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Original Article

Epidemiology and risk factors for surgical site infections following thoracic surgery

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Abstract: Background: Risk factors for surgical site infections (SSIs) are well studied after cardiac surgery but there is few data about epidemiology of these infections after non cardiac thoracic surgery. We aimed to investigate epidemiology, risk factors and outcome of postoperative SSIs following thoracic surgery. Methods: All of the patients who undergone thoracic surgical procedure, between 2004 and 2012 were surveyed prospectively for the presence of SSI. Risk factors for SSIs after open thoracic surgery were analysed with a case-control study: 80 patients with SSIs were compared with 96 patients who were operated during the study period but did not develop SSI. Results: A total of 100 surgical site infections diagnosed in 4572 patients (2.18%). Open surgery was associated with SSIs more frequently than thoracoscopic surgery (P<0.001). Risk adjusted rates for open thoracic SSI were available between 2009 to 2012 and 1.91%, 3.59% and 7.69% for risk index category 0, 1 and 2-3 respectively. *Staphylococus aureus* (25%), coagulase-negative staphylococci (18%) and (17%) were the most frequently isolated microorganisms. Diabetes mellitus (DM), an American Society of Anestesiology (ASA) score ≥3, preoperative white blood cell (WBC) count and the number of blood products used perioperatively were found to be independent risk factors for SSIs. Mortality rate and total length of hospital stay were significantly higher in patients with SSIs. Conclusion: Higher WBC count before surgery could indicate higher risk of SSI after thoracic surgery. Decreasing blood and blood product use perioperatively could lower the rate of SSIs.

Keywords: Thoracic surgery, surgical site infection, risk factors

Introduction

Surgical site infections (SSIs) are among the most frequent nosocomial infections after surgery. SSIs affect patients by increasing morbidity and mortality and they affect economy of health care systems by increasing the length of hospital stay and costs [1]. Therefore risk factors for SSIs should be investigated and the modifiable ones should be eliminated if possible.

Demographic data of the patients, comorbidities, and preoperative, perioperative and postoperative risk factors of SSIs were investigated in several studies involving different types of surgeries [2]. Gender, DM, wound class, American Society of Anestesiology (ASA) score, duration and non endothoracoscopic interventions are among the most frequently reported risk factors for SSIs [3]. Although risk factors for SSI after cardiac surgery were investigated extensively [4, 5], there is very few data about SSIs after thoracic surgery. In this study we aimed to investigate epidemiology, risk factors and outcome of postoperative infections following non cardiac thoracic surgery.

Methods

The study was conducted in a 550 bed teaching hospital in Istanbul, Turkey. All patients who had thoracic surgical procedure, either with thoracatomy or sternotomy or video assisted thoracoscopy between 2004 and 2012 were surveyed prospectively both with laboratory

Table 1. Risk adjusted surgical site infection rates after incisional thoracic surgery

Year	RIC* 0		RIC 1		RIC 2, 3		Total	
	Number of operations	Thoracic SSI** N (%)	Number of operations	Thoracic SSI N (%)	Number of operation	Thoracic SSI N (%)	Number of operations	Thoracic SSI N (%)
2009	149	5 (3.35)	144	7 (4.86)	20	3 (15)	313	15 (4.79)
2010	203	2 (0.99)	123	0 (0)	23	0 (0)	349	2 (0.57)
2011	264	8 (3.03)	85	7 (8.14)	15	1 (6.67)	364	16 (4.39)
2012	166	0 (0)	66	1 (1.52)	7	1 (14.29)	239	2 (0.83)
Total	782	15 (1.91)	418	15 (3.59)	65	5 (7.69)	1265	35 (2.76)

*RIC, risk index category. **Surgical site infections.

and patient based methods for the presence of SSI. All The patients that had infection of any site before surgery were excluded. All thoracic SSIs of inpatients and outpatients were made jointly by an infectious disease specialist and a thoracic surgeon by using clinical and laboratory findings of the patients. The Centers for Disease Control and Prevention (CDC) criteria were used for the diagnosis of SSIs [6].

Eighty patients with SSIs after open thoracic surgery were compared with 96 patients who were operated during the study period but did not develop SSI in this retrospective case control study. Demographic characteristics of the patients, preoperative and perioperative variables and comorbidities were recorded by using hospital database system. Cefazolin was given to all of the patients undergoing thoracic surgery in the study period, vancomycin was used alone when a patient had allery to cefazolin or combined with cefazolin in the case of nasal MRSA carriage after 2007. The duration of antibiotic prophylaxis was recorded. Skin preparation was done by using povidone iodine until 2010, it was switched to 2% and 70% isopropyl alcohol in all patients after 2010.

Preoperative characteristics included: age and sex of the patients, duration of preoperative hospital stay, ASA score and comorbidities DM, chronic obstructive lung disease (COPD), renal failure, malignity, smoking. Preoperative laboratory tests (white blood cell (WBC) count, hemoglobin, albumin and creatinine levels), perioperative charecteristics (duration of surgery, amount of blood and blood products used during surgery, type of the procedure (thoracotomy or sternotomy) were recorded. Rates of SSI were stratified according to the risk index developed by (CDC)'s National Nosocomial Infections Surveillance System. (NNIS) [7].

NNIS risk index score for each patient was calculated by assigning one point for each; contaminated wound according to the CDC definition, an ASA score ≥3, and surgical procedures lasting longer than the NNIS-derived 75th percentile for procedure duration, T time. (T time: 180 minutes for thoracic surgery) [7]. The type of SSI (superficial, deep and organ-space), causative microorganism, duration of hospital stay and mortality rate were also recorded.

Statistical analyses were done using SPSS for Windows software, version 16.0. Chi-square and Student's *t* tests were used for the univariate analysis of categorical and continuous variables of patient characteristics, respectively. Continuous variables with non-normal distribution were compared by using Mann-Whitney U test. Independent risk factors for SSI were determined by logistic regression analysis. Variables found to be significant ($P<0.05$) in univariate analysis or reported to be risk factor for mortality in the literature were included in the logistic regression analysis.

Results

A total of 100 surgical site infections diagnosed in 4572 patients (2.18%) (90 SSI after 3151 open thoracic surgery, 10 SSI after 1421 thoracoscopic thoracic surgery) who had thoracic surgical operations during the study period. SSIs were seen more frequently after open thoracic surgery than thoracoscopic surgery ($P<0.001$). Risk adjusted rates for open thoracic SSI were available between 2009 to 2012 and 1.91%, 3.59% and 7.69% for risk index category 0, 1 and 2, 3 respectively (**Table 1**). SSIs were classified as superficial, deep and organ-space in 27 (27%), 32 (32%) and 41 (41%) of 100 cases with SSI, respectively. *Staphylococus aureus* (25%) (19% methicillin resistant), coagu-

Table 2. Isolated microorganisms according to type of surgical site infections

Microorganism	Superficial SSI N	Deep SSI N	Organ-Space SSI N	Total N (%)
Staphylococcus aureus	6	9	10	25 (25)
Methicillin-sensitive *S.aureus*	2	2	2	6 (6)
Methicillin-resistant *S.aureus*	4	7	8	19 (19)
Coagulase-negative Staphylococcus	10	7	1	18 (18)
Enterobacteriaceae	6	3	8	17 (17)
Acinetobacter baumannii	2	4	7	13 (13)
Pseudomonas aeruginosa	1	1	6	8 (8)
Polimicrobial infection	0	5	4	9 (9)
Others	0	2	4	6 (6)
Not defined	2	1	1	4 (4)
TOTAL	27	32	41	100

lase-negative staphylococci (18%), *Enterobacteriaceae* (17%), *Acinetobacter baummannii* (13%) and *Pseudomonas aeruginosa* (8%) were the most frequently isolated microorganisms (**Table 2**) and 9% of SSI's were polimicrobial. Causative microorganisms were not differed over the years (P>0.005) except MRSA which is significantly higher before 2008 (P=0.012).

We did not find a statistical significance between patients with and without SSIs when we compared age, sex, preoperative length of hospital stay, preoperative albumin levels, presence of COPD, presence of malignity and smoking status. An ASA score of 3 or 4, presence of DM, preoperative blood WBC count and hemoglobin and glucose level, number of blood and blood products used perioperatively, were associated with SSIs in univariate analysis (P<0.05).

DM (Odds Ratio (OR) 2.40, 95% Confidence Interval (CI) 1.10-5.23), an ASA score of 3 or 4 (OR 3.05, 95% CI 1.22-7.60), preoperative blood WBC count (OR 1.207, 95% CI 1.07-1.35) and the number of blood and blood products used perioperatively (OR 1.15, 95% CI 1.009-1.314) were found to be independent risk factors for SSIs after open thoracic surgery in logistic regression analysis. Epidemiologic, clinical and laboratory features of patients with and without SSIs after thoracic surgery are shown on **Table 3**.

Mortality rate (7.5% versus 1%, P=0.030) and total length of hospital stay (33.38±17.76 versus 12.39±7.63 days, P< 0.001) were significantly higher in patients with SSIs than patients without SSIs.

Discussion

To our knowledge this is the largest study assessing features of SSIs after thoracic surgery. We determined 100 surgical site infections diagnosed in 4572 patients, this means a rate of 2.18% SSIs (2.85% for open thoracic surgery and 0.7% for thoracoscopic thoracic surgery). SSIs were seen more frequently after open surgery than thoracoscopic surgery in our study, which is in accordance with other studies [8, 9]. Nan et al reported 76 (25.8%) nosocomial infections after lung surgery in 295 patients, 16 (5.4%) of them were reported as wound infections [10]. Tsiouris et al reported 3.5% wound infections after thoracotomy and 2.2% in any other thoracic procedures in dependent patients in a study that investigated preoperative risk stratification for thoracic surgery [11]. These rates are similar to our study.

It will be better to compare our results with National Healthcare Safety Network (NHSN) report. Risk adjusted rates for open thoracic SSI were available between 2009 to 2012 in our patients and 1.91%, 3.59% and 7.69% for risk index category 0, 1 and 2, 3 respectively. These rates are 0.76% and 2.04% for risk index category 0.1 and 2.3 respectively in NHSN report [12]. Our results are slightly higher than the ones in NHSN report. This may be because of our hospital is a 550 bed teaching hospital and the procedures that take place in our hospital are complicated. Also bed size >500 is found to be an independent risk factor for SSIs after thoracic surgery in NHSN report [3].

Patients with co morbidities have been reported to have more nosocomial infections [4, 10]. Diabetes mellitus is confirmed as an important independent risk factor for SSIs after cardiac surgery and spinal surgery in several studies [4, 9, 13-16]. DM may cause microangiopathy resulting decreased nutrition and oxygen delivery to peripheral tissue that may reduce the

Table 3. Epidemiologic, clinical and laboratory features of patients with and without surgical site infections after incisional thoracic surgery

Variable	Patients with SSI* (n: 80)	Patients without SSI* (n: 96)	Univariate analysis P	Multivariate analysis	
				P	OR (CI 95%)**
Age (Mean), mean ± SD	56.26±15.35	53.78±16.4	0.306		
Male, n	53	62	0.817		
COPD, n	33	31	0.241		
DM, n	29	16	0.004	0.027	2.40 (1.10-5.23)
Malignity, n	41	61	0.069		
Smokers, n	47	47	0.109		
ASA class 3 or 4, n	21	10	0.007	0.016	3.05 (1.22-7.60)
Preoperative length of hospital stay (days), mean ± SD	5.99±5.02	5.22±5.56	0.346		
Preoperative albumin level (g/dL), mean ± SD	3.48±0.84	3.78±1.05	0.270		
Preoperative creatinin level (g/dL), mean ± SD	0.91±0.34	0.85±0.22	0.163		
Preoperative blood glucose level (mg/dL), mean ± SD	118.80±43.54	105.90±30.19	0.027		
Preoperative WBC*** number (/uL), mean ± SD	10.38±4.49	7.99±2.65	<0.001	0.001	1.207 (1.07-1.35)
Preoperative hemoglobin level (g/dL), mean ± SD	12.16±2.0	12.99±1.49	0.003	0.097	0.84 (0.69-1.03)
Surgical approach, n			0.127		
Thoracotomy	76	85			
Sternotomy	4	11			
Procedure type, n			0.119		
Lung resection	48	62			
Plevral surgery	17	12			
Others	15	24			
Duration of antimicrobial prophylaxy mean ± SD	2.54±0.83	2.73±0.65	0.095		
Duration of surgery, minute, mean ± SD	221±120	204±88	0.296		
Total number of blood products used (Unit), mean ± SD	2.68±3.70	1.09±2.20	0.002	0.036	1.15 (1.009-1.314)
Total length of hospital stay (days), mean ± SD	33.38±17.76	12.39±7.63	<0.001		
Mortality (%)	6	1	0.030		

*SSI: surgical site infection; **OR: odd ratio; CI: confidence interval; ***WBC: white blood cell.

body's ability to fight with infections. Poor blood glucose control alters immune function by defecting neutrophil, immunoglobulin and complement functions [17]. Defective fibroblast proliferation and impaired synthesis of collagen causes delayed wound healing in diabetic patients [16]. Because all of these reasons diabetic patients have more surgical site infections after surgery. DM was found to be an independent risk factor for SSI after thoracic surgery in two other studies, also [9, 18]. Although preoperative blood glucose levels were higher in patients with SSIs than the control group in our study, there was no statistical significance.

Duration of surgery is found to be an independent risk factor for thoracic surgery in NHSN report and some other studies [3, 8, 10, 19]. Although mean duration of surgery was longer in patients with SSIs then control group (220±121 versus 202±88) in our study, it was not statistically significant.

ASA physical status has been shown to be a highly predictive indicator of SSIs [10, 20, 21]. We have found an ASA score ≥3 as an independent risk factor for SSIs after thoracic surgery.

We found higher level of WBC as an independent risk factor for SSIs after open thoracic surgery. Since we excluded the patients with infection of any site previous to surgery, higher number of WBC in our study populations could not reflect the previous infection. WBC count accepted as a valid marker of inflammation and as a predictor of future adverse outcomes including mortality, cardiac events, stroke, bleeding, readmission or mediastinitis in patients undergoing coronary revascularization with cardiopulmonary bypass [22, 23]. The cause of the association between a higher WBC count and a higher risk of adverse outcomes is not known yet. We do not know whether increasing numbers of WBC are directly responsible for increas-

ing injury or the increasing WBC count may serve only as a marker of an underlying inflammatory state [22, 23]. But like in coronary revascularization surgery, our findings support that WBC count measured prior to thoracic surgery could aid in identifying and managing patients at heightened risk of adverse events including SSIs after thoracic surgery.

Preoperative length of hospital stay ≥3 days is reported as an independent risk factor for SSIs after VATS in one study [19]. Although preoperative hospital stay was longer in patients with SSI (6.20±5.23, 5.27±5.48 respectively) in our study, we did not find a significant relationship between SSI and preoperative duration of hospital stay after open thoracic surgical procedures.

Blood transfusion has shown to be an important factor in the development of postoperative infections mediated through immunosuppression [24, 25]. The increase in nosocomial infection after surgery in patients receiving red blood cell transfusions has been described previously [2, 10, 18, 26]. Suppression of phagocytosis because of hemoglobin exposure may increase bacterial infections [27]. Also, large amounts of foreign antigens are introduced to the recipients' circulation during blood transfusion and this may cause transfusion-associated immunomodulation [27]. Total number of blood and blood products used perioperatively increased risk of SSI in our study. Rational use of blood and blood products could be resulted in lower rates of these infections.

Staphylococus aureus was the most common etiological agent in SSIs after thorasic surgery in this study. Although isolated microorganisms are reported in limited number of studies, it is similar in other studies [10, 19, 27, 29]. Causative microorganisms of thoracal SSIs were not different over the years except MRSA which was significantly lower after 2008 (P=0.016). This was probably related with the control of nosocomial MRSA infections in our hospital after 2008 [30].

We found that the length of hospital stay was longer in patients with SSIs and mortality rate was higher [10, 28]. The mean length of total hospital stay was significantly higher in patients with SSIs than control group (33.16±17.68, 12.38±7.52 respectively). The 30 day operative mortality rate after thoracic surgery is between 1.6% and 12% in the literature, our rate is 10.8% and is similar to other studies (10). Because of this higher mortality rate caused by SSI's, prevention of these infections is very important.

There are some limitations of our study. Although the SSIs were surveyed prospectively, the case control part of the study was done retrospectively. The data was collected from our surveillance system and therefore we could not assess all of the variables that may increase the risk of SSIs. We could not access the data of all operated patients so we included 96 age and sex matched control subjects operated and did not have SSI in the same time period.

Despite these limitations our study is the largest investigation of epidemiology of SSIs after thoracic surgery. We found that patients with higher WBC count before surgery, an ASA score ≥3 and DM and who had higher number of blood and blood products perioperatively have a higher risk of SSIs. Diabetic patients should be followed cautiously after thoracic surgery because of high risk of SSI. Higher WBC count before surgery could indicate higher risk of SSI after thoracic surgery. Decreasing the number of blood products used during surgery could reduce the rate of SSIs after thoracic surgery.

Disclosure of conflict of interest

None.

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