Incidence and risk factors of sternal wound infection at site of incision after open-heart surgery

• **Objective:** To identify the incidence of sternal wound infection and the risk factors before, during and after open-heart surgery in an Iranian critical care unit.
• **Method:** A descriptive, analytic study investigating all open-heart surgery patients from March 2010 to March 2011, in terms of the incidence of sternal wound infection and the risk factors before, during, and after surgery. Patients were examined for signs of infection at the site of surgical incision on presentation to the ward, daily during their stay, and on discharge. The same investigator reviewed all wounds, every day.
• **Results:** The incidence of sternal wound infection was found to be 10%. Multivariate regression analysis identified the following risk factors: diabetes (OR: 0.439; 95%CI: 0.21–0.95; p=0.04), age (OR: 1.033; 95%CI: 1.003–1.064; p=0.03), hyperlipidaemia (OR: 1.008; 95%CI: 1.005–1.011; p < 0.001), history of respiratory disorders ([COPD] OR: 2.952; 95%CI: 1.3–6.4; p=0.007), female gender (OR: 2.06; 95%CI: 1.40–3.03; p < 0.008), and history of addiction to opiates (OR: 2.33; 95%CI: 1.56–3.49; p < 0.006).
• **Conclusion:** This study found a high rate of surgical sternal wound infection in open-heart surgery patients in an Iranian critical care unit, suggesting that the medical and care-giving team in the cardiac intensive care unit need further education.
• **Declaration of interest:** There were no external sources of funding for this study. The authors have no conflicts of interest to declare.

open-heart surgery; sternal wound infection; incidence; risk factors

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Coronary heart disease is the primary cause of mortality in patients with heart disease.[1] One of the most frequent methods for treatment of coronary heart disease is bypass surgery of coronary arteries; however, such surgeries can lead to a number of complications.[2] One of the most significant complications of such surgeries is sternal wound infection, where there is a surgical incision on the thorax.

Sternal wound infections can be either superficial or deep, at the site of the surgical incision. Previous studies have reported mortality rates of 8–25%, due to wound infection at the site of surgical incision in open-heart surgery patients.[3,4] Tortoriello et al. reported that, in children who had undergone heart surgery between 1987 and 2002, sternal wound infection was a major reason for mortality.[5]

Studies on the incidence of wound infection at the site of surgical incision in open-heart surgery patients have reported a variety of results. The incidence of re-operation for deep sternal wound infection in the UK is reported as 0.6%, with a further 0.5% having a sterile sternal re-suture.[6] Softah et al. reported a 4.25% rate for such infections,[7] also reporting that *Staphylococcus aureus* and *Staphylococcus epidermidis* were the two main bacteria responsible for such infections.[7] Nakano et al. surveyed risk factors for wound infection after off-pump coronary artery bypass grafting, reporting an incidence of sternal wound infection of 6.5%.[8] In another study, Popov et al. reported that treatment of deep sternal wound infections, due to Gram-positive organisms, with a daptomycin-containing antibiotic regimen was safe, effective and led to an immediate improvement of local wound conditions.[9]

Studies also reported that negative pressure wound therapy (NPWT) is effective in prevention of sternal wound infections.[10] There are a number of suggestions for possible mechanisms of the preventive action of NPWT, including improving the local blood flow, removing fluids and components in these fluids, helping keep the incision edges together, protecting the wound from external contamination and promoting incision healing.[11]

In another study, Guaragna et al. reported that obesity is a risk factor for sternal wound infection in patients undergoing heart surgery.[12] They found that, in obese patients, the levels of antibiotics in the tissues utilised during prophylaxis in the preoperative period were inadequate, as these patients present with a greater volume. They also reported that the preoperational preparation of the skin of obese patients may be more difficult, or even inadequate.[12]

A retrospective study by Diez et al. supported the findings of Guargagna et al., reporting that obesity and chronic obstructive pulmonary disease can increase the risk of such infections.[13] In contrast, Lepelletier et al. reported that obesity and chronic

obstructive pulmonary disease (COPD) do not have any effect on the rate of wound infection.[14] They reported that factors such as heart transplantation, secondary surgery to cure tamponade after the primary surgery, and usage of the internal mammary artery for graft are all among the factors associated with wound infection.[14] In a study in the UK, Lu et al. determined factors such as bilateral internal mammary arteries, increasing number of grafts, re-exploration for bleeding, and increased duration of mechanical ventilation as risk factor for sternal wound infection.[15]

Sternal wound infection at the site of surgical incision incurs high costs and mortality in open-heart surgery patients;[16,17] therefore, it is important to prevent such infections. For this purpose, we first need to know the rate and the risk factors of such infections. Considering the diversities in the previous reports in this regard, the present study aims to determine the rate and the risk factors of wound infection in the site of surgical incision (deep and superficial infection) in the open-heart surgery patients.

Methods

This descriptive, analytic study was conducted in the cardiac intensive care unit in Shafa Hospital, Iran. Three specialist cardiology surgeons work in this ward, with 13 cardiac intensive care unit beds. All open-heart surgery is performed in a three-bed operation room, near the cardiac intensive care unit, which is specially designed for these surgeries.

All patients who underwent open-heart surgery from March 2010 to March 2011 were assessed for inclusion in the research. The inclusion criteria for the study were:

- Surgical incision on chest
- Lack of a recent history of fever and infection
- Lack of any background disease affecting the immune system.

Ethical approval was obtained from the research centre of the Kerman University of Medical Sciences. Written consent was obtained from each participant prior to their heart surgery. Before obtaining the patients' consent, the research was comprehensively described to each patient, and they were assured that the information collected from them would be used only for research purposes.

Data were collected from all three surgeons. Wound infections (deep and superficial) were diagnosed by the heart surgeon and the infectious medicine specialist of the hospital. Infection was defined as involving the fascia or deeper, with at least one of the following:[18]

- Evidence of infection seen at re-operation
- Spontaneous dehiscence
- Positive culture of mediastinal fluid and/or positive blood culture
- Chest pain with sternal instability and temperature higher than 38°C.

Patients' were examined for signs of infection at the site of surgical incision on presentation to the ward, daily during their stay, and on discharge. The same investigator reviewed all wounds, every day.

In the institute, nurses are responsible for postoperative wound management. After admission to cardiac intensive care units, nurses assess the patient's wound status. Wound cleaning and dressing change are performed every 8 hours, with use of sterile techniques. Sterile gauze and sodium chloride 0.09% are used for wound cleaning.

Risk factors

In order to determine the risk factors of infection in open-heart surgery patients, a checklist of potential risk factors for all patients was prepared, based on the existing literature and our own personal experience. This checklist include factors such as age, sex, history of cardiac surgery, high blood pressure, diabetes, hyperlipidaemia, history of addiction, COPD, duration of pump usage during surgery, and duration of stay in the cardiac intensive care unit.

Demographic information of the patients was recorded from their files. After admission to the cardiac intensive care unit, the patient's dressing was removed after 48–72 hours, depending on the status of the patient.

Statistical analysis

Descriptive statistics, including mean, range and standard deviation (SD), were calculated for the demographic and clinical characteristics of the patients. Risk factors were analysed using the Chi-squared test and independent samples Student's t-test for qualitative and quantitative variables, respectively. The relative importance of these items was then studied by multivariate regression analysis. All statistical analyses were performed using SPSS software (v18.0; PASW Statistics).

Results

In total 520 patients underwent open-heart surgery in our hospital during the 1-year period of the study (Table 1). Of them, 68% were male (n=351) and 32% were female (n=169). Mean age of the patients was 57.5±11.1 years (18–83 years). Approximately 98% (n=508) of the studied patients had a history of heart infarcts. Mean duration of cardiac intensive care unit stay was 2.9±1.5 days. Almost 67.3% of the patients reported a history of high blood pressure.

Ten per cent (n=52) of the patients exhibited the signs of infection in the site of surgical incision. Mean age of the patients who were suffering wound infection was 58.8±9.8 years. The multivariate regression analysis identified the following risk factors:

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- Diabetes (OR: 0.439; 95%CI: 0.21–0.95; p=0.04)
- Age (OR: 1.033; 95%CI: 1.003–1.064; p=0.03)
- Hyperlipidaemia (total cholesterol more than 200mg/dl and triglycerides more than 150mg/dl, obtained from venous blood sample; OR: 1.008; 95%CI: 1.005–1.011; p<0.001)
- History of respiratory disorders ([COPD] OR: 2.952; 95%CI: 1.3–6.4; p=0.007)
- Female gender (OR: 2.06; 95%CI: 1.40–3.03; p 0.008)
- History of addiction to opiates (OR: 2.33; 95%CI: 1.56–3.49; p<0.006).

Factors such as history of cardiac surgery, history of high blood pressure, duration of pump usage during surgery, and duration of stay in cardiac intensive care unit did not display any correlation with the incidence of sternal wound infection.

Table 1. Demographics and general medical background of patients treated

No. of patients	520
Gender (n)	
• Male	351 (68%)
• Female	169 (32%)
Age (years)	57.5 ± 11.1 (18–83)
Duration of cardiac intensive care unit stay (days)	2.9 ± 1.5
Comorbidities (n)	
• Diabetes	411 (79%)
• Hypertension	350 (67%)
• Hyperllpaedimia	366 (70%)
• Heart infarcts	508 (98%)

Results given as n (%), unless otherwise specified

Discussion

Surgical-wound infections are one of the most common hospital-acquired infections;[19] they may complicate illness, lead to anxiety, increase patient's discomfort and could even result in death.[20] Similarly, open-heart surgery is one of the most common methods of treatment for coronary arterial disease in Iran. Sternal wound infection can affect the quality of this kind of surgery, and can increase the mortality of patients. Surgical site infection is a strong predictor for poor long-term survival after coronary artery bypass surgery;[21] moreover, infection of surgical wound incurs a lot of costs for these patients and for the medical system.

Our results found the incidence of wound infection in the site of surgical incision to be 10%, which is higher than that of other studies. Graf et al. investigated the effect of precise, interdisciplinary infection control measures on the incidence of deep sternal surgical site infections, reporting an initial incidence of 3.6%, reducing to 1.8% after implementation of the measures.[19] In another study, Garey et al. reported a rate of sternal wound infection of 5.9%.[22]

In Western Europe, especially the UK, research has shown an average rate of sternal wound infection of about 0.5%.[6] Published studies have given conflicting results regarding incidence of wound infection at the site of surgical incision, likely due to differences in the methodologies used. Previous studies have mostly been retrospective, analysing existing hospital documentation to estimate incidence of wound infection; this method can decrease the precision of results.

Our incidence also includes both deep and superficial infections, which could account for the difference compared with other studies, which usually assessed either deep or superficial infections, not both. Additionally, there can be variations in incidence according to the institution where the surgical procedure was performed, as well as its geographic location.

In Iran, there are no specialist wound-care personnel (either physicians or nurses). The duty of care for wounds of all aetiologies is on the nurses, who do not have specific training in management of wounds, or of the sites of surgical incisions.[23] Furthermore, surgeons also do not have specialised training on wound management, especially sternal wounds. One of the reasons the incidence of wound infection observed in the present study is higher than that in other studies could be the lack of a trained personnel. Wound training could include not only recommended dressing usage, but also other aspects of wound management, such as use of antibiotic prophylaxis, correct wound assessment for clinical signs of infection, type of suture used (such as intracutaneous or transcutaneous suture), use of NPWT when indicated, use of correct technique for preoperative skin preparation, surgical management of sternal wound complications, use of new guidelines in wound management, and patient and family education, as well as establishing wound research centres in hospitals.

The present study showed that factors such as diabetes, old age, female gender, history of diseases in the pulmonary system (COPD), opiate addiction and lipidaemia can increase the risk of wound infection. Other factors, such as obesity, history of cardiac surgery, history of high blood pressure, duration of pump usage during surgery, and duration of stay in cardiac intensive care unit, did not show any relation with the incidence of wound infection.

Diabetic patients are at higher risk of wound infection because hyperglycaemia affects immunologic defences, granulocyte adherence, chemotaxis, phagocytosis and bactericidal function.[24] Van der Burger et al. surveyed 1548 patients admitted to a Belgian surgical intensive care unit, reporting that patients who were randomised to intensive blood glucose control (with insulin infusion to maintain blood glucose levels at 4.4–6.1mmol/l during their

stay in the intensive care unit) had 46% fewer septic complications and 34% lower mortality than patients managed in the conventional manner.[25] n this regard, McAlister et al. also reported that patients with diabetes are at higher risk of wound infection compared with other patients.[26]

Similar to our findings, Garey et al. reported that older patients are at higher risk of sternal wound infection.[22] Older patients who need cardiothoracic surgery usually have increased risk factors for wound infection. The immune system in this group of patients usually is disrupted; also, prevalence of other risk factors that affect wound healing, such as malnutrition and diabetes, is higher among older patients.

Results of our study also showed that female patients have a greater possibility of developing wound infection after bypass surgery, which could be a reflection of their greater severity of illness, older age, smaller body surface areas, and increased comorbidity on presentation for surgery.[27–29]

Background diseases in the pulmonary system, such as chronic lung diseases, were identified as a risk factor for wound infection. Diez et al. similarly determined COPD to increase risk of wound infection.[16] Explanations for these findings in patients with COPD might include high suture-line pressure or collagen abnormalities described in smokers.[30] Also, nicotine in cigarettes is known to inhibit the antibody-forming cell response and lymphocyte proliferation,[31] which may prevent the development of a protective immune response to microbial pathogens.[31] Furthermore, patients with COPD are more susceptible to infection of the operative wound due to tissue hypoxaemia. Many of these patients need corticoid therapy in the pre- and/or postoperative periods, which could facilitate the onset of infection.[13]

Recently, Iran has suffered from drug abuse and its consequences. Ancient Iranians believed that the use of opium reduced the incidence of heart disease. However, these results identified opiate addiction to be a risk factor for development of wound infection. While opiates directly modulate host immunity, their effects on physiological function of nonspecific host mechanisms are thought to also alter immune responses and play an important role in increased susceptibility to infection.[32] These effects are proposed to act through the central nervous system and the hypothalamus–pituitary–adrenal (HPA) axis. Opiates are known to alter the release of HPA hormones (corticotrophin-releasing hormone and adrenocorticotrophic hormone), which, in turn, alter glucocorticoids (cortisol and corticosterone), the end-effectors of the HPA axis.[33] The glucocorticoids play an important role in decreasing and regulating cellular immune responses.[32]

Conclusion

The present study showed that there is a 10% risk of surgical wound infection in the patients with open-heart surgery. This is high in comparison to other studies in this field. Factors such as old age, female gender, diabetes, opiate addiction and history of respiratory diseases are among the risk factors for development of such infections.

The results suggest that the educational and medical systems in Iran, need to consider training some well-educated personnel on the prevention and management of wounds, leading to the development of specialised wound-care personal. In order to reach this goal, we have to learn from developed countries, such as the UK, and from the societies active in this field. ■

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