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SURGICAL SITE INFECTION– THE AUTHORS' OWN PROSPECTIVE RESEARCH

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Surgical site infection is a common complication in surgery, which increases treatment cost, extends hospitalization time and can lead to septic complications.
The aim of the study was analysis of postoperative infections in own material and finding significant risk factors with preserving the obligatory procedures in the clinic.
Material and methods. Prospective analysis of 270 consecutively operated patients aged from 18 to 101 was performed with observation of early infection until 7th day postoperatively. Factors judged included: age, sex, BMI, operation type: elective or urgent, physical preparation for surgery, antibiotic prophylaxis, length and type of surgery. Wound observation card was used. Data were analysed statistically (t-Student's test, chi^2 test, U Mann Whitney test and logistic regression analysis).
Results. Wound infection was observed in 33 patients (12.22% of the entire group). In 24 (8.88%) it was a superficial infection and in 9 (3.33%) deep infection. Statistically significant risk factors were age, presence of diabetes, operation time and operations on large bowel. The average age of patients with present infection was 61.2. In the group without infection there were 6,3% patients with diabetes and 20.8% in the group with infection. In our study diabetes increased the risk of infection four times. The longer the operation time the higher was the risk of deep infection (without complications 76.2 minutes, superficial 94.9 minutes, deep 148.9 minutes). Operations on large bowel were performed in 11.9%of all study patients. In the group of 33 patients with surgical wound infection, 39.4% had colon surgery, 39.4% of all deep infections and 29.2% of all superficial infections.
Conclusions. In own study material significant risk factors of surgical wound infection were: age, presence of diabetes, length of operation, large bowel surgery. In preoperative course risk factors should be identified to perform certain prophylactic procedures to lower the risk of infectious complications.
Key words: surgical site infection, risk factors of postoperative infection, surgical wound infection prophylaxis

The most common infectious complication after surgical intervention is surgical site infection (SSI), previously referred to as surgical wound infection (1). Such infections may affect not only wounds, but also body cavities or organs following surgical interventions. The term was introduced by Horan in 1992 (2).

In 1992, the National Nosocomial Infections Surveillance System (NNISS) classified SSI into: a) superficial (the skin and subcutaneous tissue), b) deep (fascia and muscles), or c) affecting organs or body cavities at the surgical site. Depending on the time to develop an infection, it may be early (up to 7 days after the operation) or late (up to 30 days or, if an implant is in place, up to one year) (2). Various SSI risk indexes have been introduced, taking into account their main causes and the likelihood of infection development. One of them is the SENIC (Study of the Efficacy of Nosocomial Infections Control) index, including the following risk factors: 1) abdominal surgery, 2) duration of the intervention more than 2 hours, 3) contaminated or dirty surgical field, and 4) more than 3 of the above components. According to this index, SSI develops in 1% of patients without risk factors, 3.6% of those

with one factor, 8.9% with two factors, 17.2% with three, and 27% with four factors (3).

Each infectious complication after surgery delays the patient's discharge and may lead to serious septic complications, including the patient's death; in addition, treatment costs increase significantly. In an excellently documented study published in 2005, based on more than three years' observation in 140 hospitals in the United Kingdom (more than 67,000 surgical interventions), estimated additional costs due to infections ranged from GBP 959 to GBP 6,103, depending on the type of the intervention (4). It may be supposed that at present costs related to treatment of complications are much higher.

In our country, studies concerning surgical site infections are missing, especially those that might analyse the actual situation with respect to medical as well as economic aspects of this extremely important problem. The National Health Fund pays for the basic procedure; if a complication occurs, its costs, unfortunately, will be incurred by the hospital. According to the literature, we must always be prepared for a complication in the form of SSI. Being aware of the causes of SSI, we should do everything we can to prevent such complications; while theoretically possible, it is hardly feasible. Therefore, we decided to conduct our own research to evaluate the actual importance of the problem of surgical site infections in our department and to investigate potential causes of such infections.

Our objective was an attempt to analyse the current situation and, based on the results of this analysis, to develop algorithms to avoid the complications under consideration.

MATERIAL AND METHODS

The study was carried out at the 2nd Department and Chair of General and Oncological Surgery of the University Teaching Hospital in Wrocław, from March 3rd, 2012, till June 20th, 2012. The investigated group consisted of 270 subsequent patients who underwent surgical treatment and provided consent to participate in the study. Only patients who refused consent were excluded. The study was prospective. A questionnaire was developed, including: a) general information (the patient's record no., sex, age, BMI, date of admission, elective vs. emergency surgery, diagnosis, concomitant diseases, steroid therapy); b) physical preparation for the intervention (mechanical bowel preparation, bath, skin disinfectant, time and method of hair removal, appropriate underwear before the intervention); c) data concerning the intervention (date, duration, clean vs. contaminated surgical site, complications, antibiotic prevention, duration of postoperative drainage, blood transfusions, date of discharge). Data obtained from the following documents, mandatory in our department, were also included in the study: 1) surgical wound observation and topical assessment card (wound appearance, smell, the presence of cloudy or purulent discharge, inflammatory infiltration, oedema, or cellulitis), 2) nutritional risk assessment card, and 3) perioperative antibiotic prevention card. It was assumed that only early infections, i.e. those developing up to 7 days after a surgical intervention, would be observed.

All the obtained data have been compared using the t-Student's test, chi^2 test, or Mann-Whitney test, depending on the type and distribution of a specific variable. The mean and standard deviation values and the numbers and proportions are presented for continuous and discrete variables, respectively. Logistic regression analysis has also been performed; development of SSI was considered a dependent variable and demographic and clinical characteristics, clean/contaminated surgical site, preparation for the intervention, and concomitant diseases were included as independent variables.

Characteristics of the investigated group are presented in tab. 1. The patients (n = 270) were classified in three age groups: group 1 – up to 39 years, group 2 – 40-60 years, and group 3 – 61 years or older; the patient's sex, BMI, concomitant diseases (including diabetes, malignancies, and venous ulceration), and steroid therapy were also taken into account. The patients' age ranged from 18 to 101 years; the most numerous group were patients aged 61 years or more. In the investigated group, 39% of patients were overweight (BMI 25-30) and 21% – obese (BMI >30). Concomitant diseases were present in 35.2% of all patients and 47% of those aged 61 years or more. Malignancies were present in 23.7% of all patients and 34.2% of those in the eldest group; diabetes was present in 7.8% of all patients and the

Table 1. Characteristics of the investigated group

	Whole group n=270	Group 1 n=60	Group 2 n=93	Group 3 n=117
Age				
Range	18-101	18-39	40-60	61-101
Mean ± SD	55,6 ± 17,1	31,3 ± 5,4	51,7 ± 5,4	71,3 ± 8,3
Men (%)	45,2	36,7	47,3	47,9
BMI (kg/m^2)	26,4 ± 5,1	24,2 ± 5,5	26,4 ± 5,3	27,4 ± 4,3
Concomitant diseases (%)				
All	35,2	15	33,3	47
Diabetes	7,8	1,7	6,5	12
Malignancies	23,7	1,7	24,7	34,2
Steroid therapy	1,8	11,7	7,5	6,8
Venous ulceration	1,9	0	2,2	2,6

prevalence rate was also highest (12%) in the third age group.

In tab. 2 types of the procedure and in tab. 3 characteristics (clean/contaminated surgical site, emergency vs. elective surgery) and duration of the procedure are presented across the age groups.

RESULTS

In our department, specific procedures are performed in order to prevent infectious complications; these include: a whole-body bath before the surgical procedure, hair removal, the use of disinfectant cleaning products and laxatives (especially before abdominal surgery), and mandatory antibiotic prevention (Tarfazolin 1 g administered at the operating room, immediately prior to anaesthesia).

In the whole group of 270 patients, surgical site infection developed in 33 patients (12.22%); in 24 cases (8.88% of all patients) infection was superficial and in 9(3.33%) – deep. Demographic data and infection development depending on concomitant diseases and steroid therapy are presented in tab. 4. The following groups were considered: A – deep SSI, B – superficial SSI, A+B – all SSI, C – no SSI. Analysis of these data revealed that in the investigated group development of SSI, especially deep SSI, was statistically significantly more common in the elderly. No statistically significant differences were found with respect to sex or BMI. Concomitant diseases were present in 51.1% of 33 patients with SSI (a statistically significant difference) and in 66.7% of 9 patients with deep infection. Statistical significance was also observed with respect to diabetes but not malignancies, venous ulceration, or steroid therapy.

Types of the performed surgical procedures are presented in tab. 5. Development of SSI was statistically significantly more common follow-

Table 2. Types of surgical procedures depending on the patient's age

Type of the surgical procedure (%)	Whole group n=270	Group 1 n=60	Group 2 n=93	Group 3 n=117
Appendectomy	5,6	20	1,1	1,7
Lower limb varicose veins	8,5	10	10,8	6
Cholelithiasis and choledocholithiasis	16,3	21,7	21,5	9,4
Hernia	18,1	16,7	14	22,2
Thyroid gland surgery	8,5	6,7	8,6	9,4
Superficial tumours	3,3	1,7	5,4	2,6
Lower limb amputation	1,9	1,7	3,2	3,4
Anal surgery	3,3	6,7	5,4	1,7
Abdominal surgery	13	5	9,7	17,1
Colorectal surgery	11,9	1,7	7,5	18,8
Breast surgery	5,9	3,3	1,1	6
Other	3,7	5	12,9	1,7

Table 3. Characteristics and duration of the procedure

	Whole group n=270	Group 1 n=60	Group 2 n=93	Group 3 n=117
Grade 1 clean	161 (67%)	44 (73,3%)	65 (69,9%)	72 (61,5%)
Grade 2 clean-contaminated	80 (29,6%)	14 (23,3%)	28 (30,1%)	38 (32,5%)
Grade 3 contaminated	0	0	0	0
Grade 4 dirty or contaminated	9 (3,3%)	2 (3,3%)	0	7 (6%)
Emergency (urgent) surgery	25 (9,3%)	13 (21,7%)	3 (3,2%)	9 (7,7%)
Elective surgery	245 (90,7%)	47 (78,3%)	90 (96,8%)	108 (92,3%)
Mean duration of the procedure (min)	80,2 ± 47,3	63,8 ± 28,4	80,5 ± 47,4	88,5 ± 52,8

Table 4. Demographic data and infection development depending on concomitant diseases and steroid therapy

	Group A+B n=33	Group A n=9	Group B n=24	Group C n=237
Mean age	61,2 ± 14,3*	68,9 ± 15,5	58,3 ± 12,9	54,9 ± 17,3
Men (%)	52	44	54	44
BMI (kg/m^2)	26,5 ± 4,2	28,3 ± 4,3	25,8 ± 4,2	26,4 ± 5,2
Concomitant diseases potentially affecting infection development (%)				
All	51,5*	66,7	45,8	32,9
Diabetes	18,2*	11,1	20,8	6,3
Malignancies	33,3	44,4	29,2	22,4
Steroid therapy	3	11,1	0	8,9
Venous ulceration	6,1	11,1	4,2	1,3

* $p < 0.05$ vs. group C

Table 5. Types of surgical procedures and development of SSI

Type of the surgical procedure (%)	Group A+B n=33	Group A n=9	Group B n=24	Group C n=237
Appendectomy	9,1	0	12,5	5,1
Lower limb varicose veins	0	0	0	9,7
Cholelithiasis and choledocholithiasis	0	0	0	18,6
Hernia	3	0	4,2	20,3
Thyroid gland surgery	6,1	0	8,3	8,9
Superficial tumours	0	0	0	3,8
Lower limb amputation	9,1*	0	12,5	0,8
Anal surgery	6,1	0	8,3	3
Abdominal surgery	21,2	22,2	20,8	11,8
Colorectal surgery	39,4*	66,7	29,2	8
Breast surgery	0	0	0	6,8
Other	6,1	11,1	4,2	3,4

* $p < 0.001$ vs group C

ing limb amputations, colorectal surgery, and other major abdominal surgery. Deep infections were most common after colorectal surgery.

Characteristics (clean/contaminated surgical site, emergency vs. elective surgery) and duration of the procedure are presented in tab. 6. In most patients (181), the surgical site was clean (grade 1); in this group, SSI developed in 7 patients, with deep infection in one patient. In 9 patients, the surgical site was dirty-contaminated (grade 4); in this group, SSI was absent in 5 patients, deep in one pa-

Table 6. Characteristics and duration of the procedure

	Group A+B n=33	Group A n=9	Group B n=24	Group C n=237
Grade 1 clean	7 (21,2%)#	1 (11,1%)	6 (25%)	174 (73,4%)
Grade 2 clean-contaminated	22 (66,7%)#	7 (77,8%)	15 (62,5%)	58 (24,5%)
Grade 3 contaminated	0	0	0	0
Grade 4 dirty or contaminated	4 (12,1%)*	1 (11,1%)	3 (12,5%)	5 (2,1%)
Emergency (urgent) surgery	5 (15,2%)	1 (11,1%)	4 (16,7%)	20 (8,4%)
Elective surgery	28 (84,8%)	8 (88,9%)	20 (83,3%)	217 (91,6%)
Mean duration of the procedure (min)	109,5 ± 72,3*	148,9 ± 114,4	94,8 ± 45,4	76,2 ± 47,3

* $p < 0.05$ vs group C, # $p < 0.001$ vs group C

tient, and superficial in 3 patients. A majority of the patients (245) received elective surgery, while 25 patients received emergency treatment; this factor was not associated with infection development. Duration of the procedure had a significant effect on SSI development: the procedures were longest in patients with deep infections, significantly shorter in those with superficial infections, and shortest in those without complications.

Multivariate analysis revealed that development of SSI was significantly associated with colorectal surgery and concomitant diabetes, while clean surgical site reduced the risk of infection.

DISCUSSION

Surgical site infection is an undesirable but unfortunately the most common and inherent complication of surgical procedures. Studies analysing the causes of SSI are ongoing; virtually all risk factors are known, prevention methods are being studied, and the literature on this subject is remarkably rich (5-8). It is widely known that postoperative infection entails the risk of serious complications, including sepsis and death, delays the patient's discharge, and substantially increases treatment costs. Studies evaluating the scale of the problem in Poland are missing. In practice, surgeons are aware of the risk factors of SSI development and, surely, try to prevent it; procedures aimed at prevention of this complication are introduced, and, should such a complication occur, it is usually attributed to "force majeure", without an attempt to investigate potential negligence on the part of the personnel. However, in our opinion such an approach is wrong – every case should be thoroughly analysed in order to find potential problems that may be resolved in the future. Publications concerning involuntary negligence of the personnel may be found in the literature (9, 10, 11).

The aim of our research was analysis of our own data with respect to development of surgical site infection. We attempted to evaluate the weight of the problem as well as specific factors affecting development of infection in our patients and the possibility to avoid them in the future. Our observation was limited to the early postoperative period, i.e. 7 days.

Statistical analysis of our data revealed the following significant risk factors: the patient's age, diabetes, duration of the surgical procedure, and colorectal surgery (clean-contaminated surgical site).

In our data, the patients' age (n = 270) ranged from 18 to 101 years (mean: 55.6 ±17.1) and in all 33 cases infection developed in patients aged 61.2 (±13.3) years. In theory, the patient's advanced age itself is not a contraindication for surgery; however, our findings confirm observations of other authors – postoperative infections are more common in the elderly (12, 13).

Diabetes is a recognised risk factor of SSI. Infection in diabetic patients, especially after

colorectal surgery, is 3.8 times more common than in normoglycaemic individuals (14). Similar findings have been reported by other authors, e.g. Enzler M from Mayo Clinic (12). In our data, diabetes affected 20.8% of patients with superficial SSI in comparison with 6.3% of patients with diabetes and without infection. In this group of patients, we found no significant differences between deep and superficial infection. Multivariate analysis revealed that diabetes increased the risk of SSI by four times. In our opinion, such patients require special care, with glycaemic control before the procedure, and glycaemia in the postoperative period should be maintained close to the normal range.

Duration of the surgical procedure is an independent and significant risk factor of surgical site infection, and constitutes one of three components of the SENIC index used to calculate the likelihood of SSI development (3). In a very interesting study, American authors analysed more than 60,000 surgical procedures performed with or without the presence of a resident and found that usually procedures took slightly more time when a resident was present, and that duration of the procedure and not the presence of a resident was an independent risk factor (15). The analysis of our data confirmed that longer duration of the procedure was a significant risk factor of postoperative infection and that duration of the procedure correlated with the likelihood of deep infection. In patients without complications, the mean duration of the procedure was 76.2 minutes, while in patients with superficial infection it was 94.8 minutes and in those with deep infection – 148.9 minutes.

Colorectal surgery is a recognised risk factor; the surgical site was classified as clean-contaminated (controlled opening) or dirty-contaminated (when intestinal perforation occurred) (3). Mohan H.M. found that in as much as 49% of patients in whom the gastrointestinal tract was opened surgical site cultures revealed the presence of intestinal bacteria (16). In our research, colorectal surgery (except appendicitis) was performed in 11.9% of all 270 patients. In patients with SSI, as much as 39.4% underwent colorectal surgery (including 39.4% of all cases of deep infection and 29.2% of cases of superficial infection).

In our data, no statistical significance was found for such recognised risk factors as body weight, steroid therapy, or malignancies. Perhaps such relationships could be observed if the investigated group was larger or the observation period longer. Seven cases of SSI in patients with clean surgical site (i.e. 21.2% of all observed cases) require a separate, thorough analysis. Additional risk factors, other than clean/contaminated surgical site, must be considered in these cases.

CONCLUSIONS

The analysis of our data revealed significant risk of postoperative infection in the circumstances and procedures applied in our department. Our research allows for the following conclusions:

1. It has been confirmed that the patient's age, diabetes, duration of the surgical procedure, and colorectal surgery are significant risk factors of surgical site infection.
2. The risk of infection should be thoroughly evaluated for each individual patient before the procedure. This will make it possible to identify patients in whom preventive procedures should be applied with special care and to introduce additional procedures as necessary.

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