Cardiac surgical treatment of the patients with renal insufficiency

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Abstract

Cardiac surgical treatment of the patients with renal insufficiency became more frequent necessity Also postoperative renal insufficiency occurs pretty often after cardiac surgery. That is in part a result of broadening of operative indications, which might concern patients with multiple diseases. Patients with renal insufficiency and coexistent heart diseases, patients with endocarditis and patients with renal insufficiency after cardiac surgery require the treatment of cardiac surgeons and nephrologists.

Heart diseases are the main cause of the mortality in the dialysis patients. Among the patients with renal diseases the cardiac surgeon most often receive long-term dialysis patients with coexistent heart diseases, who needs cardiac surgery (coronary artery by-pass grafting, valve operations). The amount of these operations increases, however it does not exceed 1% of overall number of cardiac operations. This group however, is very exacting and carries a high operative risk. Dialysis patients are exposed to increased risk of infection. 75% of them reveal infections in the form of sepsis. The presence of bacteria in the bloodstream increase the risk of infectious endocarditis. 6% of dialysis patients with IE require surgery.

The prevention of renal failure after cardiac surgery is also very important. Renal insufficiency occurs in 12% of patients after cardiac surgery with the use of extracorporeal circulation. Renal failure complicates postoperative course and is of high risk for the patient. The mortality due to acute postoperative renal failure, which requires hemofiltration, reaches 70%.

The proper cardiac surgical and nephrological management of renal insufficiency in patients selected for cardiac surgery as well as in patients with postoperative renal insufficiency is necessary to obtain good operative results.

Key words: renal insufficiency, cardiac surgery, heart diseases, dialysis.

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Introduction

Cardiac surgical treatment of the patients with renal insufficiency became more frequent necessity. Also postoperative renal insufficiency occurs pretty often after cardiac surgery. That is in part a result of broadening of operative indications, which might concern patients with multiple diseases. It is also in part negative effect of medicine progress. Which patients and which illnesses require the treatment both of professions; cardiac surgeon and nephrologist?

A – patients with renal insufficiency and coexistent heart diseases

B – patients with endocarditis

C – patients with renal insufficiency after cardiac surgery

Patients with renal insufficiency and coexistent heart diseases

Among the patients with renal diseases the cardiac surgeon most often receive long-term dialysis patients with coexistent heart diseases, who needs cardiac surgery. The amount of these operations increases, however it does not exceed 1% of overall number of cardiac operations. This group however, is very exacting and carries a high operative risk.

It has been shown that heart diseases are the main cause of

the mortality in the dialysis patients. 50% of all deaths in that group of the patients are caused by cardiac complications [1]. An increased tendency of occurrence of calcifications within the heart is the common nominative for every heart disease in the dialysis patients. Extraskeletal calcinosis occurs in 16% of the dialysis patients [2]. These calcifications have a close relationship to cardiovascular diseases and thrombotic events occurrence. Calcification of mitral ring, stenosis of mitral valve, stenosis of aortic valve, coronary artery disease (CAD) and peripheral atherosclerosis belonged to this group of illnesses. All of these diseases are life-threatening.

Secondary hiperparathyroidism is the main mechanism responsible for extraskeletal calcifications. It causes in inorganic phosphates and calcium plasma concentration increase. Extraskeletal calcifications take places mostly within the articular capsules. Histological structure of fibrous heart skeleton is similar, that is why calcium deposits within the heart [2]. Besides the tendency of calcification, higher mortality rate in long-term dialysis patients is related to coronary artery risk factors such as: hypertension, hyperlipidemia and bicarbonates metabolism disturbances. In addition all of these disorders accelerate the atherosclerosis. Surgical treatment of CAD, by using coronary artery by-pass grafting (CABG) becomes a standard procedure in long-term dialysis patients. It happens because of increased amount of the dialysis patients. This population is growing old and the age is also one of the risk factor for CAD.

Heart disease mortality is related to the age of the dialysis patients:

- in the group of patients within the age between 20-64 years cardiac deaths occur about 85/1000 patients per 1 year.
- in the group of patients over 65 years – about 131/1000 patients per 1 year.

Surgical treatment of ischemic heart disease in long-term dialysis patients has been applied since 30 years. The first CABG operation in the patient with renal insufficiency was performed by Menzoin in 1974. Taking into account that Favoloro for the first time initiated surgical treatment of ischemic heart disease in 1967, beginning of using that method in the dialysis patients was very early [1].

There are no uniform studies concerning modern cardiac surgical treatment results of long-term dialysis patients. The amount of studied patients is not yet enough to give the reliable conclusions. That is the result of small number of such the patients udergoing CABG every year. It is also very difficult to collect homogeneous group of these patients. Various operative qualification, operative and anaesthesiology technique progress and postoperative care changing through the years make difficult to collect homogeneous group for the study.

That is why there are no guidelines concerning operative qualification and operative methods in that group of patients yet.

Therefore all of the studies from the last years seemed to be too pessimistic when considering permanent treatment progress.

In 2000 Khaitan et al. in the group of 70 dialysis patients undergoing cardiac surgery showed hospital mortality rate of 14%, and complications rate of 50% [1]. 27 patients died within 5 years. The quality of life was improved only in 41% of the patients. There was no longer survival of the dialysis patients underwent cardiac surgery compared with those who had no surgery and the mortality rate for them was about 22% per one year in the United States. Khaitan observed the highest mortality rate in the group of the patients who had CABG together with valve operation [1]. There were no complications in the group of the patients after single elective operation, which were prepared for transplantation.

The high operative mortality, bad short and long-term results in some group of these patients, should indicate the patients who would take most advantage of cardiac surgical treatment:

- patients selected to kidneys transplantation,
- patients with advanced CAD or valvular heart disease in III / IV class for CCS or NYHA,
- patients with well or slightly abnormal left ventricular function,
- patients prepared to elective CABG or valve operation.

Invasive cardiology also finds its role in CAD patients undergoing dialysis. Koyanagi compared results of CABG and percutaneous transluminal coronary angioplasty (PTCA) with the stent implantation performed in the dialysis patients [3]. There were made about 2.5 grafts and 1.7 PTCA with the stenting per one patient. Angiography made after one month has shown 5% closed grafts (all arterial by-passes were patent) and 25% restenosis after stent PTCA. 70% of CABG patients and 18% of the patients after PTCA were free of angina pectoris after 5 years. It shows big difficulties in selecting the optimal treatment in that group of patients. While PTCA would not give sufficient results, and CABG in spite of the higher risk of postoperative bleeding and worse wound healing, remains the treatment of choice but when using at least one of the arterial graft. Survival after CABG and PTCA is decidedly longer than in cases of conservative treatment in long-term dialysis patients. Herzog observed, that 74% of medically treated dialysis patients died within two years after myocardial infarction (MI) [4]. If the patients were treated with CABG or PTCA procedure, two years survival was 56% and 48% respectively [4].

Valvular heart diseases are the following cardiac surgery problem after CAD in dialysis patients. In population of the patients without renal insufficiency CABG is performed in about 70-80% and valve operations in about 20-30%. Otherwise in the dialysis patients valve operations are performed more frequently, however CABG is still in majority [5]. Structural damage of the heart valves, which is more frequently presented in the dialysis patients, is combined with calcification of the fibrous heart skeleton and the valves. There are no differences in operative qualification procedure between the dialysis and non-dialysis patients undergoing valve operation.

Selection of the type of valve prosthesis should be done by the cardiac surgeon together with the nephrologist in respect of prosthesis durability and patient live expectancy. The durability of the biological prosthesis is estimated for 8-10 years. Biological prosthesis getting calcified after 10 years and after 15 years most of them need to be replaced, but this type of prosthesis do not need anticoagulation therapy. The durability of the mechanical valves is unlimited, but the need of anticoagulation treatment

carries 1-2% risk of bleeding and is associated with 0.2-0.4% of the risk of mortality per year.

The mortality rate for the dialysis patients exceeds 20% in the Unites States [1]. Cardiac surgeons in the U.S. prefer the biological prosthesis in spite of its limited durability, especially in the dialysis patients. The calcification and dysfunction of the biological prosthesis is getting faster in that group of patients. In Europe the mortality rate for the dialysis patients is estimated for about 10-12% per year. Therefore mechanical prosthesis are implanted more often in Europe. They have unlimited durability, but they have also higher possibility of infections and need permanent anticoagulation treatment, what could effect in higher complications percentage. Therefore, the decision about choosing the prosthesis should be made by the cardiac surgeon together with the nephrologist. All the time, this decision should be individualised and be depended on estimated time of survival.

One-year mortality rate for postoperative patients with implanted mechanical valve is estimated for 3-4%. It consists from:

- infections of mechanical valve (0.2-1.4 cases/1000 patients per one year) – they could have a bacterial background (mostly in the dialysis patients). They could be also a consequence of non-bacterial thrombotic endocarditis. Leucocytes infiltrate inside the thrombus and then ulcerating vegetation becomes. In the end of this process perivalvular abscess arises.
- thrombotic events (1.5-2.0 cases/100 patients per one year).
- bleedings (1-2% per one year) are responsibility for one-year mortality rate about 0.2-0.4%.
- prosthesis dysfunction – which concerns mechanical valve very rare. Mostly the biological prosthesis getting dysfunction. 60% of them are replaced after 15 years. The reoperation mortality is about 15%.

There are often more than one heart disease in population of the patients with renal dysfunction undergoing cardiac surgery. CAD and aortic valve disease belong to the same group of diseases related with degeneration process. These diseases often coexist together.

The occurrence of them is increased by the age. About 50% of the patients with aortic valve disease have more or less advanced coronary artery disease coexisted. CAD more often coexists with aortic valve stenosis than with aortic valve insufficiency. When symptomatical advanced CAD and aortic valve defect coexist together, the decision about the simultaneous operation is easy to take. When CAD patient selected for surgery has not very severe aortic valve disease, the decision about complex operation must be carefully done. The qualification for the operation is a little different for the patients with renal insufficiency than for the patients without it. The decision about the simultaneous operation is made according to: operative risk estimation of each of surgical procedures, estimated life expectancy, and estimated progress of the diseases. It is also important to estimate the risk related to mechanical valve prosthesis.

The risk of CABG is not so high, when left ventricular function is good, the risk is about 1-2%. The similar risk (2-4%) is for single valve replacement operation. The risk of simultaneous operation of valve and coronary arteries is higher (4-8%). However the risk of these operations made separately (CABG first, and valve replacement later) increases to 15%.

Trivial aortic stenosis (gradient of 25 mm Hg and aortic area surface higher than 1-1.5 cm^2) in the patients without renal dysfunction is not an indication for simultaneous valve replacement during CABG. On the other hand in dialysis patients the gradient increases not less than 10 mm Hg per one year. It means that dialysis patients with CAD selected for CABG with not significant aortic stenosis will require the valve replacement operation within five years.

There are not big differences in operative indications between the dialysis and non-dialysis patients. After previous CABG each valve operation is more difficult and could effect in the higher operative risk. It is a result of older age of the patients, progression of main disease and left ventricular function deterioration, which is the result of non-corrected valve dysfunction. The reoperation is also more difficult, because of adhesions. During the re-do surgery the risk of implanted grafts injury exists, especially concerning arterial graft – internal thoracic artery. The injury of mammary artery means an irreversible loss of the best arterial conduit.

Patients with infective endocarditis (IE)

Dialysis patients are characterised by an increased risk of occurrence of infection. It happens due to the defect in cellular immunity, neutrophil function, complement activation and the necessity to maintain vascular or peritoneal access. It is important that 75% of dialysis patients reveal infections in the form of sepsis, which is the cause of death in 25% of patients within the age 20-44, 15% – in the group of patients aged over 45 years [6]. The presence of bacteria in the bloodstream in the course of sepsis is a significant risk of infectious endocarditis occurrence.

Twenty years ago, IE occurred mainly in patients with valvular heart disease complicated with bacterial infection. Streptococcus was the main (60-80%) microorganism responsible for IE, most patients had rheumatic disease in their history. During the past years, the profile of patients falling ill with IE as well as the kind of most frequent pathogens were changed. The percentage of patients with rheumatic disease was diminished while the number of patients undergoing intensive and invasive therapy was elevated [7]. The increase in IE incidence in drug-addicts was also noticed.

Nowadays the main risk factor of IE becomes hemodialysis and the most frequent pathogen is Staphylococcus aureus. Immunosuppressive treatment, past operations, and infections of implanted artificial valves are also the risk factors. Streptococcus viridans is the second frequent pathogen responsible for IE. It should be noticed that while a 30-day-mortality in cases of IE is approximately 16%, with Streptococcus it reaches 50%.

IE in dialysis patients is a complication associated with high mortality. Patients with synthetic intravascular dialysis angioaccess are more likely to develop IE then patients with native arteriovenous fistulas, although IE in patients with fistula is characterised by higher mortality [6,8]. Prolonged antibiotic therapy is advised in all patients with IE. The patients with right-

sided IE, large bacterial vegetations in valves, diabetes mellitus, and increased leukocytosis should obtain special attention [9]. The frequency of IE occurrence is higher in patients undergoing hemodialysis (18%) than peritoneal dialysis (10.5%) [10]. The high risk of maintaining the vascular access caused trial of its removal in the course of IE therapy with consequent application of peritoneal dialysis [11]. That led to mortality lowering among patients dialysed peritoneally and treated with antibiotics to 8% in comparison with 55% among patients whose way of dialysis was not altered. Three patients out of both groups were operated on.

Approximately 6% of dialysis patients with IE undergo cardiosurgical treatment. The selection of an appropriate kind of valvular prosthesis is then of great importance. Recurrent bacteremia inclines to choose biological valves, which better tolerates infected environment. However, the implantation of such a valve to a young person can have the consequences of its fast degeneration after a few years and the risk of reoperation reaching 15%.

The prevention and management of postoperative renal failure

The prevention of renal failure after cardiac surgery and appropriate patient management, are important problems. It has been shown, that renal insufficiency occurs in 12% of patients after cardiac surgery with the use of extracorporeal circulation. Such a high percentage results from the complexity of surgical procedure, which requires long time of operation, significant blood loss, use of extracorporeal circulation and hypothermia. Renal failure complicates postoperative course and is of high risk for the patient. The mortality due to acute postoperative renal failure, which requires hemofiltration, reaches 70%.

There are many preoperative factors that predispose a patient to the occurrence of postoperative renal failure. These are: preoperative renal insufficiency, coexisting diabetes mellitus, advanced age, left ventricle failure, emergency operation, unstable angina pectoris, past strokes. It should be noticed that patients with normal renal function before the operation, rarely develop renal failure after operation. Creatinine level exceeding 1.5 mg% is an independent risk factor of postoperative renal failure, while higher than 2 mg% affects the increase in perioperative mortality. Preoperative insufficiency of renal function is reflected in each scale stratifying cardiosurgical operation risk. The scale most often used in Poland, the Euroscore scale, gives 2 points (in 12 points scale) in the case of creatinine level exceeding 2.3 mg%.

The pathogenesis of renal failure after cardiac surgery is complex. Blood, flowing through the cardiopulmonary by-pass, is exposed to thrombogenic artificial surface (drains, oxygenator) and the blood cells are damaged by the roller pump. It induces the whole body response in form of the complement activation, anaphylatoxins C3a, C5a initiating inflammatory response. The level of anaphylatoxin C3a is proportional to postoperative multiorganic damage. Whole body inflammatory reaction, leading to the increase in vascular permeability, induces accumulation of fluids in amount of 150 ml/kg of body weight. The second postoperative day is characterized by the increase of fluid in extracellular space by approximately 1/3 with body water increase by 13%. However, the unfavourable effect of CPB passes in most patients after few hours or days. Furosemid is capable of reversing CPB effect on renal flow. Dopamine in low doses has also synergic effect. Mannitol protects kidney function by increasing blood flow through the kidneys and glomerular filtration elevation.

Nonpulsative blood flow generated by cardiopulmonary by-pass, blood pressure drops below 50 mm Hg, resulting in tissue hypoperfusion are further potential risk factors of renal failure. Hemolysis always happens during cardiac operations. It is the result of a roller pump and sucking blood from the operative field. Free hemoglobin, which binds with plasma proteins: haptoglobin, hemopexin, and methemalbumin, is released during hemolysis. After the saturation of the binding sites, hemoglobin is filtrated by glomerules and reabsorption occurs through proximal renal tubules. The maintenance of urine alkalinity decreases possibility of hemoglobin precipitation in renal tubules.

A long duration of the aorta cross-clamping as well as cardioplegic cardiac arrest with high-potassium cardioplegic solution are other factors of renal failure. They can impair myocardial contraction and finally – cause renal hypoperfusion. Extracorporeal circulation duration, i.e. the complexity of operation, is a very important factor inducing these mechanisms. Thus, isolated procedures (CABG or valvular operations) are far less risky than complex ones [12].

It is assessed that blood and plasma flow through the kidneys, creatinine clearance, and urine secretion during the operation gradually decrease. The application of higher flows and pressures by the extracorporeal circulation pump can improve plasma flow, glomerular filtration, and sodium secretion. Hypothermia lowers glomerular filtration, renal blood flow, and osmolarity clearance but elevates filtration fraction and potassium secretion. One usually try to obtain hemodilution, which diminishes blood viscosity and enables linear blood flow through the systemic circulation and decreases the risk of central and systemic microembolism. The hematocrit lowering is tolerated to 20%; the level considered the borderline as far as oxygen transport is concerned. Hemodilution compensates unfavourable hypothermia effect by elevating renal blood by its viscosity decrease. The increased cortical flow affects urine secretion and free water clearance elevation, and thus counteracts the effect of vasopressin, secreted in response to hemodilution. High levels of aldosterone, vasopressin, and cortisol induce the kidneys to stop sodium and water and secrete potassium.

It should be added that there are many intraoperative factors that contribute to the increase of postoperative renal failure risk. These are: long extracorporeal circulation, bleeding, blood transfusions, low cardiac output, the necessity of catecholamines application, intraaortic balloon counterpulsation, and infection. Patients with preoperative renal insufficiency have their prognosis improved by forced diuresis; oliguria and nephrotoxic drugs avoidance is essential. If preoperative creatinine level exceeds 2.0 mg%, dopamine infusion in low doses is applied (2-5 μg/kg/min) before, during, and after the operation. Oliguria is treated with mannitol (12.5-25 mg) and furosemid intrave-

nously (10-100 mg, or higher doses). If there is no possibility of restoration of diuresis and hemodialysis is necessary, mortality reaches 70%.

While valvular heart diseases are operated on obligatory with the use of extracorporeal circulation, the coronary artery by-pass grafting, while operated without opening the cardiac chambers, could be performed on beating heart (OPCAB), if conditions are conducive. Approximately 20% of operations all over the world are performed without extracorporeal circulation. It was shown that OPCAB operations have lower percentage of renal complications, though not eliminated, than operations with extracorporeal circulation [12-14]. According to Provenchere, postoperative renal failure is much more related to the other factors than extracorporeal circulation, like advanced age, active endocarditis, recent (up to 48 hours) application of radiocontrast agent, poor postoperative cardiac function, and only then extracorporeal circulation [15]. Thus, most of the factors are preoperative ones and the surgeon has no influence upon them. However, the operative method is chosen by the surgeon and OPCAB operation is the one of choice in patients with increased risk of acute postoperative renal failure. Although we realize relatively small influence of operative method and the fact that not every operation can be performed in OPCAB.

Conclusions

In conclusion, heart diseases are the main cause of the mortality in the dialysis patients. Also postoperative renal insufficiency occurs pretty often after cardiac surgery. The proper cardiac surgical and nephrological management of renal insufficiency in patients selected for cardiac surgery as well as in patients with postoperative renal insufficiency is necessary to obtain good operative results.

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