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Factors Influencing the Occurrence of Infectious Complications after CABG – Single Centre Study

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Abstract

Introduction: Infectious complications after cardiac surgery procedures may lead to catastrophic consequences for the patient. Infection occurring in the perioperative period significantly increases both the length of hospitalization and the treatment costs.

Methods: A prospective, observational study was performed in a group of 299 CABG patients operated in the Department of Cardiac Surgery of the Pomeranian Medical University. All patients were evaluated in the context of infections occurring early in the postoperative period, i.e. until the 7th postoperative day. The influence of analysed factors on the rate of infections in the early postoperative period after CABG was assessed.

Results: Both the period of preoperative ischaemic heart disease and the operative risk (ESlog) were significantly higher in the group of patients presenting with postoperative infection. In the group of patients with infection the reperfusion time was significantly longer when compared with the other group. Logistic regression analysis shown significantly higher volume of post operative drainage in a group of patients with infection.

Summary: Our results showed no significant differences in the amount of transfused blood products when comparing the group with and without postoperative infection. Only the amount of drainage from the operative site, was a risk factor of post operative infection in cardiac surgery patients.

Keywords: Cardiac surgery; Septic complication; Risk factors

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Introduction

Cardiac surgery procedures bear an increased risk of infectious complications, related to invasiveness of the operating technique and activation of inflammatory reactions. Infectious complications may lead to catastrophic consequences for the patient and are the cause for prolonged hospitalization and therefore increased treatment costs. Limiting infectious complications requires not only an improvement in surgical techniques, but also an implementation of adequate microbiological and epidemiological strategy. According to the literature the frequency of infections after cardiac surgery is between 3,2% and 27% [1-3]. The mortality rate among cardiac surgery patients with infection complicating the postoperative course is approx. 17% and in patients without infection it is 3% [4]. Other multicenter studies have shown that the frequency of infections after operations with the use of cardiopulmonary bypass approaches nearly 27% [1]. Among the most common problems, lower respiratory tract infections predominate, with the frequency close to 57% of all perioperative infections [3]. This seems to be a very serious issue, as the mortality in Ventilator Associated Pneumonia (VAP) reaches 46%. Infection occurring in the perioperative period significantly increases both the length of hospitalization and the treatment costs [3,5,6]. The increased occurrence of infective complications after cardiac surgery is multifactorial in origin. Patient's condition prior to the operation, as well as the intraoperative course are important components of the risk of infection here. The purpose of the present study was to an evaluation of the influence of analysed factors on the frequency of infective complications after CABG.

Material and Methods

A prospective, observational study was performed in a group of 299 patients with ischaemic

Table 1: Study group characteristics.

	Study group n=299	Infections (-) n=253	Infections (+) n=46	P
	Mean ± SD	Mean ± SD	Mean ± SD	
Age (years)	64.4 ± 9.9	63.3 ± 9.9	65.5 ± 8.9	0.393
Weight (kg)	78.6 ± 13.7	78.6 ± 13.7	78.5 ± 12.5	0.451
Height (cm)	167.1 ± 9.2	166.8 ± 9.2	167.4 ± 8.9	0.881
BMI (kg/m^2)	28.1 ± 4.1	28.2 ± 4.1	27.9 ± 3.6	0.379
Sex				
Males	76 (25.4%)	66 (26.5%)	10 (21%)	
Females	223 (74.6%)	187 (73.5%)	36 (79%)	0.572
Both	299	253	46	
IHD (months)	64.4 ± 9.9	55.4 ± 93.5	97.9 ± 188.4	1E-04
ESlog (%)	6.5 ± 7.4	5.9 ± 6.8	9.4 ± 9.4	0.003
CCS (points)	2.9 ± 0.7	2.9 ± 0.7	2.9 ± 0.7	0.917
NYHA (points)	1.2 ± 1.34	1.2 ± 1.3	1.2 ± 1.5	0.108

Legend: SD: Standard Deviation; BMI: Body Mass Index; IHD: Ischaemic Heart Disease; ESlog: EuroSCORE Logistics; CCS: Canadian Society of Cardiology; NYHA: New York Heart Association

Table 2: The variables regarding the perioperative course.

	Study group n=299	Infections (-) n=253	Infections (+) n=46	
	Mean ± SD	Mean ± SD	Mean ± SD	P
Perfusion time (minutes)	56.5 ± 32.6	55.2 ± 20.9	61.9 ± 16.9	0.052
Reperfusion time (minutes)	23.8 ± 10.4	21.8 ± 15.1	31.3 ± 41.2	0.007
WBC prior to surgery (thousands/ml)	7.8 ± 3.9	7.6 ± 4.0	8.1 ± 2.7	0.002
CRP prior to surgery (mg/l)	6.4 ± 11.7	6.6 ± 12.3	5.5 ± 6.8	1E-04
Preoperative creatinine (mg/dl)	0.98 ± 0.29	0.97 ± 0.28	1.00 ± 0.35	0.054
CKMB (ng/ml)	49.1 ± 41.3	47.6 ± 40.2	58.0 ± 46.9	0.589
Drainage (ml)	845.5 ± 589.1	783.2 ± 445.1	1208.5 ± 1040.8	1E-04
PRBCs (ml)	1018.8 ± 701.6	992.1 ± 702.9	1150.0 ± 692.5	0.974
FFP (ml)	798.9 ± 353.4	776.5 ± 325.9	875.0 ± 399.0	0.187
CRP day 1 (mg/l)	77.5 ± 44.6	74.3 ± 38.7	96.3 ± 67.5	1E-04
CRP day 2 (mg/l)	139.5 ± 67.7	133.9 ± 63.5	171.9 ± 81.7	0.021
WBC day 1 (tys./ml)	10.0 ± 3.2	9.8 ± 2.9	11.2 ± 4.3	2E-04
WBC day 2 (tys./ml)	11.3 ± 3.8	11.1 ± 3.5	13.2 ± 4.7	0.005
PCT day 1 (ng/ml)	4.3 ± 9.0	3.3 ± 6.6	8.1 ± 14.8	1E-04
PCT day 2 (ng/ml)	5.8 ± 15.8	4.2 ± 10.5	17.1 ± 34.8	1E-04
Crea day 1 (mg/dl)	1.2 ± 0.8	1.2 ± 0.8	1.3 ± 0.7	0.3
Crea day 2 (mg/dl)	2.1 ± 8.3	2.2 ± 8.9	1.4 ± 1.0	0.054

Legend: SD: Standard Deviation; WBC: White Cell Count; PRBCs: Packed Red Blood Cells; FFP: Fresh Frozen Plasma; CRP: C-Reactive Protein; PCT: Procalcitonin; Crea: Creatinine

heart disease operated in the Department of Cardiac Surgery of the Pomeranian Medical University. Patients were qualified for the study after obtaining an informed consent accepted by the Bioethics Committee of the Pomeranian Medical University (KB-0080/176/09 issued on 23.11.2009). All patients were qualified for operative treatment of the ischaemic heart disease with the use of extra-corporeal circulation by one of the consultant cardiac surgeons from the Department of Cardiac Surgery of the Pomeranian Medical University, according to the EACTS guidelines. The data regarding sex, age, height, weight, concomitant diseases and past medical history was collected from standard medical records. Additional data collected for this study was the history of smoking, the length of ischaemic heart disease and family history. During hospitalization the severity of ischaemic heart disease was evaluated according to Canadian Cardiovascular Society (CCS) and the operative risk according to the ESlog scale. Patients were prepared for the operation according to the internal protocol of the Department of Cardiac Surgery of the Pomeranian Medical University. The protocol covered preoperative laboratory studies: full blood count, electrolytes levels, C-reactive protein and creatinine levels. Depending on the laboratory values for haematology, blood products were grouped and saved. During the ambulatory preoperative outpatient visit a nose swab was performed towards Methicillin Resistant Staphylococcus Aureus (MRSA) carrier status. An absolute prerequisite for each patient was to be washed directly before entering the operative suite, with hair removal if necessary. Antibiotic prophylaxis (IInd Generation

Table 3: Mono factorial analysis.

	R_1	R_2	Z	P
Age	37227.5	7622.5	-1.3393	0.18
EuroSCORE Logistic	36956.5	7893.5	-1.841	0.065
Length of hospitalization	36720.5	8129.5	-2.3166	0.02
Cost of hospitalization	36630	8220	-2.4462	0.014
Length of IHD	32583.5	5919.5	-0.1697	0.865
Smoking	38539	6311	1.2922	0.196
Height	36889	6476	0.0259	0.979
Weight	36916	6449	0.0779	0.937
BMI	36940.5	6424.5	0.125	0.9
Perfusion times	32778.5	6842.5	-1.2898	0.197
Cross clamping	36067	5554	1.3125	0.189
Number of by-passes	37293	6072	0.8358	0.403
CKMB	35768	7892	-2.0389	0.041
Drainage	35387	7978	-2.2519	0.024
PRBCs	11109.5	2585.5	-1.3456	0.178
FFP	6572.5	1683.5	-1.2969	0.194
Platelets	346	150	-1.4101	0.158

Legend: WBC: White Cell Count; PRBCs: Packed Red Blood Cells; FFP: Fresh Frozen Plasma; CKMB: Myocardial Isoenzyme of Creatinine Kinase; myR_1: Rang Sum in the Group without Infection (n=253); R_2: Rang Sum in the Group with Infection (n=46); Z: Test Statistics Value

Cephalosporin Antibiotic) was given 30 minutes prior to skin incision. The operation was performed using standard technique for coronary artery bypass grafting via mid-line sternotomy. The bypass material was either internal mammarian artery or saphenous vein. The data analysis included intraoperative data regarding the number of grafts, length of extra-corporeal circulation, aortic clamping time, vasopressor requirements and the amount of blood products transfused. All patients were evaluated in the context of infections occurring early in the postoperative period, i.e. until the 7th postoperative day. Infectious complications were those confirmed microbiologically - operative site infection, blood borne infections and pneumonia. The influence of analysed factors on the rate of infections in the early postoperative period after CABG was assessed. The data was analysed using statistical methods. Both monofactorial and multifactorial analyses were performed which led to a development of a model of postoperative infections including both demographic and clinical data. To achieve this both traditional statistical methods of classification were utilised, i.e. logistic regression or naive Bayes classifier as well as newer methods, more popular for classification in biostatistics - methods of machine learning. The method of support vector machine was used as means of multifactorial analysis. The above mentioned analyses were performed using the STATISTICA, R and Weka programs (licence no. AXAP302C295811AR-B).

Results

The demographical data, as well as data regarding concomitant diseases, the preoperative risk and the performance of cardiovascular system are shown in the (Table 1). In the study group nearly 26% were women, 74% were men. There were no significant differences regarding age, weight, height or BMI among patients with infection as compared to patients without infection. Both the period of preoperative ischaemic heart disease and the operative risk (ESlog) were significantly higher in the group of patients presenting with

Table 4: Multifactorial analysis.

	HR	95% CI	SE	P
CKMB	1.004	1.011	0	0.2
Drainage	2.199	3.581	0.25	0

Legend: CKMB: Myocardial Isoenzyme of Creatinine Kinase; HR: Hazard Risk; CI: Confidence Interval, SE: Standard Error

postoperative infection. The data regarding the perioperative course are shown in (Table 2). In the group of patients with infection the reperfusion time was significantly longer when compared with the other group. The initial inflammation markers reached statistical significance, with higher CRP and lower WBC values in the group without infection. Within the study group there were 46 cases of microbiologically confirmed infections, which was approx. 15.4% of the whole study group. Isolated pneumonia was diagnosed in 12 cases, vascular bed infections in 4 patients and operative site infections in 9 patients. In 11 cases the occurrence of fever and positive blood cultures was associated with positive BAL cultures, with the same pathogen isolated from both sites. Similarly – in 10 cases of operative site infections the blood cultures were positive for the same pathogen. The analysis involved the type of pathogen causing infection, in regard to the species, as well as the distinction between Gram (+) and Gram (-) bacteria. Among all of the pathogens, only 19% were Gram (+) bacteria, however nearly 80% were Gram (-) bacteria. Among Gram (+) bacteria more than 90 % were MRSE and MSSA. In the Gram (-) group half of the infections were caused by multi-resistant non-fermenting rods, with nearly half caused by the Enterobacteriacae family. The results of the monofactorial analysis using non-parametric U-Mann-Whitney test are shown in (Table 3). The difference between the two groups was statistically significant when regarding the length of hospitalization, cost of treatment, CKMB level, as well as the postoperative drainage. The parameters which naturally differentiate the two groups, such as WBC, PCT and CRP, were excluded from the analysis. Logistic regression analysis used only the parameters that determine the severity of postoperative course, i.e. CKMB and the volume of drainage. The results of multifactorial analysis are shown in (Table 4).

Discussion

Infections occurring in the postoperative period are still major problems in cardiac surgery. The frequency of infections reported after CABG, depending on the source, ranges from 3.2% to 15% of all operated patients. The divergent results are the effect of differing variable degree of hygienic and preventive procedures in different centres around the world, as well as an incomparable difference in the issues regarding location and equipment supply. Rapid movement of patients between the wards and hospitals renders inadequacy in determining the number of infections. Chen et al. [2] in a study published in year 2012 and performed in a group of 10500 patients undergoing cardiac procedures showed the frequency of cardiac surgery related infections at 3.2%. On the other hand Jabbur et al. [7] in year 2010 reported a nearly 15% infection rate among 392 patients included in the study. Similarly, in a study performed by the authors the infection rate after CABG was as high as 15.4%. The differences in the frequency of infections do not result from the material status and technological advancement of the American, Libian or Polish societies only, but also on the definitions used in the study. In the study by Chen a postoperative infection was only reported as vascular bed or sternum wound infection confirmed microbiologically. On the other hand, in the study by Jabbur the range of infections above the two

mentioned studies, also included pneumonia or lower leg wound infections if confirmed microbiologically. In the study presented by us the vascular bed infection was diagnosed if at least one positive blood culture was obtained, with the exclusion of the saprophytic skin flora, occurring in patients with at least one episode of fever. Quite commonly, despite a positive blood culture the symptoms resolved without any antibiotic therapy. Often it was dependent on time to receive positive blood cultures (72 hrs or more). In these cases the most common pathogen was Coagulase Negative Staphylococcus (CNS). It is also important to point out that Chen registered the infections after cardiac surgery since year 2000. Initially the infection rate was 5.4%, i.e. almost twice as high as cited in the publication from year 2012. This observation confirms the pivotal role of constant personnel training, as well as reporting and analysing the reasons for infections. When analysing clinical forms of infections occurring after CABG it is important to notice that approximately 50% is pneumonia, 40% is infection of the operative site, with isolated vascular bed infections being only 9% of all infectious episodes. From the observations made by us it is clear that pneumonia is by far the most common clinical manifestation of infection reaching 51%. In approx. 50% of cases of pneumonia the same pathogen was cultured from patients blood, due to the fact that in these cases the infection was generalized. In the literature available to us, the frequency of pneumonia in the postoperative period in cardiac surgery patients was between 3 and 42% [8-10]. In the presented study it achieved 8% of all patients. This comprises a high percentage as compared to the results obtained by Kinlin et al. [11], where in the group of 17143 patients undergoing CABG in 32 hospitals in USA the frequency of pneumonia in the postoperative period was at the level of 2%. The study by Kinlin et al. [12] however, was based on the data entry by nurses from cardiac surgery centres to a central database, without fully defined infection criteria. In a similar study by Vogle in a large group of patients undergoing major surgery, including 87318 cardiac surgery patients, also performed in USA the frequency of pneumonia was 7.8%. This study confirms the observations of other authors, that cardiac surgery patients are the most vulnerable for postoperative pneumonia. The majority of the scientific reports agree on the fact that the operative site infections are between 35 and 45% of all infections after cardiac surgery [2,9,13,14]. The authors of this study obtained similar results. The important characteristics of the operative site infections is the fact that majority of them are caused by skin flora, especially by Staphylococcus aureus and Coagulase Negative Staphylococci (CNS). In the study by Chen et al. [15] 52.5% of the reported infections of the sternum is caused by bacteria from the Staphylococcus family, where half were MRCNS and 25% was MSSA and 25% was MRSA. Similarly, in our study Gram (+) bacteria accounted for 41% of pathogens responsible for the operative site infection. This is important when regarding the pathomechanism and the source of infection. The source of infection is the patient's own flora despite routine preoperative procedures leading to a decrease in the number of bacteria at the site, i.e. hair shaving, body washing and surgical preparation of the field. The aetiology of infections after CABG depends on the local epidemiology and microbiological situation. Gram positive pathogens comprise some 50% of the flora in the majority of Anglo-Saxon countries, whereas in Central and Eastern Europe, including Poland Gram negative bacteria predominate. In our study the Gram (-) bacteria covered 80% of all pathogens causing infections, including 49% of non-fermenting bacteria. This situation forms a significant epidemiological problem, because the majority of antibiotic resistance mechanisms occur in Gram negative bacteria and the non-fermenting bacteria are usually multi-drug resistant. The analysis covered postoperative haemodynamic and clotting parameters, as well as the inflammatory response. The standard postoperative heart function assessment after CABG covers the measurement of phosphocreatinine kinase levels (CK-MB). Minimal increase of CK-MB depicts the injury of cardiac muscle which can occur due to the operation. A significant increase of serum CK-MB level after coronary arteries bypass operation most commonly occurs due to inadequate revascularization of the diseased arteries. A comparison of maximum levels of phosphocreatinine kinase evaluated in the postoperative period after CABG showed no statistical significance. The efficacy of revascularization in both groups was similar. The monofactorial analysis, however, performed with the U Mann-Whitney test showed that the CKMB level was an important factor for the development of infection. The logistic regression analysis did not confirm the above finding leading to inconclusive results. Clinical assessment of haemostasis in the postoperative period covered the analysis of drainage from the operative site, the volume of packed red blood cells and fresh frozen plasma transfused. The drainage depended upon the operative technique, haemostasis and patient conditions related to concomitant diseases and medications. The operative technique is a factor depending on the surgeon, his abilities, experience, concentration or physical fitness during the operation. These factors may play an important role in the need for blood transfusion. Our results showed no significant differences in the amount of transfused blood products when comparing the group with and without postoperative infection. The amount of drainage from the operative site however, showed statistical significance between the two subgroups both in univariate analysis and logistic regression analysis. Observations regarding the correlation between volume of postoperative drainage and the occurrence of infection performed by other authors are ambiguous. The analysis performed by Haley based on 13961 CABG procedures performed in 2008 in the state of New York showed that the postoperative bleeding requiring a re-operation is an independent risk factor for the development of infection after CABG. On the contrary, when analysing a group of 7557 patients undergoing cardiac surgery Guillou was unable to show a relationship between infection and the volume of drainage and use of blood products [16,17]. The key problem appears to be the re-operation leading to the introduction of bacteria into the mediastinum on one hand and infections caused by slow resorption of mediastinal haematoma on the other hand. In those cases when re-sternotomy was not undertaken the patient is at risk of lung and heart compression from the clotting blood or pericardiac fluid [18]. Therefore each of those operations leads inevitably to the increased risk of infection. It should also be remembered that major blood loss causes immunological impairment, concomitantly leading to bacterial translocation from endogenous sites.

References

1. Bratzler DW, Houck PM, Ricgards C, Steele L, Dellinger EP, Fry DE, et al. Use of antimicrobial prophylaxis for major surgery: baseline results from National Surgical Infection Prevention Project. Arch Surg. 2005;140(2):174-82.

2. Chen LF, Arduino JM, Sheng S, Muhlbaier LH, Kanafani ZA, Harris AD, et al. Fraser TG, Allen K, Corey GR, Fowler VG Jr. Epidemiology and outcome of major postoperative infections following cardiac surgery: risk factors and impact of pathogen type. Am J Infect Control. 2012;40(10):963-8.

3. Hortal J, Giannella M, Pérez MJ, Barrio JM, Desco M, Bouza E, et al.

Incidence and risk factors for ventilator-associated pneumonia after major heart surgery. Intensive Care Med. 2009;35(9):1518-25.

4. Lola I, Levidiotou S, Petrou A, Arnaoutoglou H, Apostolakis E, Papadopoulos GS. Are there independent predisposing factors for postoperative infections following open heart surgery? J Cardiothorac Surg. 2011;6:151.
5. Falagas ME, Rosmarakis ES, Rellos K, Michalopoulos A, Samonis G, Prapas SN. Microbiologically documented nosocomial infections after coronary artery bypass surgery without cardiopulmonary bypass. J Thorac Cardiovasc Surg. 2006;132(3):481-90.
6. Schuller D, Morrow LE. Pulmonary complications after coronary revascularization. Curr Opin Cardiol. 2000;15(5):309-15.
7. Jabbur H, Madi-Jebara S, Jabbur K, Yazigi A, Haddad F, Hayek G, et al. Yazbeck P, Antakly MC. Does nasal decontamination reduce the incidence of infections after cardiac surgery? J Med Liban. 2010;58(2):65-70.
8. Carrel TP, Eisinger E, Vogt M, Turina MI. Pneumonia after cardiac is predictable by tracheal aspirates but cannot be prevented by prolonged antibiotic prophylaxis. Ann Thorac Surg. 2001;72(1):143- 8.
9. Colon G, Perez CM, Guzman M. Perioperative outcomes in octogenarians undergoing cardiac surgery in Puerto Rico. P R Health Sci J. 2000;19(2):115-22.
10. Sanchez R, Haft JI. Temporal relationship of complications after coronary artery bypass graft surgery: scheduling for safe discharge. Am Heart J. 1994;127(2):282-6.
11. Kinlin LM, Kirchner C, Zhang H, Daley J, Fisman DN. Derivation and validation of a clinical prediction rule for nosocomial pneumonia after coronary artery bypass graft surgery. Clin Infect Dis. 2010;50(4):493-501.
12. Vogel T, Dombrovskiy V, Lowry S. In-Hospital Delay of Elective Surgery for High Volume Procedures: The Impact on Infectious Complications. J Am Coll Surg. 2010;211(6):784-90.
13. Bode LG, Kluytmans JA, Wertheim HF, Bogaers D, Roosendaal R, Troelstra A, et al. Preventing Surgical-site infections in nasal cerries of Staphylococcus aureus. N Eng J Med. 2010;362(1):9-17.
14. Michalopoulos A, Geroulanos S, Rosmarakis ES, Falagas ME. Frequency, characteristics, and predictors of microbiologically documented nosocomial infections after cardiac surgery. Eur J Cardiothorac Surg. 2006;29(4):456-60.
15. Owens DC, Stoessel K. Surgical site infections: epidemiology, microbiology and prevention. J Hosp Infect. 2008;70(2):3-10.
16. Darouiche RO, Wall MJ, Itani KM, Otterson MF, Webb AL, Carrick MM, et al. Chlorhexidine-alcohol versus povidone-iodine for surgical site antisepsis. N Engl J Med. 2010;362:18-26.
17. Guillou V, Tavolacci MP, Baste JM, Hubscher C, Bedoit E, Bessou JP, et al. Litzler PY. Surgical site infection after central venous catheter-related infection in cardiac surgery. Analysis of a cohort of 7557 patients. J Hosp Infect. 2011;79(3):236-41.
18. Haley V, Van Antwerpen C, Tsivitis M, Doughty D, Gase K, Hazamy P, et al. Risk factors for coronary artery bypass graft chest surgical site infections in New York State, 2008. Am J Infect Control. 2012;40(1):22-8.