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Surgical site infections: incidence and trends at a community teaching hospital

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Abstract

BACKGROUND: There has been increased national attention on methicillin-resistant *Staphylococcus aureus* (MRSA) and surgical site infections (SSIs) highlighted by the media, the public, and federal agencies. It was therefore considered important to analyze the trends and incidence of inpatient detected SSIs and associated resistant organisms at our own institution.

METHODS: The analysis reflects the cultures and sensitivities of SSI on the surgical services at Monmouth Medical Center, a 527-bed community teaching hospital, from January 2003 through December 2007. The SSIs included in the study were those detected in hospitalized patients.

RESULTS: There were 312 surgical patients who developed SSIs. Contrary to observed national trends, our study demonstrated a statistically significant decrease in the incidence of MRSA among all the surgical services. We also noted a statistically significant decrease trend of SSIs in orthopedic surgery. The 312 patients' cultures yielded 399 bacterial strains. The most common strains varied with the service. Overall, the most common isolate identified was *Staphylococcus* species, numbering 143% or 35.8% of all isolates. MRSA was identified in 46 SSIs and 8 SSIs were positive for vancomycin-resistant enterococci (VRE).

CONCLUSIONS: Only a hospital-specific SSI analysis can help focus improvement with clinical impact. The scrutiny of SSI analysis has highlighted SSI problems in the pediatric and orthopedic surgery services that have been addressed.

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Despite remarkable advances in the use of aseptic techniques and antibiotics, surgical site infections (SSIs) remain a major source of morbidity and mortality in the surgical patient and are the most common nosocomial infections in this group of patients. Up to 1.4 million cases of SSIs occur per year in the United States, affecting 2% to 5% of all surgeries and result in expenses in excess of 1 billion dollars per year.[1] In addition to accruing increased hospital costs, SSIs account for longer hospital stays and greater demands in patient care.[2]

Recently, there has been an increased focus on the role of antibiotic resistant organisms such as methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) in SSIs. Concerns have centered on increased morbidity and mortality associated with these types of infections with increased resources employed to control infections in the face of limited therapeutic options. This seems to be even more foreboding as the percentage of MRSA as a total of all staphylococcal infections has almost

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tripled from 22% in 1995 to 63% in 2004.[3] Additionally, studies have shown MRSA to be the leading cause of SSIs in patients undergoing vascular, orthopedic, and cardiac surgery.[4–6]

For these reasons, the last several decades have seen renewed attempts at controlling SSIs. The initiative has adopted a multifaceted approach, involving efforts by surgeons, infectious disease physicians and specialists, nurses, academics, pharmaceutical agencies, and more recently governmental bodies.

The National Nosocomial Infections Surveillance (NNIS) program was instituted in 1970 to determine the incidence of SSIs and allow for its surveillance.[7] Data points include surgical procedure based on ICD9 coding and risk factors used to create a composite index. It has been demonstrated that through the implementation of a team based approach in which practice changes are implemented and adhered to, that the rate of MRSA infection can be significantly decreased.[8–10]

Methods

This study was performed at Monmouth Medical Center, a 527-bed teaching hospital located in central New Jersey where approximately 12,000 surgeries are performed annually. The surgical services include general, orthopedic, vascular, pediatrics, otolaryngology, genitourinary, cardiothoracic, plastics, obstetrics, and gynecology.

A dedicated infection control team has been involved in the surveillance of SSIs at Monmouth Medical Center via retrospective chart review. The infection control team received information on all microbiology cultures related to surgical wounds, which were then matched to the patient's medical chart to determine whether the culture was related to an operative procedure. Patients were included in the database in all cases of detection of inpatient SSI, readmission for SSI following surgery, emergency department evaluation for an SSI, or if an SSI was found to have developed on an unrelated readmission. The infection control team was not directly involved in care of surgical wounds. Therefore, wounds that were opened and not cultured were not included in the database. Surgeon office follow-up data were not included in this study unless the surgeon made the decision to admit the patient or have them evaluated in the emergency department, in which case cultures were taken on admission, resulting in inclusion into the database by the infection control team.

Patient data were entered in an Excel spreadsheet (Microsoft, Redmond, WA) and included date of surgical procedure, date of infection identification, attending surgeon, surgical procedure, surgical service, isolated culture and sensitivity, and wound classification. An SSI was defined as a postsurgical infection that developed within 30 days after surgery. SSIs that involved implanted prosthetics were included in the study if they occurred within 1 year of the date of surgery as per the Centers for Disease Control convention.[11]

The surveillance of SSIs at Monmouth Medical Center from 2003 through 2007 is the data set for this study. These data were analyzed to determine the trends of cultures and sensitivities involved in SSIs. We used the NNIS data collected from January 1992 through June 2004 as a benchmark to compare our incidence of SSIs.[11]

The Student's *t* test was employed. Categorical data were tested using χ^2 test with linear regression. Statistical significance was made at $P \leq .05$. Statistics were performed using Texasoft WINKS SDA software, 7th edition (Cedar Hill, TX, 2007).

Results

From January 2003 to December 2007, 312 surgical patients were identified with SSIs. The number of SSIs per year ranged from 58 to 67, averaging 62.4 with a SD of 3.6 and a 95% confidence interval (CI) that ranged from 59.2 to 65.2.

The incidence of SSIs was based on annual surgical volume, which was tabulated since 2005. The yearly incidence of SSIs ranged from .52% to .63% (mean .56%). The yearly incidence of SSIs in the patients undergoing general surgical procedures ranged from .84% to 1.11% (mean 1.01%). There was no statistically significant trend in the annual incidence of SSIs in either group over those 3 years, *P* values of .536 and .588, respectively.

The most common procedures associated with SSIs among all surgical services were colon resections, Caesarean sections, appendectomies, and small bowel resection. They accounted for 14.1% (44), 9.9% (31), 8.7% (27), and 8.3% (26) of all SSIs, respectively.

We observed 33.7% (105) general surgery SSIs, accounting for the majority of SSIs. They ranged from 17 to 24 SSIs per year (mean 21 SSIs/yr). General surgery did not demonstrate any statistically significant trend over the 5-year review ($P = .73$). The most common general SSIs were attributed to colon resections, appendectomies, and small bowel resection, numbering 41.9% (44), 25.7% (27), and 24.8% (26), respectively.

Orthopedics accounted for 19.9% (62) of SSIs, with the frequency of SSIs having decreased to a third of their value over 5 years, which was a statistically significant trend ($P = .046$). Pediatric surgery accounted for 7.1% (22) of SSIs over the 5-year period, with almost half occurring in the last year of the study, 2007. No statistically significant trend was identified ($P = .213$). The remaining surgical services did not demonstrate any statistical significant change in frequency of SSIs.

SSI, cultures

A total of 399 cultures were obtained from 312 SSIs patients over 5 years. Overall, the most common cultures among all surgical services were *S aureus* (24.8%), *Entero-*

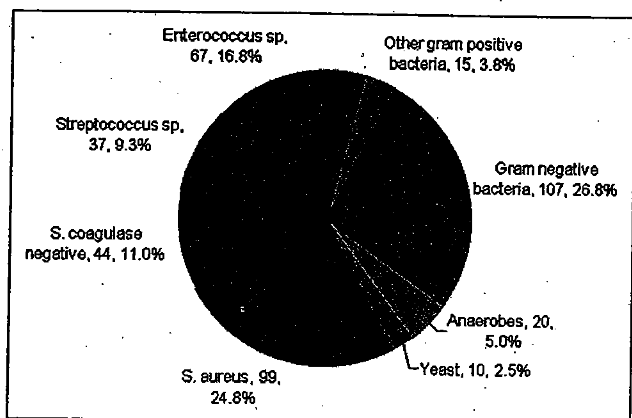

Figure 1 Distribution of SSI culture isolates.

coccus species (16.8%, predominately *E faecalis* and *E faecium*), and coagulase-negative *Staphylococcus* species (11.0%, predominately *S epidermidis*) (Fig. 1). MRSA was present in 46 SSIs, or 46.5% of all SSIs with *S aureus*.

Bacterial isolates were chronologically reviewed to determine the presence of any trends (Fig. 2). On review of all the surgical services, linear regression analysis demonstrated a statistically significant decreased trend in the yearly frequency of MRSA ($P = .027$). No trend was identified in the annual frequency of MSSA and coagulase-negative *Staphylococcus* ($P = .169$ and $P = .816$, respectively). No statistical significant trend was identified in the frequency of VRE.

The most common isolates in the general surgical service in order of decreasing frequency were *Enterococcus* 28.7% (39), *S aureus* 14.0% (19) and coagulase-negative *Staphylococcus* species 12.5% (17). The overall percentage of gram-negative isolates were 22.1% (30 cultures). There was no statistically significant trend in annual frequency of general surgery service VRE or MRSA SSI cultures over the 5 years of this study.

SSI wound classification

There was an increase in class II SSIs in 2007. Associated with this increase was the frequency of negative cultures (from 4 to 12). Although there was a decrease and increase in class III and IV SSIs, respectively, this was not of statistical significance due to small sample size in both groups.

Comments

Our study demonstrated an average incidence of .56% SSIs per year among all surgical services. This number is below the average SSI rate of 2.61% presented by the NNIS review.[12] Our rates of SSIs were similar to a study reviewing the incidence of SSIs in patients undergoing elective surgery, where their incidence of SSIs ranged from .4% to 1.8% depending on whether the patient underwent surgery on the same day as admission.[13]

The incidence of general surgical SSIs in the NNIS study was .81% for herniorrhaphy, 3.11% for combined biliary, liver, and pancreatic cases, and up to 4.97% for small bowel cases. The overall incidence of SSI in the general surgical group of our study over 3 years was 1.01%.

The incidence of orthopedic SSIs in the NNIS study ranged from .79% for an open reduction of fracture to 1.04% for a spinal fusion. The overall incidence of SSI in the orthopedic service in our study was .49%. Our study

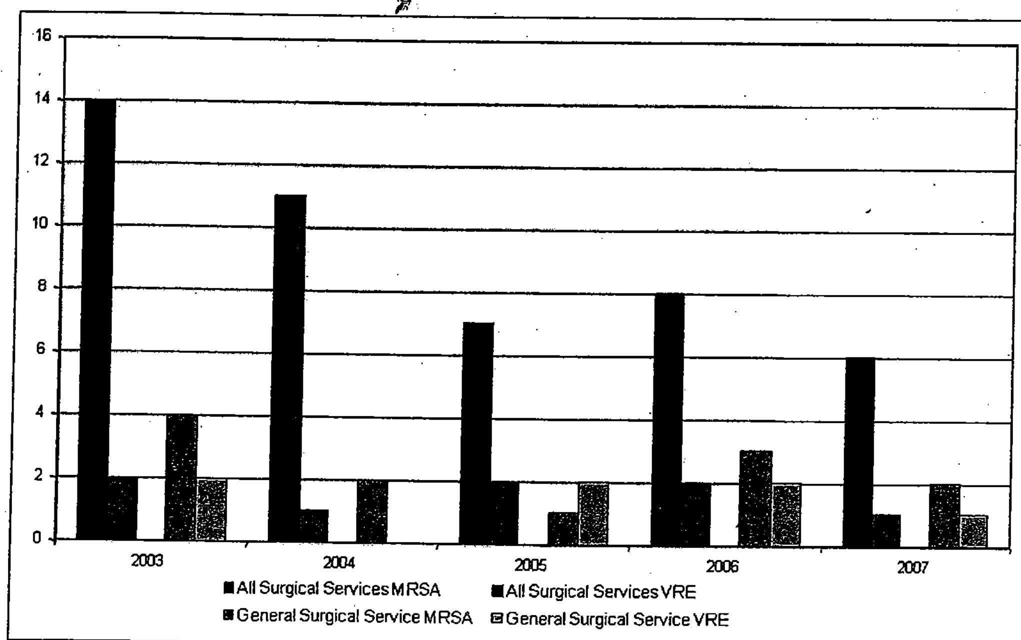

Figure 2 Annual incidence of MRSA and VRE SSI isolates in all surgical services and general surgical services.

showed that the orthopedic services have seen a 3-fold decrease in its frequency of SSIs. The decrease resulted from perioperative measures, including stricter adherence to appropriate timing and dosing of antibiotics, surveillance and maintenance of normothermia, limitation of operating room traffic, and optimization of ventilation within the operating room.

In comparison with the study on the efficacy of nosocomial infection control (SENIC) trial, with the exception of the orthopedic service, our data have not demonstrated a significant decrease in SSI frequency among the remainder of the surgical services. Studies such as the SENIC[14] and surveillance network of SSI incidence in Northern France (INCISO)[15] demonstrated a decrease in SSIs, presumably by promoting awareness of infection to the surgical staff, independent of whether new protocols or guidelines were instituted. These studies have become the foundation for the Surgical Care Improvement Program, which mandates feedback on performance measures such as administration of appropriate preoperative prophylactic antibiotics. The SENIC trial had a decrease of SSIs from 3.8% to 1.7% after the institution of SSI surveillance. There is a possibility that we are not yet witnessing a decrease in incidence due to the benefits of appropriate antibiotic coverage being balanced by increased detection rates due to the Hawthorne effect, whereby subjects improve detection due to knowledge that they are being studied.

There was a significant increase in the incidence of SSI in the pediatric surgery service in 2007 with the rate of SSIs increasing to 10 from 2 in the previous year. On review of the cultures, 16 species were isolated from pediatric SSIs in 2007, which included 8 Gram-negative isolates and 5 anaerobic isolates (*Bacteroides fragilis*), from the 3 species isolated the prior year. The increase in SSIs was attributed to inappropriate antibiotic coverage for pediatric appendectomy cases in which a first generation cephalosporin was used. This was subsequently resulted in a change to appropriate antibiotic coverage. These data detected by the surveillance program highlights its efficacy at improving quality control and demonstrates how a team-based approach can help identify a specific deficiency, which can result in the implementation of appropriate change. Similar studies have demonstrated similar outcomes, such as a study by Ryckman et al in an academic center.[16]

The most common isolated cultures among all surgical SSIs were similar to published data; the most common SSI isolates in our study were *S aureus* 24.8%, *Enterococcus* species 16.8%, and coagulase-negative *Staphylococcus* species 11.0%, compared with the 2003 NNIS report, which had incidences of *S aureus* of 22.5%, coagulase-negative *Staphylococcus* species 15.9%, and Enterococci 13.9%.[7]

We identified an increase in class II SSIs in 2007; however, of interest is that there was an increase in the frequency of negative cultures that year (from 4 to 12). Possible explanations may include prior antimicrobial therapy or the presence of slowly growing microorganisms.

The 2004 NNIS report showed an increase in VRE and MRSA nosocomial infections in the intensive care unit of 28.5% and 59.5%, respectively, when compared with the mean rate of resistance over the previous 5 years.[11] Review of our 5-year data demonstrated a statistically significant ($P < .05$) decreasing trend in the frequency of MRSA attributed SSIs among all surgical services. A possible explanation for this disparity is that most NNIS hospitals tend to be academic medical centers, which in turn provide medical care for a greater proportion of low-income and uninsured patients. Studies have demonstrated lack of insurance as an independent predictor of SSI.[17] Also, compared with other studies we did not find an increasing proportion of MRSA in staphylococcal SSIs.[4–6] At our institution we, therefore, continue to use of antimicrobials such as cefazolin for preoperative antibiotic prophylaxis rather than vancomycin, consistent with current guidelines.[18,19–22]

Of additional interest is the differentiation of MRSA SSIs between community acquired (CA-MRSA) and hospital acquired (HA-MRSA) subtypes. CA-MRSA and HA-MRSA differ in their clinical and bacteriologic characteristics, with the former arising in the community in younger individuals who lack established MRSA risk factors such as recent hospitalization, nursing home residence, or the presence of invasive medical devices.[23] HA-MRSA is resistant in vitro to multiple antimicrobial agents, while CA-MRSA resistance is limited to beta-lactams and macrolides.[23] Several studies have demonstrated ciprofloxacin susceptibility to be an accurate phenotypic marker of CA-MRSA.[24,25] Review of the susceptibility profiles of our MRSA isolates has shown that despite an overall decrease in the frequency of SSIs attributed to MRSA, the proportion of SSIs that are attributed to ciprofloxacin sensitive MRSA, and thus likely attributed to CA-MRSA isolates, has increased. On review, in 2003 only 20% of MRSA strains cultured from SSI at our hospital were susceptible to clindamycin, but by 2007 this had increased to 40%. This is consistent with other studies demonstrating an increasing proportion of MRSA SSIs attributed to CA-MRSA.[26] These findings put into question newer guidelines that call for the use of vancomycin as a prophylactic antibiotic in patients undergoing surgery.[27]

Limitations of our study were that it was retrospective in nature, limited to patients who were either admitted or evaluated in the emergency department with no outpatient follow-up, and that the infection control team was not directly involved in the care of the SSIs. It is likely that had we included SSIs detected, cultured, and managed on an outpatient basis, our overall incidence of SSI would have been greater.

Even though this study has documented the benefits of SSI surveillance as seen by the decrease in incidence of SSIs in the orthopedic service, the need for continual monitoring is imperative. Surveillance allows for identification of key factors that can be targeted as benchmarks for improvement. Monitoring SSIs identifies potential areas for

change to decrease surgical infections. We can also evaluate existing infection control measures and compare results to nationally collected data, as a major tool for quality control in surgery.

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