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Risk factors in superficial infections of surgical sites in colorectal carcinoma surgery

Dawid Murawa[1], Zefiryn Cybulski[2], Arkadiusz Spychała[1], Anna Bojanowska-Juste[3], Paweł Murawa[1]

[1] 1st Surgical Oncology Department, Great Poland Cancer Center, Poznań, Poland
[2] Microbiology Laboratory, Great Poland Cancer Center, Poznań, Poland
[3] Epidemiology Officer, Great Poland Cancer Center, Poznań, Poland

Summary

Aim The aim of the paper was to conduct a retrospective analysis of a group of patients after surgery for colorectal cancer: to define aetiological factors for, and assess drug-sensitivity of bacteria causing infection.

Materials/Methods Between January 2000 and June 2004, 350 patients underwent surgery for colorectal cancer. Within that group 17 (4,86%) patients developed postoperative wound infections within 30 days of the operation. In all cases we performed microbiological examinations. All the cases of infections were analysed, with special attention being paid to the following groups of risk factors: patient-related and perioperative procedures.

Results In all, 17 cases of superficial infections were identified within the skin and subcutaneous tissues. The most frequently identified aetiological factors were colibacillus species and *Enterococcus faecalis*. Targeted antibiotic therapy was applied, based on the results of antibiograms. Rapid recovery was observed in all patients. The most important patient-related risk factors included: BMI over 25 kg/m^2 in 11 (64.7%) patients, high (3rd) degree of neoplastic advancement in 13 (76.5%) patients and preoperative radiotherapy in 7 (41.2%) patients. All infections were found in patients after resection of the sigmoid colon or rectum.

Conclusions The most frequent aetiological factor identified, on the basis of cultures, was bacterial flora of the colorectum. 1. The most important risk factors include: degree of neoplastic advancement, obesity and preoperative radiotherapy. 2. The application of appropriate systems for the preparation of the patient during the perioperative period has a great influence on the frequency of infections. 3. Because high drug-resistance in bacterial cultures is a real possibility, it is essential to perform antibiograms in order to help select the most appropriate antibiotics for the treatment of infections.

Key words colorectal cancer • surgical site infection • infection prophylaxis

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Author's address: Zefiryn Cybulski, Microbiology Laboratory, Great Poland Cancer Center, Garbary 15 Str., 61-866 Poznań, Poland, e-mail: zefiryn.cybulski@wco.pl

Background

In 1992, the American Centers for Disease Control and Prevention (CDC) and the Surgical Infection Society introduced a new term to describe certain wound infections, namely surgical site infection (SSI). Under this new term, superficial infections are distinguished (skin and subcutaneous tissue) from deep infections and those of the organs and anatomic spaces [1]. It has long been known that appropriate aseptics, antiseptics and antibiotic prophylaxis play a vital role in the reduction of the number of postoperative wound infections. For obvious reasons, colorectal surgery is related to the highest percentage of infections. The frequency of SSI occurrence in colorectal carcinoma surgery covers a very wide range, from 3% up to as much as 60% in the case of emergency operations resulting from complications of neoplastic diseases (perforations, obstructions). SSI in operated patients altogether amounts to 14–16% [2,3]. Data which show that 77% of surgical patients' deaths are directly or indirectly related to the problem of infections are also worth attention. On average SSI increases the risk of death more than twofold (2.2 times) in comparison to patients without infections [4].

SSI is also an economic problem as patients with these complications stay in hospital 7–10 days longer than others. In consequence, treatment costs may be increased by around 20% [4,5].

Aim

The aim of the paper was to conduct a retrospective analysis of a group of patients after surgery for colorectal cancer with respect to risk factors related to the patient and local/surgical factors (peri-operative procedures).

Material and Methods

Between January 2000 and June 2004, 350 patients treated in the 1st Surgical Oncology Department, Wielkopolska Oncology Centre, underwent colorectal resection owing to the presence of a neoplasm. Within this group, 17 cases of superficial surgical site infection were noted within 30 days of the operation. In each case, material was taken for culture. The cultures were made on the following media: Columbia agar, CPS, Drygalski medium, D-Coccosel, Cetrimide, Albicans ID2, Schaedler medium with vitamin K_3 and agar, and BHI broth. All the media were produced by the bio-Merieux company. The identification of micro-organisms was carried out on the basis of standard bacteriological methods, using bio-Merieux tests. The drug sensitivity of cultured Gram-negative bacilli was tested using the ATB Expression system and antibiogram tests ATB G- or ATBPSE, while the drug sensitivity of enterococci was tested using ATB Strep and ATB Enteroc.

Cases of deep and organ SSIs were not analysed in this paper. Factors which may have influenced the occurrence of infection in the examined group were analysed. Patient-related factors were listed, such as: age, BMI value, laboratory parameters of the state of nutrition, anaemia, blood glucose level, the degree of progression of the neoplasm, concomitant diseases and application of preoperative radiotherapy. Another group were local/surgical factors, i.e. peri-operative procedures in a broad sense. Due to the retrospective character of this paper, the rules applied in our department were presented: physical preparation of the colorectum, antibiotic prophylaxis – oral and systemic, applied sutures and surgical practice.

Statistical analysis was not performed owning to low numbers of cases.

Results

In all 17 (4.86%) patients the infection was superficial, i.e. it was observed on the skin and in the subcutaneous tissue. Most frequently the aetiological factors of infection were colibacilli, observed in 8 patients, and *Enterococcus faecalis*, cultured from materials collected from 7 patients (Table 1). In accordance with the results of antibiograms, antibiotic therapy was begun and the wound was debrided. In all cases, the effect was a rapid recovery from the infection. In the aforementioned group the occurrence of patient-related risk factors were analysed. High BMI (over 25 kg/m^2) was noted in 11 (64.7%) patients and a high (3rd stage) degree of progression of the neoplasm in 13 (76.5%) patients. Preoperative radiotherapy, applied in 7 (41.2%) cases, also seemed to be a factor increasing the risk of SSI. However, no influence of the following risk factors was observed: malnutrition, anaemia – 1 (5.9%) patient, diabetes – 1 (5.9%) patient, age over 70 – 2 (11.8%) patients. It is worth stressing that all the infections were observed in patients after resection of the sigmoid or rectum. Patients were admitted to the department more than 3 days before the operation. In Tables 2 and 3 the results

Table 1. Bacterial flora isolated from the wound.

Patient initials	Diagnosis	Isolated bacteria	Date
Z.M.	Ca recti	*S. aureus, E. faecalis*	2003
N.P	Ca recti	*P.mirabilis, E.hirae*	2003
J.T	Ca recti	*S. aureus, E. faecalis, Propionibacterium acnes*	2003
M.Ł	Ca recti	*K. pneumoniae, E. coli*	2003
K.B	Ca recti	*E. coli, P. aeruginosa*	2002
G.Z	Ca recti	*E.coli, P. aeruginosa*	2002
K.A	Ca recti	*E. coli*	2004
R.S	Ca sigmae	*Propionibacterium acnes, E. faecalis*	2001
A.E	Ca sigmae	*E. cloacae, E. faecalis, K. pneumoniae, Citrobact. freundii*	2001
U.J	Ca sigmae	*E. coli, E. faecalis*	2000
S.J	Ca sigmae	*E. coli, E. faecalis*	2000
S.S	Ca recti	*S. epidermidis*	2001
W.U	Ca recti	*E. coli, E. faecalis*	2001
O.Z	Ca recti	*S. epidermidis*	2000
B.M	Ca recti	*S. anginosus*	2001
P.WL.	Ca recti	*E.coli, P. aeruginosa*	2004
K.T	Ca recti	*Staphylococcus spp.*	2004

of *E. coli* and *E. faecalis* drug sensitivity tests are shown. Of the eight strains of colibacilli presented in Table 2, seven showed resistance to amoxicillin and cephalothin, six to ticarcillin, four to piperacillin, three to co-trimoxazole and one to amoxicillin/clavulinic acid. All strains were sensitive to cefotaxime, tobramycin, amikacin, gentamycin and ciprofloxacin. Similarly, all strains of *E. faecalis* identified showed sensitivity to gentamycin and beta-lactam antibiotics as well as teicoplanin and vancomycin. Local/surgical risk factors, i.e. perioperative procedures, are usually related to a collection of practices developed and applied in a given centre. In our department, one day before surgery to the colorectum, we carry out a mechanical lavage of the colorectum using a Fortrans preparation. Also implemented is antibiotic prophylaxis, currently including oral administration of metronidazole and neomycin at 6 p.m. and 11 p.m. on the day preceding the operation. Systemic administration of metronidazole and a 2nd generation cephalosporin is carried out half an hour prior to surgery and is continued up to 24 hours after the operation. The Team for Prophylaxis of Hospital Infections is responsible for the scheme of antibiotic prophylaxis. Besides this system, we pay attention to the need for a thorough bath on the day preceding the operation, shaving, directly before the operation, and the rule of operating within three days of admission to hospital. For intra-operative procedures we follow the rules defined in the literature as "good surgical practice". This is a whole complex of procedures that are vital to the prophylaxis of infections (delicate and bloodless preparation of tissues, changing of gloves after removing the preparation, removing the tools used for connection). Subcutaneous drains are carefully applied, e.g. in the case of thick and bleeding fatty tissue. Monofilament sutures are used to close the abdominal wall.

Discussion

In the United States alone, 2.1 million hospital infections are registered every year. Of those, 1/5 are surgical site infections. This is an increasing problem that requires additional financial outlay. As a result, the identification of patients at increased risk of infection, and the optimisation of preoperative preparation and perioperative care should be taken into special consideration [2,5,6]. As various research shows, appropriate procedures may contribute to a considerable reduction in the frequency of infections [1–6]. Because of its retrospective character, this paper

Table 2. *E. coli* drug-sensitivity.

Antibiotic	Number of strains		
	s	i	r
Amoxycillin	1	0	7
Amoxycillin/clavulinic acid	6	1	1
Ticarcillin	2	0	6
Piperacillin	5	1	4
Cefalotine	1	0	7
Cefotaxime	8	0	0
Tobramycin	8	0	0
Amicacin	8	0	0
Gentamycin	8	0	0
Ciprofloxacin	8	0	0
Co-trimoxazole	5	0	3

s – sensitive; i – intermediate sensitivity; r – resistant.

Table 3. *E. faecalis* drug-sensitivity.

Antibiotic	Number of strains		
	s	i	r
Penicillin	7	0	0
Ampicillin	7	0	0
Erythromycin	0	5	2
Gentamycin	7	0	0
Streptomycin	4	0	3
Ciprofloxacin	2	2	3
Tetracycline	4	0	3
Teicoplanin	7	0	0
Vancomycin	7	0	0

s – sensitive; i – intermediate sensitivity; r – resistant.

analysed only selected risk factors and, due to the low percentage of superficial SSIs for colorectal surgery, the applied system of perioperative procedures attracts attention.

Tang and colleagues prospectively analysed a group of 2809 patients after resection of the colorectum in terms of SSI risk factors. This was the greatest research of its kind from a single centre. The authors noted that in the group they studied, the most significant risk factor was intraoperative or postoperative blood transfusion. Allogenic blood induces immunosuppression and predisposes the patient to postoperative infections [3]. This was confirmed by research done by Jensen and colleagues and by Heiss and co-workers [7,8]. On the other hand there are reports, including those from the Sloan-Kettering Memorial Cancer Center in New York, that blood transfusion does not significantly increase the risk of infection in groups of cancer patients [9].

Table 4. Surgical site infection – risk factors.

Sloan-Kettering Memorial Cancer Center	National Nosocomial Infections Surveillance
Obesity Preoperative length of hospital stay ≥ 3 days ASA physical assessment score 3, 4 or 5 Operation time ≥4 hours class III or class IV procedure	ASA physical assessment score 3, 4 or 5 Operation time ≥T (time depending on procedure type) Class III or class IV procedure

In many reports, obesity is presented as a well documented SSI risk factor [5,9–11]. Furthermore, it is pointed out that in this group of patients antibiotic prophylaxis should include higher than normal doses, in order to obtain appropriate concentrations in the tissues [9]. Obesity was also observed in most patients with infections in our study. In some publications diabetes, malnutrition and loss of body mass are listed as relevant factors. Moreover, a significant role for those factors is especially stressed in the case of organ infections. In diabetics a preoperative blood glucose level of ≥200 is an independent SSI risk factor (increased 4.4x) [2,12]. However, Zerr and colleagues showed that preoperative control of the blood glucose level facilitates the elimination of this important risk factor [12].

Increased risk of SSI has also been described in patients who have been in hospital for 3 or more days prior to surgery [9,13]. It is worth noting that in the group we evaluated, all the patients were admitted more than 3 days before the operation. Many publications suggest that such situations should not arise. For example, one should take care to carry out as many necessary examinations as possible in the ambulatory manner, before admission to hospital [9,10].

The aforementioned risk factors concern all operated patients. However, additional problems should be taken into consideration in the case of patients with neoplastic disease. It has been assumed that the neoplastic process itself, which induces immunosuppression, is an SSI risk factor. In the group of infections which appeared in our material, the vast majority were people with an advanced degree of neoplastic progression. It is worth noting that the evaluated material comprised only resection cases. In the literature on SSI in patients with colorectal carcinoma, the problem of the degree of neoplastic progression is rarely presented [9]. An interesting paper by Malone and colleagues, which retrospectively analysed SSI risk factors in 5031 surgical patients, showed that the occurrence of ascites significantly increases the risk of wound infections. However, the same publication showed no increased risk in the case of disseminated neoplastic processes [2]. Could the application of chemotherapy and/or radiotherapy increase the risk of SSI? In our group, patients after preoperative radiotherapy of rectal carcinoma (5x5Gy) represented a considerable portion of the infections (41.2%). International literature suggests that radiotherapy may increase the risk of SSI by impairing wound healing, especially if conducted within the 2 weeks before or after the operation. In addition to this, attention is drawn to the increased difficulty in diagnosing SSI in the event of such post-radiation symptoms as erythema or fibrosis occurring [9,13].

Obviously there are even more infection risk factors presented in different reports. The following, at least, are worth noting: smoking, alcohol abuse, steroid therapy, distant sites of infections and renal failure [2,3,9–11]. Thus, in everyday clinical practice, it seems reasonable to limit attention to the most important SSI risk factors (screening procedure). In the literature on the subject, the SSI risk indexes suggested by the Sloan-Kettering Memorial Cancer Center or the National Nosocomial Infections Surveillance unit (Table 4) are good examples of such conduct [9,14].

From the results of our research, seven out of the eight cultured strains of *E. coli* showed resistance to amoxicillin. Other authors have also pointed out the high resistance of colibacilli to this drug [15,16]. When considering antibiograms of *E. faecalis* strains it must be stressed that, in the examined material, no strains resistant to beta-lactam antibiotics were observed and that these drugs are frequently applied in the antibiotic therapy of infections caused by enterococci. Furthermore, no VRE (Vancomycin Resistant Enterococcus) strains were found. These currently represent a serious threat, owing to their high resistance to antibiotics [17].

It has been proved that the application of prophylactic antibiotic therapy in colorectal surgery considerably reduces the number of infections and deaths in comparison to groups that do not receive such prophylaxis. However, discussions continue on the choice of antibiotic, administration time and duration of application, and also, whether a single drug or several should be applied, and the means of administering them. There are no agreed standards in this respect [18,19]. The aforementioned work of Tang showed that there are no differences in the frequency of surgical site infections related to the antibiotic applied, if the patient has additionally received oral administration of an antibiotic acting on anaerobic bacteria [3]. Numerous papers state that an individual dose of antibiotic lasting up to 3 hours is a sufficient standard for operations planned on the colorectum [3,6,20]. However, there are authors who suggest prolonging such antibiotic therapy for up to 72 hours after surgery. The antibiotic should be administered directly before the operation (up to one hour before). Research has shown that antibiotic prophylaxis is correctly applied in only 40% of cases. The most frequent error concerns the time of administration of the antibiotic, for example, after the operation. This is a gross procedural error which does not decrease the frequency of SSI at all, and in addition to that, may mask infections which may only reveal themselves clinically later [21]. In the United States, in preparation for an operation on the colorectum, more than 80% of surgeons apply mechanical cleansing of the colorectum in combination with systemic and oral antibiotic therapy, bringing optimal effects [11,22,23]. A similar system has been a standard in our department for several years. Our results seem to confirm the correctness of this procedure.

What remains a difficult problem for discussion in the case of SSI is the question of good surgical practice and the influence of the surgeon as an individual on the frequency of infections. Research exists which shows that the use of monofilament sutures reduces the risk of infections, when compared with the use of multifilament sutures. Similarly, it is recommended that the use of sutures, to move the subcutaneous fatty tissue closer, should be avoided. The application of subcutaneous drains should also be limited to the necessary minimum. It is preferable to devote time to thoroughness of haemostasis. In surgical technique one should also pay attention to appropriate preparation of the tissues, minimisation of bleeding, removal of ischaemic tissues, clearance of dead spaces and avoidance of contact with tissues with secretions from the alimentary tract [11,24].

In this discussion it is also worth noting one further problem, which is also visible in our group of patients: Why were all the patients with SSIs after surgery to the left half of the colon? Barber, of the Sloan-Kettering Memorial Cancer Center asked a similar question in his report. The author thought that it is necessary to take into consideration the need to change the classification of some of the operated patients from Class II (clean-contaminated) to Class III (contaminated) of cleanliness of the surgical field in the event that unfavourable conditions arise during the operation, e.g. escape of the colorectal contents. Such situations may arise in operations which are technically difficult, such as. resection of the rectum in a deep and narrow pelvis. Here one should perhaps consider further prolonging antibiotic prophylaxis [9].

Conclusions

1. Most frequently, bacterial flora of the colorectum was the aetiological factor of wound infection.

2. In the analysed material it was found that the degree of progression of the neoplasm, obesity (high BMI) and preoperative radiotherapy have the greatest influence on the risk of surgical site infection.

3. Appropriate observance of a system of patient preparation in the perioperative period has a great influence on reducing the percentage of wound infections.

4. Owing to the possible of appearance of strains with high resistance to drugs it is necessary to produce antibiograms, thus allowing for the selection of an appropriate antibiotic in the treatment of surgical site infections.

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