

Surgical Site Infection in the Elderly Population

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Surgical site infections (SSIs) account for 11% of nosocomial infections among older patients. This report reviews the available data and presents medical and surgical perspectives on the epidemiology, outcomes, and prevention of SSI in the elderly population. The risk for SSI does not seem to increase after the age of 65 years. Several risk factors for SSI are similar among elderly patients and younger patients, but financial factors and factors related to health services may differ between the groups. The clinical presentation of infection and the pathogens that cause infection are similar among elderly patients and younger patients. However, the mortality rate, the duration of hospitalization, and the costs associated with hospital care are greater for elderly patients with SSI than for younger patients with SSI. Several modalities for SSI prevention have been well studied in the general surgical population but have not been specifically evaluated in the elderly surgical population. Insights and opinions pertaining to modalities for SSI prevention in the elderly population and areas of import for future research are discussed.

Each year in the United States, 5 common operations are performed for >1 million patients aged ≥ 65 years [1]. Furthermore, the percentage of operations performed for patients aged ≥ 65 years increased from 19% of all surgical operations in 1980 to 43% of all surgical operations in 1998 [1]. The number of elderly patients who undergo operative procedures in the United States will increase in the future, because the size of the population that is aged ≥ 65 years is projected to increase from 35 million to 71 million by 2030 [2, 3].

Although surgical procedures often benefit elderly patients, the procedures may be complicated by surgical site infection (SSI) [4]. SSI is a nosocomial infection that is associated with significant attributable mortality, morbidity, and costs. SSI impacts health care professionals in many fields; for instance, surgeons encounter SSI as a surgical complication, infectious diseases specialists often are involved in the treatment of SSI, and generalists provide care with regard to the patient's other medical, psychosocial, and functional issues. Despite a rapidly aging surgical population and the frequency with which SSI occurs, there is a dearth of data pertaining to SSI in the elderly population. This report offers perspectives from the medical

and surgical fields on SSI in the elderly population and reviews the epidemiology of and the risk factors and outcomes for SSI in elderly patients, as well as methods for SSI prevention. Areas of future research also are discussed.

THE MEDICAL PERSPECTIVE

Risk factors. SSIs account for 11% of all nosocomial infections in patients aged ≥ 65 years [5]. Although the risk factors for SSI in the general population have been well studied, few studies have adequately addressed risk factors for SSI in the elderly population.

A recent study examined risk factors for SSI among patients who were aged >64 years; the study included 569 patients with SSI and 589 control subjects [6]. The procedures most commonly performed for the study subjects were cardiothoracic procedures (31.5% of all procedures) and orthopedic procedures (22.2% of all procedures). Several variables that were identified as risk factors in the elderly population had been previously identified as risk factors for SSI in the general population, including comorbid conditions and perioperative factors. The following 3 variables that had not been previously identified as risk factors in the general population were identified as being independently associated with a decreased risk for SSI in the elderly population: being >75 years of age, having private health care insurance, and having had surgery performed on the same day that admission to the hospital occurred. The protective effect of being >75 years of age might

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relate to a surgical selection bias or a “hardy survivor” effect, private health care insurance might be a marker for patients who are of relatively high socioeconomic status, and same-day surgery might be a marker for healthy, functional elderly surgical patients. These associations should be further explored, as should the associations of impaired basic and instrumental activities of daily living, cognitive impairment, frailty, use of multiple medications, nutritional status, and residence in a nursing home with the risk of SSI among older patients.

Increasing age as a risk factor for SSI. Although the risk for many infectious diseases increases with age, the association between increasing age and risk of SSI is unclear. Investigators who have studied this association have reported conflicting results. Several researchers have concluded that increased age was associated with an increased risk for SSI [7–9], but others have concluded that increased age was not an independent risk factor for SSI [10–12]. In fact, in some studies, advanced age was associated with a decreased risk, particularly for SSI that was diagnosed after discharge of a patient from a hospital [13, 14]. Some studies were limited by small sample size [10, 11, 13], were performed at a single institution [10, 11, 13], and/or examined the risk for SSI associated with only a single type of surgery [7, 11].

A recent study that included 11 hospitals and >144,000 separate surgical procedures reported a complex relationship between the risk for SSI and increasing age [15]. An increase in risk was noted until the age of 65 years. After the age of 65 years, the risk for SSI decreased. The latter finding raises interesting questions. Do older patients who are at increased risk for SSI (e.g., frail patients with multiple comorbid conditions) undergo surgery less frequently than do their healthier peers—possibly because clinicians judged their risk for adverse clinical outcomes to be too high? Do very old patients who undergo surgery have a decreased risk for SSI because of the “hardy survivor” effect (in other words, persons who survive to much older ages may have a genetic makeup that enables them to better withstand threats to health, compared with some middle-aged persons) [16, 17]? Whether a combination of these effects results in a relatively healthy elderly surgical population requires further research.

Outcomes. SSI has been shown to adversely affect mortality, duration of hospitalization, and costs associated with hospitalization [18, 19], but few studies have addressed these outcomes in the elderly population. This is surprising, because elderly patients with infection are more likely to have adverse outcomes, compared with younger patients [20, 21], and persons aged ≥ 65 years have health care costs that are 3–5-fold higher per capita than those of younger persons [22].

One recent study demonstrated that, compared with uninfected elderly patients, elderly patients with SSI due to *Staphylococcus aureus* were >5 times more likely to die, accrued >2-

fold more days of hospitalization postoperatively, and had a 2-fold increase in costs associated with hospitalization (mean attributable costs per episode of SSI, \$41,117). Compared with younger patients with SSI due to *S. aureus*, elderly patients with SSI due to *S. aureus* were 3 times more likely to die, and they accrued more days of hospitalization (median days, 9 days vs. 13 days; $P = .001$) and higher hospitalization costs (median cost, \$45,767 vs. \$85,658; $P < .001$) [23].

An outcome of great importance that is affected by SSI is functional status. Older adults prize their self-sufficiency, and they rank independent functioning as a key component of good quality of life. Important elements of independence include the ability to perform basic activities of daily living (e.g., bathing and dressing), instrumental activities of daily living (e.g., traveling and shopping), and advanced activities of daily living (e.g., work and leisure activities), as well as retain intact cognitive function (e.g., memory and reasoning). In a recent study, there was a decline in some elements of functional status among adults of all ages after development of SSI [24]. However, the impact of SSI on the functional status of elderly patients has not been adequately studied. SSI may have a negative impact on the functional status of elderly patients for several reasons. The stress of infection may exacerbate a preexisting disability, and SSI may worsen age- or disease-related conditions that influence adequate functioning. Future studies should focus on the impact of SSI on functional status, so that interventions that can better support elderly patients with SSI can be implemented.

Because elderly patients with SSI are at increased risk for adverse clinical and fiscal events, interventions should be designed to improve the outcomes for elderly patients with SSI. In randomized, controlled trials, the multidisciplinary geriatric evaluation and management health services model has been shown to improve the care of frail, elderly patients with complex conditions in inpatient and outpatient settings. The outcomes that showed the most consistent improvements included the ability to perform activities of daily living and health-related quality of life [25, 26]. The geriatric evaluation and management model of care might help older patients with SSI who are frail and/or have complicated infections to improve functional status and health-related quality of life.

Prevention. There are several proven modalities to prevent SSI in the general population, but few modalities have been specifically studied in the elderly population. However, because of the increased frequency of comorbid conditions, immune senescence, and frailty among elderly persons, prevention modalities should be implemented rigorously for older patients who undergo surgery. In some instances, elderly patients might be at increased risk for a particular type of SSI, and, thus, might represent a target group for focused intervention. At our institution (Duke University Medical Center, Durham, NC), postoperative mediastinitis due to methicillin-resistant *S. aureus*

(MRSA) occurred in >1% of patients who underwent cardiothoracic surgery. Age of >70 years was identified as an independent predictor for mediastinitis due to MRSA (OR, 3.43) [27]. At our institution, elderly patients represented an appropriate group for interventions to prevent mediastinitis due to MRSA.

Preoperative antibiotic prophylaxis is an effective method for the prevention of SSI. To maximize the protective effect, antibiotics should be dosed appropriately, regardless of the age of the patients, and should be redosed during long surgical procedures. If, for a particular procedure, resistant pathogens that cause SSI (such as MRSA) are common among elderly patients, consideration should be given toward changing the antibiotic prophylaxis for elderly surgical patients to include an agent that is active against the pathogen. At our institution, because of increased rates of mediastinitis due to MRSA among elderly patients, preoperative prophylaxis regimens were changed to include vancomycin and rifampin (in addition to cefuroxime) for patients aged >70 years who underwent cardiothoracic surgery. This intervention helped to significantly decrease the rate of mediastinitis due to MRSA [28].

Aggressive control of blood glucose levels (i.e., keeping serum levels at <200 mg/dL) during the postoperative period is critical to prevent SSI after cardiothoracic surgery [29, 30]. Because the frequency of diabetes increases with age, physicians should be particularly vigilant with regard to the screening of elderly patients for diabetes before surgery, and attempts should be made to aggressively control hyperglycemia during the immediate postoperative period.

Summary. The surgical population in the United States is aging rapidly. SSI adversely impacts the clinical and fiscal outcomes of elderly patients. The association between age and SSI is complex, but it appears that patients who are aged ≥ 65 years have a decreased risk for SSI. Thus, the risk for SSI should not necessarily be a deterrent to performing surgery for the elderly population. Although some unique risk factors for SSI have been identified among elderly patients, additional research that addresses risk factors and modalities for SSI prevention in diverse populations is needed. Interventions focusing on SSI prevention and the improved management of elderly patients with SSI might improve mortality, health care costs, quality of life, and functional status for elderly surgical patients.

THE SURGICAL PERSPECTIVE

Although the rates of complications associated with surgery are frequently higher among elderly patients, few age-specific changes are made to prevent such morbidity. This lack of age-specific prophylaxis is probably related to the fact that the underlying risk factor—chronological age—is inherently immutable. However, aging is associated with medical conditions that can be modified to lessen the frequency of associated com-

plications, including SSI. There are several steps that might allow the surgeon to decrease the SSI rate to a minimum, even for the elderly patient. In this section, we review age-associated risk factors, differences in outcomes, and preventive measures.

Risk factors. Chronological age itself has occasionally been identified as a risk factor for SSI [7, 11, 31], yet the causes of this increased rate of complications require elucidation. Age-related risk factors can be divided into the following 2 categories: (1) factors associated with senescence itself and (2) diseases that predispose patients to infection and are found with increased prevalence among elderly patients.

Any clinically apparent infection occurs when the normal balance between host defense and density of microorganism contamination is tipped in the favor of microorganisms. In considering SSI, there is little reason to believe that the degree of wound contamination is greater in elderly patients. Thus, the increased incidence of SSI among older patients may logically be attributed to a diminished host response. This theory is supported by the increased incidence of other infectious diseases in the elderly population. Various mechanisms of altered host response have been reported elsewhere [32, 33]. However, one-to-one correlation between any particular immunological deficit and SSI has not been described.

Many diseases that are associated with increased risk for SSI are more commonly found in the elderly population than in the younger population. Diabetes mellitus is more prevalent with age and is associated with risk of infection. In addition, diabetes is associated with peripheral vascular disease and tissue ischemia. Atherosclerotic peripheral vascular disease similarly predisposes patients to chronic tissue ischemia and an increased risk for SSI. Malignancy is more common among older patients who are undergoing operations than among younger patients undergoing operations, but the association between malignancy and SSI is unclear. Nonetheless, it is biologically plausible that any immunologic surveillance deficit associated with enhanced tumor growth could also be associated with an increased risk for infection.

Several other global conditions are associated both with advanced age and with infectious surgical complications. Malnutrition and chronic hypoalbuminemia are associated with surgical complications [34, 35], including SSI, and advanced age is associated with poor nutritional intake and malnutrition. Chronic diseases, including higher-stage malignancy, can also be associated with hypoalbuminemia, advanced age, and increased numbers of surgical complications. The impact of cardiac disease on rates of SSI is unclear, although inadequate cardiac output can be related to ischemia at the level of the skin. Finally, loss of fat may make elderly patients more prone to hypothermia, a risk factor for SSI [36].

Outcomes. Although SSI might be diagnosed more frequently among elderly patients than among younger patients,

it is probably more relevant to consider differences in outcomes, differences in patient characteristics, or differences in responses to infection. It has been proposed that older patients are less likely to mount a robust immune response, such as fever or leukocytosis, which leads to a more subtle presentation and a delay in diagnosis. This hypothesis, however, is difficult to prove. We recently reviewed 1913 consecutive episodes of infection (occurring at all anatomic sites) in our inpatient general surgery population [9]. As expected, the crude in-hospital mortality rate was significantly higher among elderly patients than among younger patients (22% vs. 8%), as was the prevalence of significant comorbidities. Surprisingly, when we compared patients aged ≥ 70 years with patients aged < 70 years, we found similar scores for the Acute Physiology component of the APACHE II (mean score \pm SD, 8.2 ± 0.3 vs. 7.8 ± 0.2 ; $P = .2$) and similar maximum WBC counts (mean count \pm SD, $14.6 \pm 0.4 \times 10^3$ cells/mL vs. $14.1 \pm 0.2 \times 10^3$ cells/mL; $P = .4$). Despite these similarities, it is still possible that elderly patients have blunted host responses and physiologic responses that are similar to those of younger patients and that may indicate a relatively greater infectious burden.

We recently analyzed 928 episodes of SSI occurring in patients who subsequently received inpatient treatment at our hospital, specifically with reference to age-related differences (table 1). Although the APACHE II scores were higher for patients aged ≥ 65 years than for younger patients, this difference generally represented age and underlying disease factors, because the scores for the Acute Physiology component were similar between patients aged ≥ 70 years and patients aged < 70 years. There were no differences in WBC counts, maximum temperatures, or length of time from operation to diagnosis of SSI. The pathogens that caused the infections were also similar between the elderly population and the younger population; duration of antibiotic treatment was shorter in the elderly pop-

ulation, but the crude in-hospital mortality rate was almost 3 times higher (table 2).

These poorer outcomes for older patients suggest a need for increased vigilance and earlier intervention to reduce morbidity and mortality. On the other hand, surgeons should not alter their choice of antibiotic treatment for the elderly population, because the pathogens that cause infection are similar to those seen to cause infection in younger patients.

Prevention. Although prevention modalities have not been specifically studied in the elderly population, several modalities that have been investigated in the general population focus on conditions that are relatively common and severe among elderly patients. Attempts to decrease the SSI rate must focus on mutable risk factors. Interventions can be divided into the following 2 categories: interventions that are performed in the perioperative period and interventions that are implemented before an elective procedure is performed.

Because elderly patients may have an increased risk for skin ischemia or hypoxemia, maintenance of core body temperature, adequate oxygenation, and heightened attention to tissue handling and hemostasis must be emphasized. Kurz et al. [36] demonstrated a decrease in the rate of SSI from 19% to 6% among patients who underwent colorectal surgery and whose treatment involved aggressive warming and maintenance of normothermia. Increasing age was also independently associated with infection, although it is difficult to determine whether warming was associated with an even greater benefit among elderly patients. Mechanisms that have been postulated for these effects include alterations in drug metabolism, host defense, and coagulopathy [37].

Systemic oxygenation is necessary to maintain adequate levels of tissue oxygenation at the skin level. Aging, itself, may lead to decreased levels of oxygen in skin tissue [38]. Greif et al. [39] demonstrated a reduction in the rate of SSI (from 11.2%

Table 1. Characteristics of and test results for inpatients in the general surgical population who were treated for surgical site infection (SSI) at the University of Virginia Hospital, 1997–2003.

Variable	All patients (n = 928)	Patients aged <65 years (n = 689)	Patients aged ≥ 65 years (n = 239)
APACHE II score	9.6 \pm 0.2	8.9 \pm 0.2	11.7 \pm 0.4 ^a
Acute Physiology score	5.8 \pm 0.2	5.9 \pm 0.2	5.3 \pm 0.3
Age, years	52.8 \pm 0.5	46.0 \pm 0.4	72.5 \pm 0.4 ^a
No. male/no. female	494/434	376/313	118/121
WBC count, $\times 10^3$ cells/mL	13.2 \pm 0.2	13.3 \pm 0.3	12.6 \pm 0.4
T _{max} in °C	37.9 \pm 0.1	37.9 \pm 0.1	37.7 \pm 0.1
Time from operation to start of treatment for SSI, days	15.0 \pm 1.0	15.5 \pm 1.1	13.7 \pm 1.9

NOTE. All data are mean \pm SD, unless otherwise indicated. T_{max}, maximum temperature within 24 h of diagnosis of infection.

^a $P < .001$ for the difference between age groups (by Student's *t* test).

Table 2. Pathogens and outcomes for inpatients in the general surgical population who were treated for surgical site infection at the University of Virginia Hospital, 1997–2003.

Finding	All patients (n = 928)	Patients aged <65 years (n = 689)	Patients aged ≥65 years (n = 239)
Patients who had cultures performed, no.	371	293	78
Total isolates, no.	410	323	87
Pathogen(s) identified, no. (%) of isolates			
<i>Enterococcus</i> spp.	74 (20)	54 (18)	20 (26)
<i>Staphylococcus aureus</i>	63 (17)	52 (18)	11 (14)
<i>Escherichia coli</i>	37 (10)	28 (10)	9 (12)
<i>Pseudomonas aeruginosa</i>	36 (10)	25 (9)	11 (14)
<i>Candida</i> spp.	62 (17)	44 (15)	18 (23)
All other isolates	138 (37)	120 (41)	18 (23)
Outcome			
Length of hospitalization ^a , mean days ± SD	12.6 ± 0.7	12.8 ± 0.8	12.3 ± 1.0
Duration of antibiotic treatment, mean days ± SD	10.8 ± 0.3	11.1 ± 0.3	9.9 ± 0.6 ^b
Died in the hospital, no. (%) of patients	60 (6.5)	30 (4.4)	30 (12.6) ^c

^a After initiation of treatment.

^b *P* < .05 for the difference between age groups (by Student's *t* test).

^c *P* < .0001 for the difference between age groups (by χ^2 analysis).

to 5.2%) among patients who were maintained on supranormal oxygen levels. On the other hand, Pryor et al. [40] demonstrated the opposite outcome, in which the rate of SSI increased (from 11.3% to 25.0%) with the addition of supplemental oxygen. Although the effect of supranormal oxygenation remains unclear, frank hypoxia should be rigorously avoided.

Because the dermis thins with age, the skin of the elderly patient is fragile. Although surgeons must always maintain a basic level of respect for tissue, special attention, including gentle technique and a rigorous attempt to achieve complete hemostasis, should be paid to the handling and closure of the skin of older patients. Complete hemostasis may be difficult to achieve because of the use of coumadin, aspirin, or other anticoagulants.

If a procedure is elective and is scheduled to occur weeks in the future, other potential interventions can be used. Although malnutrition and hypoalbuminemia become more prevalent with age, the results of trials that attempted to decrease the number of infectious complications by giving enhanced nutrition in the preoperative period were mixed. For example, total parenteral nutrition given 7–15 days before elective operations were performed was shown to decrease the number of noninfectious complications but not the number of infectious complications [41]. On the other hand, for patients with cancer, perioperative enteral immunonutrition can reduce the number of postoperative complications, including SSI [42, 43], which suggests that enteral immunonutrition should be considered for malnourished elderly patients who are being prepared to undergo resection of a gastrointestinal malignancy.

Although aggressive glucose control in the postoperative pe-

riod has been associated with decreased rates of SSI [30], much less data is available to suggest whether this intervention also decreases infectious risks if it is implemented before surgery. Nonetheless, it is quite plausible that better glucose control before an elective procedure is performed would be beneficial, and this should be encouraged in the treatment of elderly patients with diabetes. Smoking cessation must also be encouraged among elderly patients, because smoking is associated with development of SSI, and cessation of smoking has been demonstrated in humans to decrease rates of SSI [44].

Summary. Elderly patients with SSI have worse outcomes than do younger patients. The difference is probably related to diminished host response, although we are far, in terms of the available technology, from being able to pinpoint (and counteract) any specific deficit. Although chronological age cannot be changed, other risk factors that are commonly present among older patients can be modified. Certain interventions are applicable to all surgical patients. Pathophysiologic decreases in skin oxygenation and blood flow can be partially reversed through the provision of adequate levels of oxygen and the maintenance of normothermia throughout the procedure, and gentle surgical technique must be practiced to counteract the increased fragility of the dermis of elderly patients. If sufficient time exists before a scheduled procedure is to be performed, several “subacute” interventions can be applied, including nutritional supplementation, more aggressive glucose control, and smoking cessation. Future researchers should study methods for the prevention of SSI specifically in the elderly population. Only through interventions at multiple types of health care systems and anatomic sites can the rate of

SSI among elderly patients be reduced to the physiological minimum possible.

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