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Surgical site infection surveillance in orthopedic patients in the Military Medical Academy, Belgrade

Nadzor infekcije operativnog mesta kod ortopedskih bolesnika u Vojnomedicinskoj akademiji, Beograd

Srdjan Starčević*[†], Staša Munitlak*, Biljana Mijović[‡], Dragan Mikić[†§], Vesna Šuljagić[†]

***Clinic for Orthopedic Surgery and Traumatology, [§]Clinic for Infectious and Tropical Deseases, Military Medical Academy, Belgrade, Serbia; [†]Faculty of Medicine of the Military Medical Academy, University of Defence, Belgrade, Serbia; [‡]Faculty of Medicine, University of East Sarajevo, Foča, Republic of Srpska, Bosnia and Herzegovina**

Abstract

Background/Aim. Active surveillance is an important component of surgical site infection (SSI) reduction strat-egy. The aim of this study was to analyze and compare SSI surveillance data in orthopedic patients in the Military Medical Academy (MMA), Belgrade. **Methods.** A 4-year prospective cohort study was performed to identify the in-cidence rate and risk factors for SSI in orthopedic patients in the MMA, Belgrade. We collected data regarding pa-tients characteristics, health care and micro-organisms iso-lated in SSI. The National Nosocomial Infection Surveil-lance (NNIS) risk index was subsequently calculated for each patient. The Centers for Disease Control and Preven-tion criteria were used for the diagnosis of SSI. **Results.** Assessment of 3,867 patients after different orthopedic operations revealed SSI in 109 patients. The overall incidence rate of SSI was 2.8% with the decrease from 4.6% in 2007 to 1.6% in 2010. Using NNIS risk index for surgical procedures there were: 53.7% (2,077) patients with risk 0 – the incidence rate of 1.4%; 38.9% (1,506) patients with risk 1 – the incidence rate of 3.1%; 7.3% (281) patients with risk 2 – the incidence rate of 11.7%; 0.1% (3) patients with risk 3 – without infection within the risk. Multivariate logistic regression analysis identified 6 independent risk factors associated with SSI: contaminated or dirty wounds, smoking, preoperative infection, NNIS risk index, body mass index and the length of hospital stay. **Conclusion.** The results of our study are valuable confirmation of relations between risk factors and SSI in orthopedic patients. A decreasing incidence rate of SSI (from 4.6% to 1.6%) during a 4-year active surveillance approved its implementation as an important component of SSI reduction strategy.

Key words:
orthopedic procedures; surgical wound infection; risk factors; serbia.

Apstrakt

Uvod/Cilj. Aktivno praćenje važan je deo strategije sni-ženja učestalosti infekcije operativnog mesta (IOM). Cilj rada bio je analiza i poređenje podataka dobijenih praće-njem ortopedskih bolesnika u Vojnomedicinskoj akademiji (VMA), Beograd. **Metode.** U cilju utvrđivanja stope učestalosti IOM kod ortopedskih bolesnika u VMA, kao i faktora rizika od nastanka infekcije, sprovedeno je 4-godišnje prospektivno, kohortno istraživanje. Prikupljeni su podaci o bolesnicima, o pruženim medicinskim uslugama, kao i o uzročnicima IOM. Za svakog bolesnika određen je indeks rizika od nastanka IOM Nacionalnog sistema nadzora nad bolničkim infekcijama u SAD-a (NNIS). U cilju dijagnoze IOM upotrebljeni su kriteriju-mi Centra za prevenciju i kontrolu bolesti (CDC) u SAD-u. **Rezultati.** Istraživanjem je obuhvaćeno 3 867 bolesnika nakon različitih ortopedskih operacija, od kojih je 109 imalo IOM. Ukupna stopa učestalosti IOM iznosila je 2,8%, sa tendencijom sniženja od 4,6% u 2007. godini do 1,6% u 2010. Određivanjem indeksa rizika (NNIS) došlo se do sledećih rezultata: kod 53,7% (2 077) boles-nika sa rizikom 0 – stopa učestalosti bila je 1,4%; kod 38,9% (1 506) bolesnika sa rizikom 1 – stopa učestalosti bila je 3,1%; kod 7,3% (281) bolesnika sa rizikom 2 – stopa učestalosti bila je 11,7%; kod 0,1% (3) bolesnika sa rizikom 3 – nisu registrovane IOM. Multivarijantnom logističkom regresionom analizom identifikovano je šest nezavisnih faktora rizika povezanih sa nastankom IOM: kontaminirana ili prljava operativna mesta, pušenje duvana, preoperativna infekcija, NNIS indeks rizika, indeks telesne mase i dužina hospitalizacije. **Zaključak.** Podaci dobijeni našim istraživanjem značajni su za dokazivanje odnosa između faktora rizika i nastanka IOM kod ortopedskih bolesnika. Sniženje stope učestalosti IOM od 4,6% do 1,6% tokom 4 godine aktivnog praćenja dokazuje da njegova primena predstavlja važan deo strategije sniženja učestalosti IOM.

Ključne reči:
ortopedske procedure; rana, hirurška, infekcija; faktori rizika; srbija.

Correspondence to: Srdjan Starčević, Clinic for Orthopedic Surgery and Traumatology, Military Medical Academy, Crnotravska 17, 11040 Belgrade, Serbia. Phone: +381 64 118 6286. E-mail: starcevicdrsrdjan@gmail.com

Introduction

Surgical site infections (SSIs) continue to be a significant problem in surgical patients across the globe [1–3]. The impact of these infections can be devastating for patients as well as incurring additional hospital costs. Orthopedic SSIs have substantially greater physical limitations and significant reductions in their quality of life, prolong total hospital stays and increase healthcare costs by more than 300% [4].

Active surveillance is a cornerstone of orthopedic SSI detection and SSI rates accurate calculation within an institution. Orthopedic SSI surveillance is integral to hospital infection control and quality improvement programs, with feedback of SSI rates being an important component of SSI reduction strategies in different healthcare systems [5–7].

The aim of this study was to analyze and compare surveillance data from a large cohort of orthopedic patients of the University Clinic in Serbia during a 4-year period.

Methods

Setting

The Military Medical Academy (MMA), Belgrade, Serbia, a teaching hospital of University of Defense, is a 1,200-bed tertiary healthcare center. The Clinic for Orthopedic Surgery and Traumatology is a 72-bed department of MMA. The Department of Infection Control performs continuous surveillance on all surgical patients of MMA [3].

Study population

The personnel for infection control collected data related to patients [age, gender, tobacco use, body mass index (BMI), the presence of underlying diabetes mellitus], data related to health care [length of hospital stay (LHS), preoperative LHS, preoperative preparing, preoperative infection, immunosuppressive treatment, antibiotic prophylaxis, drainage, duration of drainage, central vascular catheter, urinary catheter].

The National Nosocomial Infections Surveillance System (NNIS) risk index was subsequently calculated on the basis of data relating to the operation: wound contamination class, duration of surgery, and the American Society of Anesthesiologists (ASA) score [8, 9]. The National Research Council operative site classification was used. It classifies surgical wounds as clean, clean/contaminated, contaminated, and dirty/infected [10]. The NNIS index ranges from 0 to 3. Each of the three risk indices is worth 1 point: contaminated or dirty surgical wound, ASA score greater than 2, and the duration of surgery greater than the 75th percentile for a specific group of surgical procedures [11].

For the diagnosis of SSIs, the Centers for Disease Control and Prevention (CDC) criteria were used [12]. SSIs were classified as superficial incisional, deep incisional or organ/space in consultation with orthopedic surgeon.

Only the first episode of SSIs was included for patients who had more than one SSI during the study period. The cumulative incidence of SSIs or the rate of SSIs (%) was based on SSIs detected during hospital stay combined with SSIs identified on readmission following the initial operation. No post-discharge surveillance was performed.

Study design

A prospective cohort study was performed to identify incidence rate and risk factors (RFs) for SSIs from January 1, 2007 to December 31, 2010.

Microbiological testing was performed at the Institute of Medical Microbiology at the MMA. Isolates were identified by routine methods [13].

The incidence rate was defined as the number of SSIs *per* 100 operative procedures.

Statistical analysis of data was done using the SPSS software package (SPSS, Chicago, IL, USA, version 11.00). The results are expressed as the mean ± SD or as the proportion of the total number of patients. In all studies, testing for significant differences was conducted by χ^2 test for categorical variables and Student's *t*-test for continuous variables. The factors were considered to be significant at a p value of ≤ 0.05. All p values were two-tailed. RFs independently associated with infections were identified by multivariate logistic regression analysis of variables selected by univariate analysis with a limit for entering and removing variables of 0.05.

Results

From January 1, 2007 to December 31, 2010, a total of 3,867 different orthopedic operative procedures were evaluated (Table 1). Among these, 109 were complicated by SSI. The overall cumulative incidence rate was 2.8%, with a decrease from 4.6% in 2007 to 1.6% in 2010 (Table 2). There were 30 (27.5%) superficial, 45 (41.3%) deep incisional, and 34 (31.2%) organ-spaces infections.

Table1

Surgical site infection (SSI) rates*, by operative procedures and risk index category

Operative procedure category	Risk index category			Cumulative rate (%)
	0 n, rate (%)	1 n, rate (%)	2,3 n, rate (%)	
Limb amputation	26 (11.5)	87 (5.7)	84 (15.5)	10.7
Open fracture	2 (0)	29 (0)	10 (0)	0
Reduction of long bone fracture	295 (2.7)	128 (3.9)	18 (22.2)	3.9
Repair of neck of femur	213 (0.9)	319 (1.6)	2 (50)	1.5
Hip prosthesis	1021 (0.6)	574 (1.9)	60 (6.7)	1.3
Knee prosthesis	173 (2.9)	145 (1.4)	46 (2.2)	2.2
Other musculoskeletal procedures	347 (1.4)	224 (8.5)	64 (15.6)	5.4

Table 2

Surgical site infection (SSI) rates* by operative procedures and annual distribution Per 100 operative procedures

Operative procedure category	2007 n, rate (%)	2008 n, rate (%)	2009 n, rate (%)	2010 n, rate (%)
Limb amputation	45 (15.6)	51 (11.8)	44 (9.1)	57 (7.0)
Open fracture	8 (0)	13 (0)	4 (0)	16 (0)
Reduction of long bone fracture	86 (4.7)	109 (8.3)	126 (2.4)	120 (0.8)
Repair of the neck of the femur	73 (2.7)	140 (1.4)	148 (0.7)	173 (1.7)
Hip prosthesis	306 (1.0)	504 (2.0)	347 (1.2)	498 (0.8)
Knee prosthesis	79 (2.5)	78 (2.6)	79 (1.3)	128 (2.3)
Other musculoskeletal procedures	141 (11.3)	125 (6.4)	206 (3.4)	163 (1.8)
Total	738 (4.6)	1020 (3.6)	954 (2.1)	1155 (1.6)

***Per* 100 operative procedures; n – numbers of operative procedures.**

Using the NNIS risk index, there were: 53.7% (2,077 surgical procedures) with risk 0 and the incidence rate of 1.4%; 38.9% (1,506) with risk 1 and the incidence rate of 3.1%; 7.3% (281) with risk 2 and the incidence rate 11.7%; 0.1% (3) with risk 3 and no infection within this risk.Table 2 shows the number of procedures and cumulative incidence rates by the NNIS risk index for the period February 2007 to 31 December 2010.

The mean age of patients was 64.10 years (range 10 to 97, median 69.00 years). There were 56.2% females and 43.8% males.

The median LHS was 6.00 (mean + SE = 7.39 + 0.13) days. The patients with SSI had 9.58 days of preoperative LHS, and without SSI 7.33 days of preoperative LHS. The median LHS was 14 days (mean + SE = 16.27 + 0.16), ranging from 3 to 116 days.

The characteristics of the patients and SSI related RF according to univariate analysis are shown in Table 3. Comparison of the patients with and without SSIs revealed significant differences. Univariate analysis showed that the occurrence of SSIs was significantly associated with the following categories: diabetes mellitus, smoking, BMI, ASA score, preoperative LHS, length of stay in hospital, preoperative showering, preoperative infection, immunosuppressive treatment, drainage of the surgical site, duration of drainage, contaminated and dirty/infected wound, central vascular catheter and NNIS risk index. Gender, Intensive Care Unit (ICU) stays, antibiotic prophylaxis, urinary catheter, preoperative shaving, and age were found not to be associated with SSI.

Multivariate logistic regression analysis identified six independant RFs associated with SSI occuring in these patients (Table 4).

Table 3

Potential risk factors for the development of surgical site infection (SSI) (univariate analysis)

Variable	Patients with SSI n = 109	Patients without SSI n = 3758	*p*-value	RR (95 CI %)
Patients characteristic				
diabetes mellitus, n (%)	28 (25.7)	517 (13.8)	0.001	2.167 (1.396–3.363)
smoking, n (%)	31 (28.4)	490 (13.0)	0.000	2.651 (1.730– 4.062)
BMI (kg^2/m^2), x̄ ± SD	26.17 + 4.0	27.18 ± 4.6	0.009	1.060 (1.014–1.108)
ASA > 2, n (%)	47 (43.1)	1214 (32.3)	0.019	1.589 (1.081–2.335)
Related to health care				
preoperative length of stay (days), x̄ ± SD	7.33 + 8.1	9.58 ± 12.2	0.007	1.020 (1.005–1.034)
length of stay in hospital (days), x̄ ± SD	15.95 + .000	27.4 ± 16.1	0.000	1.057 (1.045–1.069)
preoperative showering, n (%)	92 (84.4)	3487 (92.8)	0.001	.421 (.247– .761)
preoperative infection, n (%)	10 (9.2)	85 (2.3)	0.000	4.365 (2.200–8.659)
immunosuppressive treatment, n (%)	9 (8.8)	155 (4.1)	0.039	2.092 (1.038–4.216)
drainage, n (%)	29 (26.6)	368 (9.8)	0.000	3.339 (2.154–5.176)
duration drainage (days), x̄ ± SD	0.30 ± 1.1	1.05 ± 2.2	0.000	1.279 (1.173–1.395)
contaminated and dirty/infected wound, n (%)	54 (49.5)	407 (10.8)	0.000	8.084 (5.477–11.931)
central vascular catheter, n (%)	6 (5.5)	43 (1.1)	0.000	5.033 (2.095–12.089)
NNIS risk index, n (%)			0.000	6.067 (3.954–9.309)
0	29 (26.61)	2048 (54.5)		
1	47 (43.12)	1459 (38.82)		
2	33 (30.27)	248 (6.6)		
3	0 (0)	3 (0.08)		

BMI – body mass index; ASA – American Society of Anesthesiologists; NNIS – National Nosocomial Infections System; RR – relative risk; CI – confidence interval; n (%) – numbers of patients (percentage); x̄ ± SD – mean ± standard deviation.

Table 4

Independent predictors of surgical site infection (SSI) by stepwise multivariate logistic regression

Variable	RR	95% CI	S.E.	*p*-value
Contaminated and dirty/infected wound	3.753	2.170–6.492	0.280	0.000
Smoking	2.576	1.593–4.164	0.245	0.000
Preoperative infection	2.512	1.129–5.588	0.408	0.024
NNIS risk index	2.141	1.069–4.289	0.354	0.032
Body mass index	1.066	1.017–1.118	0.024	0.008
Length of hospital stay	1.056	1.041–1.070	0.007	0.000

RR – relative risk; CI – confidence intervals; S.E. – standard error; NNIS – National Nosoconial Infecting System.

Microorganisms were isolated in 70 (64.2%) SSIs of the 109 recorded SSIs. Of these, one species was isolated from 58 SSIs, 2 from 10 SSIs, and 3 from 2 SSIs. *Staphylococcus aureus* (*S. aureus*) was most frequently isolated microorganisam 33/109 (45.7%) of laboratory confirmed SSIs (32 SSIs) of which 43.7% (18/32) were methicillin-resistant (MRSA). Next was *Acinetobacter* spp. (9 SSIs or 12.9% laboratory confirmed SSIs) of which 22.2% isolates were resistanat to carbapenems. This species followed by *Enterococcus* spp. (8 or 11.4% of laboratory confirmed SSIs) without registred resistance to vancomycin (VRE), *Klebsiella* spp. (7 SSIs or 10.0% of laboratory confirmed SSIs, of which 85.7% were the 3rd generation cephalosporin-resistant), and *Pseudomonas aeruginosa* (7 SSIs or 10.0% of laboratory confirmed SSIs of which 81.5% were resistant to fluoroquinolones, and 28.6% to carbapenems).

Discussion

The reduction in SSI incidence to a minimal level can produce great benefits for the patients and would economize resources.

In 2006 SSI surveillance has become an integral part of current hospital infection control programs in the MMA. This study provides important information about the incidence rate of orthopedic operative procedures, the orthopedic patient characteristics, RFs related to health care and microorganisms isolated from SSIs in a large group of patients admitted to the Clinic for Orthopedic Surgery and Traumatology during the study period.

The incidence rate of SSI (2.8%) found in the present study was similar to figures reported by the authors from developing countries [14]. The effectiveness of SSI surveillance in orthopedics has been demonstrated in different studies [5, 15, 16]. In our study the rate was 4.6% in the first year, which decreased to 1.6% in the fourth surveillance year.

Comparing our data with data from the systems of other countries, we found diferences in the infection rate for some procedures. Operative procedures for open fracture were not complicated with SSIs and data from this category should be interpreted with caution due to a small number of procedures (Table 1).

Also, we found that the incidence rate was much higher than that reported in the US and England for limb amputation [7, 17]. Limb amputation surgery showed decreases in SSI incidence from 15.6% in 2007 to 7.0% in 2010. That is similar to English analysis which showed consistent decreases in the inpatient SSI incidence [7].

Reduction in long bone fracture and repair of the neck of the femur were operative procedures which showed a decreasing SSI rate. Data from hospitals in England in 2011/12, showed year-on-year decreases in the incidence of SSIs for same operations, too [7].

SSIs were more common in our hospital than in hospitals in Scotland, England, and US after hip and knee protheses [7, 17, 18].

In our patients SSIs were more common in the category of other musculosceletal procedures than in the US and Brazil [14, 17], but we registered the trend of decreases in the SSI incidence from 11.3% in 2007 to 1.8% in 2010.

A number of factors may explain this difference, including different helthcare systems, type of hospital, practices, patient mix, length of stay etc.

Of 109 SSIs, 30 (27.5%) were superficial infections, 45 (41.3%) deep infections and 34 (31.2%) organ-spaces infections. In the US, some hospitals with a high volume of surgery perform surveillance only for deep incisional and organ/space infections, which termed the complex SSIs [19]. In our study complex infections were 72.5% of SSIs. Such infections require rehospitalization, revision surgery and intravenous antibiotic therapy.

An increased risk for infection in the presence of predisposing factors is of particular concern for orthopedic surgeons. The multivariate method used in our analysis allowed factors to be identified which had both a significant and an independent association with SSIs after orthopedic surgery: contaminated and dirty/infected wound, smoking, preoperative infection, NNIS risk index, body mass index, length of hospital stay (Table 4). The results of our multivariate analysis showed that the risk of SSIs increased consistently across all surgical categories where the wound class was contaminated/dirty. Although contaminated and dirty/infected wound is non-modifiable RF for SSIs, it is important to implement perioperative measures to optimize SSIs outcome. Serbian and MMA guidelines for SSIs prevention identify evidence-based measures in the perioperative period such as glucose control, skin antisepsis and antimicrobial prophylaxis to minimize the risk of wound infection [20]. Negative effects of smoking on conditions of the musculoskeletal system and treatment of these conditions, are well-documented [21]. The present study confirms that smoking is a strong predictor for SSIs in our orthopedic patients, too.

Microorganisms from a distant source of infection, principally through hematogenous spread, can cause SSIs in orthopedic patients [22]. The presence of preoperative infections significantly differed between our patients with and without SSIs. So, the practice to prevent SSIs aimed to minimize the number of microorganisms introduced into the operative site [20].

The NNIS system provides risk index for stratification of SSIs. It is widely used, operation-specific and prospectively applied and validated method for accounting for differences in case mix. The important step in our study was SSI stratification rates according to NNIS risk index.

In a report on surveillance of SSIs in Europe the cumulative incidence by NNIS risk index varied from 0.7% for hip prothesis operation with risk index of 0, to 2.7% with risk index of 2 or 3 [2]. In our study NNIS risk index for the same operations varied from 0.6% to 6.7%. For knee prosthesis operation, surveillance in Europe showed a variation of incidence by NNIS from 0.6% with a risk index of 0, to 1.9% with the risk index of 2 or 3, while our resultes showed a variation of incidence by NNIS from 2.9% with risk index of 0, to 2.2% with risk index of 2 or 3.

Yuan and Chen [23] meta-analysis showed that obesity had about two fold increased risk of SSIs in orthopedics. Our study confirms that obesity increases SSIs in orthopedics patients because of BMI determined as independent RF for SSIs (Table 4).

The LHS could be a cause and/or consequence of SSIs. Whitehouse et al. [4] reported that orthopedic SSIs prolong total hospital stays by a median of 2 weeks *per* patient. Our study showed very similar results. The patients with SSI stayed in hospital 24.72 days *vs* patients without SSI who stayed in hospital 15.95 days.

S. aureus was the most frequently isolated microorganism – 45.7% of which 43.7% were methicillin-resistant *Staphylococcus aureus* (MRSA). In France and England this pathogen was also a predominant isolate in the orthopedic categories, with decreasing occurrence of MRSA, which could be explained by the impact of various national policies directed at controlling MRSA [5, 7, 24].

Acinetobacter spp. was second most frequent germ of SSIs in our patients. There is a study which provides important information about the RFs of nosocomial *Acinetobacter* spp. infections in a large cohort of surgical patients in MMA [25].

There is a limitation of our study due to no postdischarge surveillance performed to detect SSIs. The Finish authors showed that although postdischarge surveillance had a large impact on the rate of SSIs after orthopedic surgery, it detected only a minority of deep incisional and organ/space SSIs [26].

Conclusion

The results of our study are valuable in documenting the relations between risk factors and surgical site infections in patients undergoing orthopedic surgery. Comparison of our results with the results of healthcare systems from other countries suggests active surveillance as an important component of surgical site infections reduction strategy.

The results of this study were communicated with the orthopedic surgical team to initiate greater attention to the national recommendation in prevention and control of surgical site infections.

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