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Methicillin Resistant Staphylococcus Aures: Implications for Cardiac Surgery

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METHICILLIN RESISTANT STAPHYLOCOCCUS AUREUS: IMPLICATIONS FOR CARDIAC SURGERY

by

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An Independent Project
Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Science

Grand Forks, North Dakota
August
2000

This independent project, submitted by Karen L. Johnson in partial fulfillment of the requirements for the degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisor under whom the work has been done and is hereby approved.

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Faculty Advisor

This independent project meets the standards for appearance, confirms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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Dean of the Graduate School

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Department	Nursing
Degree	Master of Science

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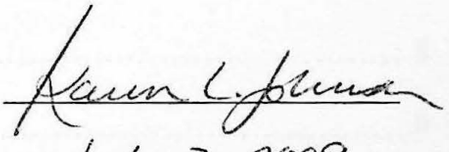
Signature 

Date July 3, 2009

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ABSTRACT

Methicillin resistant *Staphylococcus aureus* (MRSA) is a pathogen first emerging in Great Britian in 1961. Since that time, it has spread worldwide and caused epidemic infection rates in several countries. It is most commonly spread in the healthcare setting where it is labeled a "nosocomial" infection, frequently infecting patients undergoing invasive medical procedures and immune-compromised patients. Depending on the severity and location of infection in conjunction with the patient's health status, MRSA infection can be mild to fatal. The surgical setting is a key area of concern. Cardiac surgery complicated by MRSA is relatively rare, but when it does occur, the associated mortality rate is alarmingly high.

It is also possible to contract MRSA in the public setting where it is labeled "community-acquired" MRSA (CA-MRSA). CA-MRSA infections can range from simple skin infections to devastating infections such as bacteremia leading to death. The incidence of CA-MRSA has risen to approximately 14% of all MRSA infections.

The purpose of this project was to explore the incidence of MRSA and its ramifications focusing on the cardiac surgery patient. Pasteur's germ theory provided a theoretical framework to uncover the causative organism and how it spreads to susceptible hosts. Appropriate measures for prevention and treatment were explored.

This paper informs nurse anesthetists how to prevent the spread of MRSA in the cardiac surgery patient. Preventing MRSA in the cardiac surgery patient include strict contact isolation precautions in the surgical setting in the presence of MRSA, appropriate and timely

preoperative prophylactic antibiotic administration, and vigilant intraoperative glycemic and thermoregulatory control of patients.

This project was presented to two audiences: The first was a 10-minute PowerPoint presentation given at the spring meeting of the North Dakota Association of Nurse Anesthetists. The second was a 50-minute inservice presented to CRNAs and nursing staff at a Midwestern facility. Providing awareness of the growing problem of MRSA infections is the first step in reversing the trend of increasing infections. Active participation by healthcare providers in applying prevention methods provided in this project will help to prevent the spread of MRSA in the patients for whom they provide care.

Chapter 1

INTRODUCTION

The Beginning

Methicillin-resistant staphylococcus aureus (MRSA) is an infectious problem that was first isolated as early as 1961 in a British hospital and spread from the United Kingdom (UK) into European countries during that decade. In 1980 there was an upsurge of MRSA in the UK which also spread to the United States. Since that time MRSA has reached endemic proportions in several countries. In 2005, MRSA was responsible for the deaths of an estimated 19,000 people in the United States. This exceeded the number of people with reported deaths caused by the AIDS virus in the same year (Centers for Disease Control, 2007).

Staphylococcus aureus (S. aureus), frequently referred to as "staph," is a gram-positive organism commonly found in the nares or on the skin of healthy people. This is referred to as colonization. Twenty five percent to thirty percent of the population is colonized with *S. aureus.* At times, it may cause infection and require antibiotic treatment (CDC, 2005).

S.aureus may be resistant to treatment; most commonly, it is resistant to the beta-lactam antibiotics. Antibiotics within this group include methicillin, oxacillin, penicillin, and amoxicillin. *S. aureus* that is resistant to these antibiotics is called methicillin-resistant *S. aureus*, or MRSA. MRSA may cause infections that are severe or even fatal because of its resistant to treatment by one or more antibiotics. Approximately 1% of the

estimates the cost increase related to antimicrobial resistance to be $4 billion annually in the United States (Raymond, Kuehnert & Sawyer, 2002).

"Antimicrobial-resistant pathogens are an increasing threat in the surgical setting" (Raymond et al., 2002, p. 382). Resistant strains of pathogens in the surgical patient causes an even more significant increase in mortality and length of hospital stay when compared to strains that are susceptible. These infections also tend to increase the rate of treatment failure due to their resistant nature.

According to a report for the National Healthcare Safety Network (NHSN) compiled by Hidron et al. (2008) hospital-associated infections were correlated with one of four major surgery types. These included cardiac surgery (29%), abdominal surgery (26%), orthopedic surgery (18%), and neurosurgery (12%). They reported that *S.aureus* and coagulase-negative shaphylococci were the most prevalent pathogens causing SSI for most types of surgeries.

In cardiac surgery, *S. areus* is the main cause of SSI. The patient's endogenous flora have been identified as the primary source of these infections (Muñoz et al., 2007). SSIs associated with cardiac surgery are important causes for postoperative morbidity and mortality and often have the co-complication of bacteremia. The expected wound infection rate for cardiac surgery is less than 3%. Rates ranging from 1-10% have been measured in the United Kingdom and the United States (Schelenz et al., 2002). While the wound infection rate remains fairly low, the mortality rate of cardiac surgery wound infections due to MRSA has been reported to range from 30% (Mastoraki et al., 2008) to as high as 53.3% (Mekontso-Dessap, Irsch, Brun-Buisson & Loisance, 2001).

Anesthesia providers should be familiar with preventative strategies for MRSA in general as well as strategies that pertain to the surgical setting (Homa & Palfreyman, 2000; Raymond et al., 2002). Appropriate prophylactic antibiotic treatment at the time of induction is a prevention measure in which the anesthetist is directly involved (Kendall, Hart & Russell, 2002). Other perioperative factors that are controlled by the anesthetist are monitoring and maintaining normal glycemia and maintaining normothermia (CDC, 2004). Given the high mortality rates for MRSA related to cardiac surgery, it is imperative that anesthesia providers are familiar with MRSA and how best to prevent its spread in the operating room.

Purpose

The purpose of this project is to educate the reader about MRSA including its prevalence, prevention strategies, treatment options, and implications specific to surgery, and in particular, cardiac surgery. The information will be presented at an in-service to healthcare staff at a small Midwestern hospital and during the 2009 spring meeting of the North Dakota Association of Nurse Anesthetists (NDANA).

Significance

Anesthetists play a vital role in the prevention of SSIs as they are typically responsible for the administration of antibiotics at the time of anesthesia induction. This puts them in the direct role of judiciously administering antibiotics. In addition to this, they also have the opportunity to set examples for other healthcare workers in the surgical setting. They can do this through practicing vigilant contact isolation. Other ways in which they can impact the spread of MRSA is through maintaining interoperative glycemic control and normothermia. In combination, these actions by the anesthetist can

help to control the spread of MRSA and consequently, avoid the disastrous outcomes associated with MRSA.

Theoretical Framework

The theoretical framework used for this paper is the germ theory and principles of infection first proposed by Louis Pasteur in 1858 (McEwen & Wills, 2007). Pasteur theorized that an infectious disease was caused by a specific organism. Seemingly simple, this theory has had a phenomenal impact in the development of medical care and has significantly reduced the mortality rates of infection (McEwen & Wills, 2007).

Currently, applications of this theory and other theories of infection are useful in the prevention of infection. They may be used to describe processes that help in the identification, understanding, and management of infectious diseases. The process involves identifying the causative agent and the way(s) in which it may be transmitted. Once this is accomplished, prevention and treatment strategies pertaining to the infectious agent are developed (McEwen & Wills, 2007).

In the field of nursing, germ theory and principles of infection have been used in research to identify the five following components:

1. Causative agent: An invasive agent is identified as causing a specific infection. *S. aureus* is an example of a causative agent.

2. Susceptible host: In order for the causative agent to infect, it must have a host that is susceptible. Susceptibility indicates increased risk for infection. A breakdown in the skin barrier, such as a surgical wound, increases the risk for the host to be infected by *S. aureus.*

3. Mode of transmission: In order for the host to be infected, the causative agent must be transmitted to the susceptible host. In MRSA, the hands of healthcare workers are often the mode of transmission from a carrier MRSA to a susceptible host.

4. Prevention: Once the causative agent, susceptible host, and mode of transmission are identified, plans for prevention may be implemented. Several research studies focus on infection prevention. Contact isolation is a topic frequently researched in the control of the spread of MRSA.

5. Treatment: When a susceptible host is infected, effective treatment options must be employed. Research in the area of infectious diseases study the most effective methods for appropriate treatments. The uses of various antibiotics in the treatment of MRSA have been widely studied.

Practice guidelines are often developed from research findings. These guidelines are instrumental in reducing the mortality rates of infection. Although rarely acknowledged, the principles of germ theory are often used in the studies that lead to practice guidelines (McEwen & Wills, 2007).

Assumptions

The author assumes the following for this independent project:

1. The literature reviewed was accurately collected and delivered the most recently-conducted research.

2. Anesthesia providers will be interested and supportive of this project.

3. Participants in the MRSA inservice will benefit from the information provided and will use the information to help optimize patient care.

Limitations

Limitations for this independent project include the following:

1. Within the review of literature sample sizes were small in many of the studies due to the relatively small incidence rate of MRSA in cardiac surgery.

2. This project was limited to adults undergoing cardiac surgery and those infected with MRSA.

3. Information dispersed to participants of the inservice is limited to those who attended.

Definitions

For purposes of this paper, the following words are defined:

Staphylococcus: A bacteria that is nonmotile, spherical in shape and is gram-positive in nature. It is commonly found on the skin and throat. Some of its species cause severe, purulent infections. Enterotoxins may also be produced resulting in nausea, vomiting and diarrhea (Mosby's pocket dictionary, 1994).

Staphylococcus aureus (S. aureus, staph): A species of *Staphylococcus* that causes the production of a golden pigment that may have color variations. It frequently causes abscesses, endocarditis, impetigo, osteomyelitis, pneumonia, and septicemia. It can also cause pyogenic infections such as boils and carbuncles (Mosby's pocket dictionary, 1994).

Methicillin-resistant *Staphylococcus aureus* (MRSA): A strain of *S. aureus* that has developed a resistance to treatment methicillin and other antibiotics in the same class.

Methicillin-susceptible *Staphylococcus aureus* (MSSA): A strain of *S. aureus* that remains susceptible to treatment with a penicillin such as methicillin and others in the same class of antibiotic.

Surgical site infection (SSI): An infection that occurs as a direct result of surgical intervention.

Summary

MRSA is a serious threat to patients undergoing cardiac surgery. It is a problem that also affects the cost of healthcare which is currently under scrutiny. It is imperative that all people involved in caring for patients do everything within their control to prevent and treat this problem to the best of their ability. In order for this to be accomplished, recognizing the problem is necessary. Understanding the process of the spread of MRSA and how to prevent and control that spread are crucial.

The anesthetist has the opportunity to play a vital role in the prevention of MRSA in the cardiac surgery patient. This can be accomplished by recognizing the problem, practicing appropriate contact isolation for MRSA, judicious use of prophylactic antibiotics in the preoperative setting, meticulous perioperative glycemic control, and maintaining perioperative normothermia. Exercising these preventive measures can help to prevent the infection of patients with MRSA in addition to helping preserve the healthcare dollar by avoiding the escalating costs associated with MRSA nosocomial infections.

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Chapter 2

REVIEW OF THE LITERATURE

Introduction

MRSA is a serious problem facing healthcare today. Since its emergence in the 1960s, it has reached epidemic proportions in several countries. It is detrimental to hospitalized patients with weakened immune systems. It has even more costly and devastating effects on the surgical patient population with cardiac surgery ranking highest in surgical infection rates. Determination of the cause and transmission of MRSA infections in cardiac surgery are key elements in providing the best prevention and treatment. Anesthesia providers can play a vital role in this process.

A literature review of Scopus, CINAHL, PubMed and the Cochrane Library was conducted on MRSA and the cardiac surgery patient. Case reports, articles by credible sources and online resources including the Center for Disease Control were utilized for this paper ranging from the years 1948-2008. These resources were used to gather information on the prevalence and prevention measures for MRSA in cardiac surgery patients as well as treatment options for cardiac surgery patients infected with MRSA.

Development of MRSA

In reviewing the development of MRSA, it is interesting to note that its development relates to the discovery of penicillin by Alexander Fleming in the year 1928.

The first antibiotic penicillin was produced in 1944. It was effective against *S.aureus* in addition to many other bacteria (Archer et al., 2001).

Just one year later in 1945, Spink and Ferris discovered penicillinase through their research. Penicillinase, capable of being produced by *S. aureus,* is a form of ß-lactamase, an enzyme responsible for breaking down the ß-lactam ring of the penicillin molecule (Gilson & Parker, 1948). Penicillinase is an inhibitor of penicillin, rendering some strains of *S.aureus* penicillin-resistant (Archer et al., 2001).

Over the next several years, additional antibiotics deriving from penicillin were developed. Continuing research also revealed a strain of *S.aureus* that was resistant to several antibiotics including penicillin, erythromycin, streptomycin, and tetracycline; several outbreaks of penicillin-resistant *S.aureus* infections occurred. In 1960, the antibiotic methicillin was produced and found to be effective toward the resistant *S.aureus* strain. However, just one year later, the first methicillin-resistant *S.aureus* strain was isolated in a hospital in the UK which lead to outbreaks in the UK and subsequent spread to other European countries (Archer et al., 2001).

MRSA eventually emerged in the US in 1980 after an epidemic outbreak in the UK. In 1990 the UK suffered another epidemic of MRSA which then spread into Asia. From 1995-2000, the world witnessed the advancement of MRSA to develop resistance against an array of antibiotics. MRSA continued to develop and resulted in a massive world-wide spread of methicillin resistance. Some of these MRSA strains began to develop resistance to other antibiotics such as vancomycin. (Archer et al., 2001)

Current Prevalence and Impact of MRSA

S. aureus is a bacterium that is normally found on the skin and within the nose of healthy people. The term colonization refers to the bacteria found within the normal flora without active infection. Approximately 25%-30% of the population has nasal colonization and about 1% of these are colonized with MRSA. Infections from MRSA may occur. Persons undergoing invasive medical procedures or ones with weakened immune systems within hospitals or healthcare facilities are at increased risk of developing infections from MRSA. Healthcare-associated infections include surgical site infections, urinary tract infections, septicemia, and pneumonia (CDC, 2005).

MRSA is gaining a strong foothold in the healthcare arena. In 1974 only 2% of the total numbers of staph infections were MRSA infections. In 1995, that number had climbed to 22%, and in 2004 it reached 63% (CDC, 2007).

In 2005, it was estimated that MRSA infections killed approximately 19,000 people. This accounts for a higher mortality rate than the AIDS virus in the same year (CDC, 2008).

Infections at the site of surgery occurring within thirty days of an operation, or within one year after an operation involving implantation of a foreign device, are considered surgical site infections (SSIs). Most SSIs are superficial skin infections which are considered mild. They may also involve underlying tissues, organs, or an implanted material which puts the patient in a category of higher risk. As many as 290,000 SSIs occurred in 2001, and approximately 8,000 deaths were associated with these infections (Surgical site infections (SSI) (CDC, 2008).

Aside from devastating results for the patients involved, SSIs cause significant financial burdens to the health care system. In the United States, nosocomial infections cost an estimated $5 billion, and SSIs cost an estimated $1.6 billion (Banbury, 2003). He states that increased treatment costs are often not reimbursed by third-party payers.

SSIs are most commonly caused by *S. aureus.* MRSA infections account for the majority of staphylococcal wound infection in several countries. In England, it was found that 61% of all *S.aureus* isolates from SSIs were methicillin-resistant (Schelenz et al., 2005). In many US medical centers, the prevalence of MRSA exceeds 50% of nosocomial *S.aureus* isolates. MRSA-related SSI has been demonstrated to be independently associated with increased mortality rates, increased hospitalization stays, as well as increased hospital charges in comparison to patients with no SSI or ones infected with MRSA SSIs (Dodds Ashley et al., 2004).

Banbury (2003) reported the mortality rate of MRSA infections to be up to three times that of MSSA infections and there has been an increase in prevalence of MRSA in the past two to three decades. He reported that MRSA infections cost an average of $3700 more to treat than infections caused by MSSA and may not be reimbursable by third-party payers.

Prevalence and Impact of MRSA in Cardiovascular Surgery

Muñoz et al. (2007) acknowledge *S. aureus* as being the most common cause of SSI in patients having major heart surgery. The endogenous flora of the patients is cited as the principal source. Hidron et al. (2008) reported that healthcare-associated infections were the result of procedures most associated with one of four major procedure types. The highest percent was cardiovascular surgeries being the most prevalent at 29%.

Shelenz et al. (2005) indicated that in the UK and several other countries, the dominant cause of staphylococcal wound infection is methicillin-resistant.

These SSIs associated with MRSA are linked with postoperative morbidity and increased mortality rates in cardiac surgery. Bacteremia is often an accompanying complication. Expected wound infection rates for coronary artery bypass graft (CABG) is less than 3%. However, Shelenz et al. (2005) reported a rate ranging from 1% to 10% in both the UK and USA.

Mekontso-Dessap et al. (2001) brought attention to another alarming aspect of MRSA in cardiovascular surgery patients. They reported a mortality rate of 53.3% in patients having MRSA mediastinitis. This was compared to a mortality rate of 19.2% in patients having MSSA mediastinitis.

Summary of Impact of MRSA

The development of MRSA has been continuous and unrelenting since first reported. Though a spectrum of antibiotic drugs has been developed against MRSA, it continues to be a worthy opponent of health. Healthcare-associated infections are common, and SSIs, particularly those involving cardiovascular surgeries, are reported as high as 29%.

Risk of MRSA in Cardiac Surgery

All surgical patients are at increased risk of contracting MRSA. The two major transfer mechanisms for MRSA are the admission of infected or colonized patients serving as a reservoir, or from a colonized or infected healthcare worker. MRSA can be spread via direct or indirect contact which is usually conveyed by the hands of caregivers or by contaminated environmental surfaces. The increased use and abuse of antibiotics

has increased the number and virulence of antibiotic-resistant organisms (Homa & Palfreyman, 2000).

In the surgical patient, MRSA has been isolated from the anterior nares, sputum, perineum, and the rectum. It has also been found in surgical or burn wounds, decubitus ulcers, tracheostomies, and gastrostomies of patients who are colonized or infected with MRSA. Similar to other settings within a healthcare facility, the primary mode of transmission is by the hands of healthcare workers who have become contaminated from contact with infected or colonized patients. Contaminated devices, items, and environmental surfaces are significant contributing sources of transmission as well (Homa & Palfreyman, 2000).

Patients undergoing cardiac surgery face additional risks for contracting MRSA as compared to the general surgical population. *S. aureus* is the main cause of SSI after major heart surgery, with the patient's endogenous flora as the principal source (Muñoz et al, 2007). Casewell (1998) found that 30-40% of patients admitted to the hospital were carriers of *S. aureus* in the anterior nares. This proportion increased during the course of hospitalization. Casewell also found that 20-35% were persistent nasal carriers. 30-70% were intermittent or occasional carriers and 10-40% were never carriers. This study also showed that in persistent carriers, the same strain of *S. areus* was carried for months or even years.

According to Casewell (1998), current evidence suggests that skin carriage and high infection rates are more common in heavy nasal carriers. From studies conducted in the 1960s, Casewell reported that 44% of nasal carriers with more than 100,000 colonies per culture also had positive skin cultures. In patients with less than 100,000 colonies per

culture, only 5% had positive skin cultures. Casewell's findings support nasal carriage as a definite risk factor for surgical infection and sepsis. Casewell (1998) found that surgical infection rates were 2-17 times more common in carriers of *S. aureus.* This study also found that nasal strains accounted for 40-100% of staphylococcal sepsis.

A study completed by Trautmann, Stecher, Hemmer, Luz and Panknin (2007) also found that SSIs continue to pose threats to patients. The range of SSI rates after clean surgery was found to be 1-5%. Trautmann et al. (2007) reported that endogenous flora is a significant contributing factor to those statistics. The microorganisms that are a part of the patient's endogenous flora are prone to spread during surgery. This spread contaminates sterile surgical sites, leading to infection.

Trautmann et al. (2007) found around 30% of the human population to be chronic or intermittent nasal carriers of *S. aureus.* Their study findings supported the association of *S. aureus* nasal carriage with significantly increased risk of postsurgical SSIs as compared to noncarrier risk. Similar to Casewell's results (1998), Trautmann et al. (2007) found density of colonization to be an additional risk factor. In their study, they also speculated that the mechanism of transmission may involve bacteria from the nares of the patient being released as aerosols during surgery. This could cause infection to the surgical site through an airborne route. This route was postulated in addition to hematogenous spread of *S. aureus.*

Muñoz et al. (2007) conducted research on the increased risk of surgical site infection after major heart surgery in relation to nasal carriage of *S.aureus.* In their study, they identified risk factors based on both univariate and multivariate analysis. The preoperative risk factors identified by univariate analysis were obesity ($p = 0.03$),

previous percutaneous transluminal coronary angioplasty with stent insertion ($p = 0.02$) and *S. aureus* nasal carriage ($p = 0.01$). They discovered that MRSA carriers had a significantly higher risk ($p = 0.002$). Postoperative risk factors included reintervention due to bleeding ($p = 0.03$) and reintubation ($p = 0.001$).

In the same study by Muñoz et al. (2007), the multivariate analysis revealed that independent risk factors of SSI were *S.aureus* ($p = 0.009$), reoperation ($p = 0.04$) and diabetes mellitus ($p = 003$). In their study, they also identified a significant rate of nasal carriage of *S. aureus* amongst patients having cardiac surgery ($p = 0.01$). Their study findings showed nasal carriage of *S. aureus* as an independent risk factor leading to SSI and subsequent increased mortality rates ($p = 0.01$). MRSA carriers were shown to have a much higher incidence of SSI ($p = 0.02$).

Dodds Ashley et al. (2004) conducted a study comparing the risk factors of developing post operative mediastinitis (POM) between MRSA and MSSA populations. In their bivariate analysis, factors showing a higher prevalence of POM included age greater than 70 years ($p = 0.03$), female gender ($p = 0.004$), obesity ($p = 0.04$) and diabetes ($p = 0.007$). Perioperative blood glucose levels of >200 mg/dL also increased the proportion of patients included in the MRSA mediastinitis group ($p = 0.03$). Their multivariate analysis showed a higher prevalence in the female gender ($p = 0.01$), diabetic population ($p = 0.02$), and age group greater than 70 years ($p = 0.003$) Their overall conclusion was that age, female sex, and diabetes mellitus were unique contributing risk factors for POM caused by MRSA.

Another factor that can increase the risk of transmission of MRSA in surgery is the carriage of MRSA by healthcare workers. Wang et al. (2001) published a study

regarding an outbreak of MRSA infection in cardiac surgical patients in a northern Taiwan hospital. The infection control team at this hospital was alerted to an increase in the postoperative wound infection MRSA rate following open-heart surgery. They investigated several possible sources of infection. Through isolation of the specific clone of MRSA, it was determined that the source of infection at this hospital was an assistant surgeon who had participated in all the cases identified. This individual was tested for MRSA and was found to carry the same clone as the infected patients. MRSA was found in both the anterior nares and within dermatitis of the right hand of the assistant surgeon. This individual was treated with topical mupirocin ointment to the nares and the right hand. This facility had no further cases of MRSA surgical wound infection identified after the treatment of this individual.

Summary of Risk of MRSA in Cardiac Surgery

All surgical patients are at risk of contracting MRSA. It is usually spread by caregivers' hands or contaminated environmental surfaces. S. aureus is the major cause of SSI after heart surgery, the principal source being the patient's endogenous flora. Nasal carriage is a risk factor for surgical information and sepsis. Additional risk factors are density of colonization, age great than 70, female gender, and diabetes.

Prevention of MRSA in Cardiac Surgery

In reference to the framework of germ theory, identification of the causative organism and susceptible hosts, including those at increased risk and mode(s) of transmission, are the first steps in combating germs. Prevention measures can be developed once these factors are determined. In the prevention of MRSA, several studies

have been completed to determine the best ways to prevent the nosocomial spread of MRSA.

Probably the most important step in preventing the spread of MRSA is recognition of the problem and realization of the importance of responsibility in controlling it. Accountability of this problem is held by healthcare workers as they are often the source of cross infection. Schelenz et al. (2005) focused efforts on targeting the senior surgical, nursing, infection control, and management staff to review MRSA infection rates and its control. They emphasized intensive support, education, and advice from the infection control team. They also developed nursing care pathways for the care of MRSA-colonized patients in an effort to reduce the MRSA acquisition and infection in their cardiothoracic patients.

In an article by Collignon (2008), recommendations were made for the control of MRSA in Australian healthcare facilities. It was identified that many healthcare workers felt overwhelmed by MRSA and felt it was simply a part of life over which they had little control. It was recommended that all clinicians including nurses, doctors, and chief executives of hospitals take personal responsibility for controlling MRSA infections. key points included accepting that needless morbidity and mortality resulted from health care-associated infections and that the principal mode of transmission was by the hands of health care workers. Emphasis was placed on measuring successes and failures in the effort to control the spread of MRSA. The goal was set at zero infections through adhering to basic infection control practices and other guidelines set forth for the control of MRSA.

Gleeson (2008) published that multiple infection control practices were beneficial in the prevention and control of MRSA. He included hand hygiene, identification, and isolation of MRSA carriers, patient decolonization, and environmental decontamination as primary measures for implementation. Gleeson emphasized that of these prevention and control measures, hand hygiene is the most important component. He found that hand washing with soap and water in conjunction with bedside hand disinfection using an alcohol-based solution decreased nosocomial infection and MRSA transmission rates from 16.9% to 9.9%.

Another of the initial steps in prevention and precaution is the prompt identification of MRSA. Homa and Palfreyman (2000) identified that MRSA and other multiresistant organisms are spread through direct or indirect contact. This is primarily from contact with the hands of healthcare workers, or from contact with environmental surfaces and equipment contaminated with MRSA. In order to prevent this mode of transmission, it is crucial to identify the major mechanism of introduction of MRSA into an institution. Homa and Palfreyman (2000) report this as the admission of a patient colonized or infected with MRSA into a healthcare facility.

Various opinions exist on how best to identify carriers of MRSA. Trautmann et al. (2007) reported recommendations of screening patients identified as at risk by the German Robert-Koch Institute. These were implemented at a German tertiary care hospital. The criteria included: "(1) patients with open chronic wounds or pressure sores, (2) patients transferred from secondary of tertiary acute care hospitals, (3) bed-bound patients from chronic care facilities, (4) patients with insulin-dependent diabetes mellitus, and (5) patients with chronic renal failure on dialysis" (p. 644). They also added the

recommendation to screen all patients admitted to their surgical ICU ward as a result of increased unexplained MRSA cases in this setting.

In the United Kingdom, a multi-disciplinary group developed guidelines for the control and prevention of MRSA in healthcare facilities. Their findings were published by Coia et al. (2006). In this publication, they emphasized that certain high-risk patients should be screened routinely. They defined high-risk patients as ones with a known history of MRSA colonization or infection, patients with frequent re-admission to healthcare facilities, patients transferred from another hospital, patients with recent admissions to a hospital with known high prevalence of MRSA, and residents of residential care facilities with known or likely high prevalence of MRSA carriage.

Coia et al. (2006) also stated that the final determination of the patients included in screening protocols should be determined at the local level by infection control and clinical teams. Local prevalence of MRSA in the facility, admitting diagnosis, and the risk status of the admitting unit are all contributing factors in the decision-making process at the local level. The hospital management structure is also encouraged to be involved in this process.

Screening for MRSA is typically done by obtaining cultures from the anterior nares, clinically infected sites, axilla, groin, perineum, and oropharynx (Trautmann et al 2007). This also varies among healthcare facilities in different countries. Conventional culture techniques are commonly used. These tests can take 24 to 48 hours or even longer to detect and identify *S. aureus* in nasal swabs.

In the case of cardiac surgery where nasal carriage has been determined to increase the risk of MRSA infection, this slow turn-around time can cause delays in

decision making. This is more likely to occur in the preoperative detection of carriers for which early surgery is desired. It may also lead to inappropriate use of antibiotic treatment as some clinicians may be inclined to treat everyone with mupirocin ointment to the nares instead of treating only the MRSA carriers (Banbury, 2003).

Banbury (2003) and Jog et al. (2008) propose the use of real-time polymerase chain reaction (PCR) testing to screen patients undergoing cardiac surgery. PCR testing has been simplified and expedited allowing results to be made available within a few hours. This allows for more rapid carrier identification. Jog et al. (2008) reported a reduction in the overall rate of SSI (3.30% to 2.22%) in addition to a significant reduction of MRSA infections after the introduction of PCR screening.

Other preventive measures in the control of MRSA in the general hospital population as well as the cardiac surgery patient, involve actions taken after MRSA carriers are identified as well as basic infection control measures. These include hand washing, gloving, gowning, masking, isolation, or cohortion of colonized and infected patients, and designating staff to care for MRSA colonized or infected patients (Trautmann et al., 2007). Comprehensive MRSA control programs are found to decrease the nosocomial spread and infection rates of MRSA.

Further recommendations for prevention of infectious disease spread in the surgical setting exist. Homa & Palfreyman (2000) list specific contact precautions to be taken for the surgical setting. These include the following: notification of the operating room of a MRSA patient prior to their transport to the department, bypass of the preoperative holding area with direct transport to the surgical suite, donning of gown and gloves by transporting personnel, removal of nonessential equipment from the surgical

suite, coverage of all remaining carts, tables, equipment and monitors, closure of all drawers and doors, minimize traffic in and out of the surgical suite during surgery, donning of gown, gloves and surgical mask by anesthesia providers, assigning two circulating nurses (one functioning as "clean" and one as "dirty"), using disposable items such as blood pressure cuffs and pulse oximetry transducers when possible, recovering patients in a post anesthesia care unit isolation room, placing all linens in isolation-marked bags, as well as all contaminated disposable equipment in red biohazard bags.

The CDC has a 12-step campaign of recommendations to prevent antimicrobial resistance among surgical patients. These were published in 2003 and correlate with findings published for the CDC by Raymond et al. (2002). They target the areas of prevention, effective diagnosis and treatment of infection, judicious antimicrobial use, and transmission prevention.

The first step involves prevention of surgical site infections. The CDC recommends monitoring and maintaining normal glycemia as well as normothermia. They also advise performing proper skin preparation using appropriate antiseptic agents and appropriate hair removal techniques when applicable. The last recommendation is to "think outside the wound" in an effort to stop surgical site infections.

Their second step involves prevention of device-related infections. Catheter use is only advised when essential, and proper insertion and care protocols must be practiced. Drains are only recommended if appropriate. Both drains and catheters are to be removed as soon as they are no longer deemed essential.

In the third step, specific attention is paid to the prevention of hospital-acquired pneumonia. Weaning from the ventilator as soon as is appropriate is a key element in

pneumonia prevention. Contamination prevention of respiratory equipment, ventilator tubing, and respiratory medications must be practiced. Elevation of the bed to 30 degrees and draining the ventilator circuit/tubing condensate away from the patient also reduces the potential for pneumococcal infection.

Step four is the first intervention in the effort to diagnose and treat infections effectively. Its goal is to target the pathogen. This is accomplished by targeting empiric antimicrobial therapies to their likely pathogens and obtaining appropriate cultures. In addition, optimizing the timing, regimen, dosing, route, and duration of the appropriate antimicrobial therapy and practicing safe source control as in the debridement or opening of wounds can also increase effectiveness of treatment.

Consulting experts is the fifth step recommended. This is necessary in the treatment of complicated wound infections. Experts to handle these problems may include infectious disease experts, clinical pharmacists, and surgeons.

The sixth step begins the focus on judicious antimicrobial use. Prophylactic antibiotics are to be initiated promptly within one hour preceding surgical incision. The appropriate antimicrobial and dosing are to be used and should be repeated during surgery if appropriate to maintain adequate blood levels. This will depend on the length of surgery and the half life of the antibiotic.

Discontinuation of prophylactic antibiotics is recommended within 24 hours in step number seven. This should be done even in the event that catheters or drains are still in place. Knowledge of the antibiogram, formulary, and patient population is the emphasis of step number eight.

Step nine states that vancomycin use should be reserved for known infections only. It is not to be used as a prophylactic treatment. Only staphylococcal infections, not colonization, should be treated with vancomycin and other antimicrobials should be considered for MRSA as appropriate.

In step ten, it is recommended that proper antisepsis is practiced when drawing blood cultures. It is advised to obtain at least one peripheral vein blood culture and avoid culturing vascular catheter tips. It is also advised to treat bacteremia, not the catheter tip.

Steps eleven and twelve are categorized under the prevention of transmission. They propose following infection control precautions, consulting infection control teams, practicing hand hygiene by setting an example by washing hands with soap and water or using an alcohol-based handrub. Operation is not recommended by providers with open sores on hands or the presence of artificial nails. Good habits by the entire surgical team are highly advised.

Muñoz et al. (2007) proposed two specific interventions that apply to the prevention of MRSA infection in the cardiac patient. They are important in that they are both potentially modifiable. These include preoperative intranasal application of mupirocin antibiotic ointment to the nares of MRSA carrier patients and intraoperative glycemic control with maintenance of blood glucose levels <150 mg/dL. Dodds Ashley et al. (2004) also support aggressive glycemic control as they found that hyperglycemia increases the risk of postoperative mediastinitis due to MRSA.

Antibiotic prophylaxis in cardiac surgery is a somewhat controversial recommendation for the prevention of SSI and consequently MRSA. Although it has been a practice for years, overuse and misuse of antibiotics has led to increased

antimicrobial resistance. Results of completed studies in this area stress the importance of screening patients for antimicrobial resistance, appropriate antibiotic use for type of surgery, and the proper duration of prophylactic antibiotics. For cardiac surgery, recommendations for antibiotic prophylaxis include mupirocin ointment to the nares of patients known to be MRSA carriers with other antibiotic prophylaxis targeted towards the most likely pathogen. Single doses of first, second, or third generation cephalosporins have been shown to be effective as antibiotic prophylaxis. No recommendations exist for prophylactic antibiotic treatment greater than 24 hours. Antibiotic use longer than 24 hours should be reserved for treatment of infection (Bucknell, Mohajeri, Low, McDonald & Hill, 2000; Källman & Örjan, 2007; Kendall, Hart, Pennefather & Russell, 2003).

Gleeson (2008) suggested the possibility of vaccine development for MRSA. He reported that a *S. aureus* capsular polysaccharide vaccine had been developed and provided protective immunity in patients receiving hemodialysis. Unfortunately, in a phase III trial, it failed to show long-term efficacy. Gleeson postulates that if a vaccine with long-term efficacy can be developed, the incidence and severity of both MRSA and MSSA may be reduced.

Summary of Preventing MRSA in Cardiac Surgery

Accountability for the spread of MRSA rests with healthcare workers. Hand hygiene remains the most important aspect of multiple infection control practices. Prompt identification of MRSA, especially in those patients who are carriers, is of equal importance. To save valuable time, the use of real-time PCR is recommended for cardiac patients undergoing surgery. The CDC has recommended a 12-step procedure to prevent

antimicrobial resistance that is well accepted, though antibiotic prophylaxis as a treatment remains a somewhat controversial recommendation.

Treatment of Postsurgical MRSA Infection in Cardiac Surgery

While MRSA infection in cardiac surgery is rare, it is often devastating. A wide variety of infections can be associated with cardiac surgery. They include superficial skin infections, vein graft donor site infections, mediastinal infections, deep sternal infections, pneumococcal infections, myocardial and endocardial infections, and bacteremia and septicemia. The implications of these infections vary as well as do treatment options.

Antimicrobials indicated for the treatment of MRSA infections are restricted. The drugs of choice are the glycopeptides such as vancomycin or teicoplanin. Addition of rifampin to vancomycin is indicated as a more effective therapy in patients not responding initially to solo vancomycin therapy. The development of potent antimicrobials active against difficult gram-positive cocci include the septogramins (quinupristin-dalfopristin), oxazolidinones (linezolid), glycopeptides (LY 333328) , everninomicin derivatives (SCH 27899) and semisynthetic tetracyclines (glycylcylines) has generated new enthusiasm. These and other investigational drugs show promise in the treatment of MRSA infections (Paradisi, Corti & Messeri, 2001).

A case study discussed by Wiper, Schmitt, Schofield and Roberts (2006) reported a patient who had undergone a patch repair of a ventricular aneurysmectomy. Two months following the surgery, the patient was diagnosed with MRSA endocarditis and persistent bacteremia. Initial treatment included vancomycin which was chosen based on sensitivity studies. The patient experienced clinical deterioration despite treatment. An abscess cavity was located behind the original site of vegetation. Therapy was switched

closure and addition of an omentum or muscle flap for the treatment of deep sternal wound infection (Sakamoto, Fukuda, Oosaka & Nakata, 2003), and omental transposition and closed irrigation for the treatment of MRSA mediastinitis (Hirata, Hatsuaoka, Amemiya, Ueno & Kosakai, 2003).

Summary

MRSA was first isolated in 1961. Since that time it has reached epidemic levels in various parts of the world. It occurs in the healthcare setting as a nosocomial infection and outside of the healthcare setting as a community-acquired infection. The causative organism of MRSA is *S. aureus* that has developed resistance to normal antimicrobial therapy. *S. aureus* is the most prevalent cause of surgical site infections. People undergoing invasive medical procedures or ones with weakened immune systems within hospitals or healthcare facilities are at increased risk of developing infections from MRSA.

MRSA is usually introduced into a healthcare facility by an infected or colonized individual who might be a patient or a healthcare worker. The most common mode of transmission of MRSA is by the hands of healthcare workers. MRSA manifests at many levels ranging from superficial skin infections to life-threatening bacteremias and septicemias. It has devastating consequences for the patients it infects and has catastrophic economic implications to the healthcare system as a result of prolonged hospitalization and costs of treatment.

The prevalence of MRSA in cardiac surgery is relatively low, but the mortality rate is alarmingly high. The associated costs of treatment for MRSA in cardiac surgery

are even more detrimental because of the length of treatment required as well as the extensive and invasive methods required.

Prevention of MRSA is the key factor in its management. Infection control measures such as contact isolation are instrumental in preventing its transmission. Simple hand washing is the most effective prevention method available. Prophylactic and judicious use of antibiotics are also indicated as prevention measures. For the cardiac surgery patient, mupirocin antibiotic ointment to the nares of MRSA colonized patients is indicated. In addition, perioperative management of diabetes mellitus through strict control of glycemic levels and maintenance of normothermia is also recommended as effective prevention measures.

Treatment options for cardiac surgery-associated MRSA infections include the use of antibiotics such as daptomycin and vancomycin with the addition of rifampicin. Other interventions include transesophageal echocardiography for the identification of the extent of infection, surgical debridement of wounds, primary closure and addition of an omentum or muscle flap and closed continuous irrigation of wounds infected with MRSA. These treatment measures add to the already staggering costs associated with the treatment of MRSA infections and add to the responsibility of the healthcare worker in the astute management of this problem.

Chapter Three

METHODOLOGY OF THE INDEPENDENT STUDY

Introduction

With the current prevalence rate of MRSA in cardiac surgery, it is important that anesthesia providers are familiar with the causative organism, susceptible hosts, modes of transmission, and prevention and treatment options of MRSA. It is also important that providers identify their specific role in preventing MRSA infections. The nurse anesthetist's knowledge and accountability of preventing MRSA may be incomplete. The goal of this project was to educate nurse anesthesia providers on the prevalence and implications of MRSA specifically in cardiac surgery in order to emphasize the importance of their role in the prevention measures for MRSA transmission and infection.

Target Audience

There were two target audiences for this project. The first was the anesthesia providers attending the NDANA spring meeting. Attendees were rural anesthesia providers from several different communities as well as students from the state university nurse anesthesia specialty program. The audience encompassed CRNAs that were new to the profession as well as experienced anesthetists. This target audience manifested variations in knowledge and accountability about MRSA in cardiac surgery. CRNAs were chosen as a target audience for this presentation because they play a vital role in the prevention of MRSA in cardiac surgery through administration of prophylactic

antibiotics, intraoperative measurement and monitoring of glycemic levels of cardiac surgical patients, and in the maintenance of intraoperative normothermia of cardiac surgical patients.

The second target audience of this project was nursing staff and anesthesia providers at a rural Midwestern hospital. This 25-bed critical access hospital serves a community of approximately 8,400 people and employs three nurse anesthetists. The anesthesia providers at this hospital provide services to three operating rooms. The population that was targeted and attended the in-service at this facility included registered nurses and CRNAs. This facility did not have a policy regarding MRSA in place at the time of the in-service. They had received information from their accrediting agency as to guidelines for the development of such a policy. There was a wide variety of knowledge about MRSA within among this target audience. The audience was chosen in order to review MRSA in general as well as for the cardiac surgery patient. This was done in order to address the importance of accountability and prevention measures to be taken in order to prevent MRSA transmission and infection.

Methodology and Procedures

The ten-minute power point presentation provided to the CRNAs at the state meeting stressed the role of the CRNA in the prevention of MRSA in cardiac surgery based on the knowledge of the causative organism, susceptible hosts, modes of transmission, and the prevention and treatment options available for MRSA. The fifty minute power point presented to the staff at the Midwestern facility provided information regarding the causative organism, susceptible hosts, modes of transmission, prevention, and treatment of MRSA, in the hospitalized as well as in the cardiac surgery patient. The

in-service was based on information gathered from the literature review conducted for this paper which included the following (a) review of the causative agent of MRSA, (b) review of susceptible hosts for MRSA, (c) review of the modes of transmission of MRSA, (d) prevention methods against the transmission of MRSA and MRSA infection, and (e) treatment options for MRSA infections. Prior to presenting the information at the state meeting and the in-service, the presentation was evaluated by a student advisor and nurse anesthesia assistant program director.

Evaluation of the Project

At the end of the in-service, participants were asked to anonymously evaluate the educator and educational session. The survey results showed that the information presented was relevant to their practices and presented in a well organized and easy to understand manner. The survey also revealed that the participants at the in-service planned to apply the concepts presented daily in their work by being more observant of hand washing and overall preventative measures such as gloves, gowning, and masks. They felt that the in-service improved their overall awareness and that the information needed to be heard by more people. The staff at the Midwestern facility requested that the information be presented again in conjunction with the introduction of their MRSA policy that is being developed. The participants were also asked to include any suggestions they might have for course improvement.

Summary

This paper provides a review of MRSA including its implications in the cardiac surgery patient as well as preventive measures that can be taken by the nurse anesthetist as well as other healthcare providers. Germ theory as postulated by Louis Pasteur was

utilized as the theoretical framework for the paper as it deals with the identification of a causative organism of infection, susceptible hosts, and modes of transmission which are key factors in developing prevention and treatment modalities for infections. This project was designed to educate nurse anesthetists and other healthcare providers in the factors involved in germ theory in order to apply prevention methods as well as treatment methods for MRSA. The author believes that Pasteur's germ theory was an appropriate framework for this project.

Chapter Four

DISCUSSION

Introduction

The purpose of this independent study was to educate anesthesia providers on the causative organism, susceptible hosts, and modes of transmission of MRSA, especially in the cardiac surgery patient. The goal of the project was that this information would be utilized in their practices to prevent the transmission of MRSA and development of MRSA infections as well as to be aware of various treatment modalities for MRSA infections in cardiac surgery. Utilization of this information by clinicians may result in increased accountability for prevention of MRSA, improved patient outcomes and lower rates of MRSA transmission and infection in cardiac surgery patients.

Application of the Germ Theory to MRSA

Pasteur's Germ Theory can be applied to MRSA. The causative organism identified was methicillin resistant *S. aureus.* The susceptible organism most identified in this project was the patient undergoing cardiac surgery. They are at increased risk of contracting MRSA because they are undergoing invasive surgery, are admitted to the hospital setting for an extended period of time, have invasive medical devices such as central lines and endotracheal tubes, and often have comorbidities that increase their risk of infection. Modes of transmission in this group of patients include the most common which is by the hands of healthcare workers. Another common mode of transmission in

this group is through the spread of MRSA from the nares of colonized patients directly to the sternum in cardiac surgery.

According to the studies reviewed for this project, the most effective way to control the growing problem of MRSA is through prevention methods. The germ theory emphasizes that this can be successfully implemented once the other factors are identified. Contact isolation measures have been found to be the most valuable method of preventing MRSA.

The germ theory also includes the treatment of infections. Treatment methods for MRSA include the use of various antibiotics. This remains one of the areas in need of more research including research directed at the infectious disease process of MRSA as well as designing antibiotics effective in the treatment of resistant strains of *S.aureus.*

Implications for Nursing

Nursing Practice

MRSA is a problem with growing concern worldwide. Since its emergence in the 1960s it has reached epidemic proportions in various countries. It is an infectious process with little hope for an absolute cure. In the case of a cardiac surgery patient, while the incidence rate of MRSA is moderately low, the mortality rate is staggeringly high.

The most effective action in reducing the rate of MRSA infections is through prevention. The nurse anesthetist has the opportunity to play a key role in the prevention of MRSA in the cardiac surgery patient. It is imperative that the nurse anesthetist is familiar with the infectious process associated with MRSA, especially in the area of prevention measures. The information described in this paper and presented during the two in-services helped to educate providers about the infectious process of MRSA in

cardiac surgery, giving specific prevention measures to be exercised by the nurse anesthetist. Information provided in this paper will help to increase accountability of the nurse anesthetist in managing a cardiac surgery patient with increased risk of becoming colonized or infected with MRSA. The ultimate goal of this paper was to improve patient safety and to decrease adverse outcomes associated with MRSA.

Nursing Education

The field of medicine is constantly changing with improvements in delivery of care including the development of new medications. However, antibiotic development for *S. aureus* is not expected to advance at the same pace as the development of antibiotic resistance by the organism. For this reason, it is imperative that the nurse anesthetist make every effort to prevent MRSA. The initial step in prevention is to be knowledgeable about the causative organism, susceptible hosts, and modes of transmission in order to prevent and when necessary, treat MRSA. With continued studies on the mechanism of resistance development and the most effective measures to prevent MRSA, including cost effectiveness, the nurse anesthetist must expand his or her knowledge of this problem and take accountability for the role to play in prevention. Nurse anesthetists must be familiar with specific measures they can take in the surgical setting to prevent MRSA. Information provided in this paper may prove beneficial to nurse anesthetists with varying degrees of experience.

Nursing Policy

Cardiac surgery patients susceptible to MRSA colonization or infection will continue to be a population of focus in prevention efforts of anesthesia providers. Therefore, it is imperative that anesthesia providers are knowledgeable in how to care for this patient population. Most hospitals have policies regarding MRSA prevention for their general inpatient population. This paper provides additional knowledge regarding MRSA prevention strategies for the cardiac surgery patient and establishes the basis for a policy with specific considerations for cardiac surgery patients. Information gathered from the literature review could assist anesthesia providers in predicting patients at high risk for developing MRSA and in preventing MRSA transmission and colonization or infection of the cardiac surgery patient. Improvement to existing policies of MRSA would augment patient safety and decrease adverse outcomes.

Recommendations for Further Study

Nurse anesthetists are in a position to play a vital role in the prevention of MRSA transmission. To date, several strains of MRSA have been isolated. The mechanism of antibiotic resistance has been studied and as a result, some clues are being uncovered. There have also been a number of risk factors identified for MRSA colonization and infection in the cardiac surgical patient population. In addition, there have also been specific prevention measures proven to be effective in reducing infection rates in MRSA-susceptible patients. However, further studies utilizing larger populations and other populations are recommended. Additional research in the areas of antimicrobial resistance, cost-effectiveness of prevention measures, antibiotic development, and other possible prevention measures is also needed. With more in-depth research findings and

diligent prevention practice, MRSA may be better understood, contained more effectively, and perhaps, even eradicated.

Summary

This paper creates an awareness of the increasing problem associated with MRSA infection in the cardiac surgical patient. Consequences of inadequate knowledge and implementation of prevention strategies of MRSA in cardiac surgery patients can be devastating and even fatal. Anesthesia providers must be knowledgeable about these prevention strategies and ready to accept responsibility for providing patient care that deters the occurrence of infection. This paper contains information reviewed from the current literature and serves as a basic guide to providing safe, effective care to the cardiac surgical patient population.

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