood of developing a postoperative infection from 14.2 to 6.8 postoperative infections per 1000 discharges (adjusted odds ratio, 0.85; 95% confidence interval, 0.76–0.95). Similar improvements were demonstrated in a multihospital collaborative study.[16]

Bundled care practices to prevent CAUTI are relatively new in infection prevention. Computerized reminders to discontinue urinary catheters have been shown to be effective in preventing healthcare-associated CAUTI. In a systematic review and meta-analysis of reminder systems to discontinue urinary catheters,[17] the rate of CAUTI was reduced by 52% ($P < 0.001$) with the use of a reminder or stop order. In a study by Topal et al,[18] the CAUTI rate decreased by 73% (36/1000 catheter days to 11/1000 catheter days; $P < 0.001$) using computer order entry and a nurse-directed protocol for insertion and maintenance of urinary catheters.

LIMITATIONS OF BEST PRACTICE APPROACH

Although best practices are extremely important in preventing HAI, they have significant limitations. There are critical gaps in the scientific evidence base of pathophysiology and prevention of HAI.[19] One of the obvious limitations of the bundled best practices approach is that it is not possible to know the relative effectiveness of different components. Some of the key limitations are discussed in the following sections.

Wide Variation in Rate of Infections

There is wide variation in the rate of HAI between hospitals and between types of patient care units. A review of the rate of CLABSI reported by several hundreds of participating hospitals to the CDC/National Health Safety Network illustrates this variation. The interquartile range for rate of CLABSI in medical-surgical ICUs in major teaching hospitals reported in 2002–2004, 2006–2008 and 2009 was 2.6 to 5.1, 0.6 to 2.9 and 0.3 to 2.4 CLABSI per 1000 catheter days, respectively.[20–22] In the Keystone Michigan ICU project,[8] teaching hospitals and larger hospitals had less improvement in rates of infection in response to the intervention, ie, the use of central line bundle. For teaching hospitals in the study, the