Anesthetic Management of Aortic Aneurysm

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1. Introduction

Careful preoperative evaluation of patients undergoing vascular surgical intervention holds great significance since this group of patients has almost the highest percentage of accompanying diseases with poor outcome. It is well-known that vascular disease – irrespectively of its manifestation – is a generalized disorder, the majority of patients with vascular disease smoke and have chronic pulmonary disease, also suffers from diabetes and hypertension.

Hypertension and diabetes are often associated with coronary artery disease which determines the short and long-term survival of vascular procedures. Coronary artery disease is one of the most frequent cause of the perioperative mortality and morbidity (1-5%). Goldman et al. drew the attention to the frequency of cardiac complication of vascular operations as far back as 1977 and aimed to establish a multi-factorial score index. Based on detailed surveys which covered a large patient population the perioperative incidence of myocardial infarction among patient undergoing vascular surgical procedures is 2,1 – 8,0 %, whilst the mortality is 0,6 – 5,4 %. These examinations did not consider the type of operations – open or endovascular. Beside Goldman's classic risk index numerous task forces have established their own score system for the assessment of perioperative cardiac risk. All of these highlight the significance of the fact that after being aware of the clinical risk, consultation and mutual decision making of cardiologists, anesthetists and vascular surgeons in evaluation the long-term efficiency and risk ratio is essential. The most important weak point of all score system is the utilization of data derived from patients underwent elective operations. Kertai et al. developed a simplified risk index, which is suitable for the assessment of perioperative mortality of either acute or elective patients undergoing vascular surgical operations. The American College of Cardiologist and the American Heart Association has developed a guideline for the assessment of cardiovascular risk among patients with different diseases who are undergoing non-cardiac surgery. This guideline includes the risk assessment for the patient undergoing vascular surgery. Three categories of cardiac risk have been classified in the guideline, high, intermediate and low. High cardiac risk involves the history of acute coronary syndrome, congestive heart failure, significant arrhythmias and severe heart valve diseases. Among non-cardiac surgeries associated with higher cardiac risk, the acute operations, surgery on extremely old patient, operations of the aorta, prolonged operations, operations with excessive fluid or blood loss are considered to be high-risk while carotid endarterectomy should be considered within the intermediate-risk category. The most simple clinical determining factors of cardiac risk are the age, body weight, known diabetes, congestive heart failure, angina pectoris, history of myocardial infarction and previous coronary revascularization.

2. Preoperative evaluation

Preoperative examination should include the assessment of patient's functional capacity.
In the presence of lower extremity peripheral vascular disease performing exercise stress test may be difficult, thus pharmacological stress test or specific upper body exercise test should be carried out. Severely impaired functional capacity further increases the cardiac risk. Diseases of the aorta are frequently associated with severe coronary artery disease/ The incidence and severity of coronary artery disease are remarkably higher at the diseases of the aorta.
Preoperative examination should include the following:
Assessment of cardiac risk using different noninvasive examinations.Noninvasive stress testing are the following: dipyridamole myocardial perfusion scintigraphy, radionuclide ventriculography, Holter ECG monitoring, dobutamine stress echocardiography. Several authors (Eagle and collegues, Lee and coworkers) have examined the sensitivity and specificity of these methods, and have found the dobutamine stress echocardiography to be the most appropriate test to assess this group of patients. This examination not only assesses the left ventricular dysfunction but also provides other valuable information on the ground of echocardiography. However, choosing the most appropriate type of test is undoubtedly influenced by local availabilities and cost effectiveness, as well. After assessing the cardiac risk, what therapeutic options are available to decrease it? Beta-blocker therapy at high-risk vascular patient has been proven to improve not only the perioperative but also the long-term survival. Manago et al. carried out a study, which covered a large number of patients on the effect of bisoprolol and atenolol on mortality and cardiovascular morbidity after non-cardiac surgery. Treatment of hypertension: blood pressure fluctuation at high-risk vascular patients further increases the cardiac risk. Previous anti-hypertensive therapy should be broadened by administration of beta-blockers and the directly acting, alpha-2 agonist, clonidine. Perioperative ACE-inhibitors therapy may cause intraoperative hypotension, thus administration of them are not recommended.
What further medical therapy is available to decrease the perioperative risk?
Poldermans and colleagues evaluated the effectiveness of statin therapy, and they found that the perioperative statin therapy is associated with lower postoperative mortality.
Among the evaluated drug therapies, only the perioperative beta-blocker therapy has been found to significantly decrease the mortality. Increased risk of urgent surgery, especially in elderly patients, a longer surgery, excessive blood loss due to classify interventions in high-risk group.
Of smoking among patients with vascular risk factors are also important, so increased the perioperative complications between the role of pulmonary complications. Chronic obstructive pulmonary disease and chronic bronchitis, which often encounter. The kidney complications should be considered. First, the generalized vessel disease associated with hypertension, the renin-angiotensin system leads to damage, and the second associated with diabetes to nephropathy.

3. For each type of surgery

3.1 Aortic reconstruction – Lesions affecting the abdominal aorta

Growing the progressive aortic aneurysm rupture in the final output. In ruptured cases, the deaths of over 50% indicate a value and this value has not changed significantly over the past 40 years, developments in technology and the introduction of the endovascular technique does not like routine. If known and expanding aortic aneurysm is detected, and reconstruction is the surgical mortality rate is between 0.4 to 2.3%.

The technique of anesthesia during general anesthesia supplemented with epidural anesthesia benefits. We must work towards the introduction of anesthesia, the hemodynamic stability, to eliminate changes caused by intubation. Cross-clamping of the aorta, causes a sudden increse in the afterload. This growth, provoke arrhythmias and myocardial ischemia and left ventricular failure.

3.2 If a patient with acute surgery

Aortic aneurysm rupture due to a significant amount of blood in the abdomen, in any event be deemed hypovolemic. The abdominal muscle tone affects the capacity for intra-abdominal blood vessels, this relaxation is terminated and the formation of the blood pressure to fall, then a further decrease in blood pressure by opening the abdominal cavity should be expected. So close to the team's work comes to the fore the importance of continued vigilance isolation inhalating 100% oxygen, and then rapidly after induction opening the stomach , fast and high aortic cross clamp immediately save the patient's life. This type of surgery with surgical mortality of 50% is over, and over the past 4 decades has not changed.

3.3 Thoracic, thoraco-abdominal aneurysm

The anesthesia and surgical technique despite the development of the aorta during surgery thoraco-abdomial section of the complications and mortality has not changed significantly over the past 20 years. High-traffic, high number of sick institutions in 5-14% mortality rates reported.The paraplegia, paraparetikus complication rate of 50-40% of the shares are known. The percentage of complications depends on which section of the aorta, the exclusion should be carried out. The neurological complications after pulmonary complications to be expected. The monitoring of the thoracic aneurysm surgery should be extended. Close cooperation is required between the vascular surgeon and anesthesiologist, the surgical plan must be designed carefully crafted after, the every aspect of the monitoring and the distal aortic perfusion technique. Important aspects of the arteries of the spinal cord and the renal arteries perfusion ensure and the adequate oxygenation.

If the exclusion (cross clamping) is happening, a retrograde perfusion provides security for patients. In surgery for thoracic aortic aneurysm general anesthesia of suitable technology. The most important is protection of the spinal cord, 20-30 minute cross clamping time is safe for the patient . The hypothermia is one of the most suitable method for neuroprotection.

4. Perioperative management

The patient who has been diagnosed with significant coronary artery disease during preoperative examination and is a candidate for high-risk vascular surgery is the most

challenging. In case of acute operation beta-blockers remains the only therapeutic option, while in elective patients coronary revascularization should be carried out.
If the vascular procedure is not urgent, CABG operation is preferable over PCI. Elective non-cardiac surgery is not recommended within 6 weeks of coronary revascularization with PCI and stent implantation. In these cases careful risk assessment and effectiveness evaluation is necessary. Among patients with vascular disease tobacco smoking is a significant risk factor, thus perioperative pulmonary complications are frequent. Chronic obstructive pulmonary disease and chronic bronchitis are the most common ones. Perioperative blood gas analysis can be useful in assessing the risk. If the arterial carbon-dioxide partial pressure is higher than 45 mmHg, the risk for postoperative pulmonary complication is increased. If a tobacco smoking patient is presented at the preoperative evaluation meeting 2-4 weeks prior to the operation, it is reasonable to try to persuade the patient to cease the cigarette smoking, although, cessation will increase the amount of bronchial discharge. Smoking cessation 2-3 days prior to the surgery only results in decrease of the blood carboxi-hemoglobin level. In case of history of COPD and asthma preoperative glucocorticoid therapy (40 mg of prednisolon for two days) can decrease the risk of pulmonary complications. Treating the bronchial spasm, mobilizing the bronchial discharge and performing chest physiotheraphy would improve the patients' condition. One to two days prior to surgery preoperative pulmonary function test should be performed. Decreased FEV_1/FVC ratio suggests obstructive pulmonary disease. Performing regional anesthesia can lower the operative risk by eliminating the administration of the respiratory depressive opiates. On the other hand intraoperative blood CO_2 pressure monitoring is important, since the probability of developing hypercapnia is high, as well as the postoperative CO_2 level follow up, since the pain can lead to hypoventilation. Thus adequate pain management is strongly advisable.
Renal complications should also be taken into consideration, because of the pre-existing hypertension which is usually accompanied to generalized vascular disease and which can lead to impairment of the renin-angiotensin system. Preexisting diabetic nephropathy can also influence the development of postoperative renal complications.

5. Anaesthetic management

5.1 Infrarenal aortic aneurysm

The final outcome of aneurysms that present progressive growth is the rupture. In case of aneurysm rupture the mortality reaches the 50 %, this ratio has not changed over the last 40 years, despite the technical development and the introduction and routine application of endovascular techniques. Postoperative mortality rate of reconstruction of previously known and growing aortic aneurysm varies from 0,4 to 2,3 percents.
Preparation for the operation includes setting up the following:

1. two 14 G peripheral venous line
2. central venous line
3. arterial line
4. ECG monitoring from 5 different points
5. pulsoxymetry
6. urinary catheter
7. gastric tube
8. body temperature monitoring

9. noninvasive blood pressure measurement (from the opposite side than the direct arterial pressure line)
10. In case of impaired ejection fraction (less than 30 %) or suprarenal aortic cross-clamping, routine monitoring should be completed by the use of PICCO or Swan-Ganz catheter. In case of patients with significant diastolic dysfunction continuous intraoprative TEE (trans-esophageal echocardiography) monitoring can help to evaluate the need of fluid or catecholamine therapy.

The anticoagulation maintained with use of heparin 100 unit/kg, additional heparin necessary if the clamping time prolonged. Heparin can be reversed by protamine (4mg/kg over 15 minutes) it may lead to anaphylaxis, pulmonary hypertension and myocardial depression.

At aortic operations it is recommended to prepare 4 - 6 units of red blood cell transfusion, if possible, autologous transfusion should be performed. The use of cell saver (intraoperative cell salvage machine) improves the efficacy of transfusion therapy, if it is not available normovolaemic hemodilution is required. Hemodilution does not increase the oxygen deficit of the myocardium. During fluid therapy close monitoring the 24-hour diuresis and warming the fluid infusions increases patients' safety. (Myers G)

During anesthesia, general anesthesia can be completed by the benefits of application epidural anesthesia. The thoracic epidurals decrease the stress response to surgical procedure. During induction of anesthesia care must be taken to maintain the patient's hemodynamic stability and to eliminate the hyperdynamic response caused by the intubation. In case of aortic operation close attention must be paid to physiologic changes during aortic cross-clamping. In case of abdominal aortic operation the level of cross-clamping is infrarenal, i.e. aorta is fully cross-clamped under the origin of renal arteries. Changes in patient's condition appear rapidly, thus taking prompt actions are necessary. Aortic cross-clamping causes sudden increase in systemic vascular resistance, i.e. in afterload. This increase can provoke myocardial ischemia, arrhythmia and left ventricular failure. The more proximal the cross-clamping is, the more severe the myocardial adverse consequences are. Administration of vasodilators and activation the epidural anesthesia before the cross-clamping can stabilize the patient's condition and have beneficial effect. During aortic cross-clamping the lower extremities and certain parts of large intestines receive minimal blood flow through collateral circulation, but the renal circulation are also impaired. As a result of these circulatory changes inflammatory mediators are released by leukocytes, platelets and endothelial cells.

Cessation of aortic cross-clamping causes sudden decrease in afterload, which is on the one side caused by the discontinuation of mechanical obstruction but the accumulated vasodilator mediators by getting back into the systemic circulation plays also an important role in this. Beside vasodilation, metabolic acidosis and increased capillary permeability aggravates the condition. Providing adequate circulatory volume and maintaining stable blood pressure is necessary before releasing the aortic cross-clamp. Administering mannitol and pressor drugs can be helpful to fulfill this. Every efforts must be made in order to reach as short hypoperfusion time as possible.

In the postoperative period the close monitoring should be continued and care must be taken of the adequate pain management. If the infrarenal cross-clamp time exceeds 60 minutes, the subsequent pressure rise in the renal arteries may cause systemic hypertension in the early postoperative period, which is usually transient.

Patients require monitoring after abdominal aortic aneurysm operation. The postoperative pain management is important, the early extubation, and the enteral nutrition. Appropriate thrombotic profilaxis and postoperative gastrointestinal ulcus profilaxis, the use of antacids.

5.2 Emergency AAA surgery

In case of acute operation of ruptured aortic aneurysm, the patient should be considered hypovolaemic under all circumstances due to the excessive amount of extravascular blood found in the abdominal cavity. Increased abdominal muscle tone has a pressor effect on the intraabdominal capacity vessels, which is ceased if muscle relaxants are administered during the anesthesia and this causes subsequent blood pressure drop. Hypotension is further aggravated by the opening of abdominal cavity. This fact underlines the importance of team work. Isolation and draping of the operative field is carried out while the patient is awake, under simultaneous 100 % of oxygen inhalation, followed by rapid induction, quick opening the abdominal cavity and immediate high aortic cross-clamp which actions can only save the patient's life. Heparinization is not required until the aorta is not cross clamped. After the aorta is cross clamped the fluid resuscitation can be instituted with colloids and blood. The dilutional coagulopathy is precnse, FFP and platelets ordered for the patient, and heparin is omissioned. Mortality rate of these operations exceeds the 50 percents and has not changed over the past four decades. The predictors of the survival are the patients age, the total blood loss, and the time of hypotension.
Preparation for the operation includes setting up the following:

1. two 14 G peripheral venous line
2. blood count, electrolytes coagulation screen
3. arterial line
4. ECG monitoring from 5 different points
5. pulsoxymetry
6. urinary catheter
7. gastric tube
8. body temperature monitoring
9. noninvasive blood pressure measurement (from the opposite side than the direct arterial pressure line)

Drugs and fluids:

6-10 units of cross matched blood, fresh frozen plasma and platelets
Crystalloids and colloids
Inotropes (ephedrine 3 mg/ml, adrenaline 1:100 000) and vasopressor agents (phenylephrine 100 mcg/ml, metaraminol 0.5 mg/ ml)

5.3 Thoracic – Thoracoabdominal aneurysm

Operative complications and mortality rate of thoracoabdominal aneurysm surgeries has remained remarkably high despite the development of anesthetic and surgical techniques. High, 5-14 % of mortality rates have been reported by even specialized aneurysm centers which are dealing with a large number of patients. Paraplegia and paraparesis, as postoperative complications develop at 5 - 40 % of all cases. The incidence of complications is influenced by the site of the cross-clamp. The most commonly occurring neurological complications are followed by the pulmonary ones. At thoracic aneurysm operations more vital signs is required to be monitored. It also demands closer collaboration between the vascular surgeon and the anesthetist, because every step of the monitoring has to be set up after developing the operative plan. Particular attention must be paid to the perfusion technique of the distal aorta. Providing adequate perfusion of vertebral and renal arteries and application of satisfactory ventilation are also very important.

Preparation for the operation includes setting up the following:

1. High flow venous catheter, 2 peripheral venous line and 3-lumen central venous line
2. Radial arterial cannula , inserted in the right side if the cross-clamp is placed proximally to the left subclavian artery.
   Femoral arterial cannula, if the bypass is used to maintain the distal aortic flow.
   Radial + femoral , more information can be obtained about the circulation of the lower part of the body
3. Transesophageal echocardiography – intraoperative information: LVEDP, the myocardial function and the valves status
4. Preparation for unilateral ventilation
   Positioning the double-lumen tube can be helped by bronchofiberoscopic intubation.
5. Ten units of red blood cell transfusion, FFP and platelet transfusion.
6. Monitoring of SSEPs (somatosensory evoked potentials)
7. Body temperature monitoring: core and peripheral temperature.

The aneurysm of the ascending aorta is destroyed, need an urgent surgical procedure.

If cross-clamping is applied, significant pressure elevation proximally to the cross-clamping is common. Administration of nitrates and vasodilators is recommended, in case of patient with preserved myocardial systolic function administration of isofluran and desfluran is also suggested. Nitrates can optimize the preload and are able to decrease the left ventricular wall tension. If the operation is performed under the protection of cardiopulmonary bypass (CPB), patient safety is improved if retrograde aortic perfusion is used. In order to ensure appropriate therapy, direct arterial pressure monitoring is registered from two separate regions, above and under the cross-clamping.

In case of thoracic aortic aneurysm surgery balanced anesthesia is the appropriate technique of choice. Protection of the vertebral spine is the most important task, from 20 to 30 minutes of cross-clamping time is considered to be safety. Spinal blood pressure is equal to the difference of mean distal aortic pressure and the cerebrospinal fluid pressure. Cerebrospinal fluid pressure is approximately equal to the central venous pressure. The spinal perfusion autoregulation is similar to the cerebral, appropriate blood flow is maintained between 60-120 mmHg of perfusion pressure.

Applying hypothermia is one of the best solution to ensure adequate neuroprotection, 32 – 34 degrees of Celsius of body temperature is recommended during the operation.

Impairment of renal circulation can also lead to severe complications, administration of mannitol and loop-diuretics and applying hypothermia can prevent these adverse outcomes.

During anesthesia strict attention must be paid to maintain the patient's body fluid and electrolyte balance. If the procedure is done with the patient in the left lateral thoracotomy the CPB is constructed through the femoral artery with venous drainage through right atrial, bicaval, or femoral venous cannulation. Systemic hypothermia is used , with a circulatory arrest. Surface cooling is used along with core cooling and rewarming through the CPB heat exchanger. The cooling of the head with ice during core cooling and kept cold until the period of arrest is important. The core temperature is monitored in the esophagus or tympanic membrane. (Kumar N)

Drugs and fluids:

6-10 units of cross matched blood, fresh frozen plasma and platelets
Crystalloids and colloids

Inotropes (ephedrine 3 mg/ml, adrenaline 1:100 000) and vasopressor agents (phenylephrine 100 mcg/ml, metaraminol 0.5 mg/ ml).
It is very important during induction is to minimize the hypertensive response to laryngoscopy and intubation, which may lead to further spreading of the tear and result in rupture of an aneurysm or propagation of a dissection. Dispite the factthat we could make a long surgery, a large doses of pancuronium are generally avoided. This drug has a vagolytic and norepinephrine releasing effects, which produce hypertension and tachycardia. In patients with significant reduced myocardial function etomidate 0.2 to 0.3 mg/kg may provide the hemodynamic stability during induction. Anesthesia is maintained with inhalation agents, opiates and non-depolarizing muscle relaxants.
Airway management : lesions of the ascending and transverse aortic arch are managed with a single-lumen endotracheal tube. If the aortic lesions may cause tracheal or bronchial compression better to use a left-sided double-lumen tube (DLT). The tube should be placed with using fiberoptic bronchoscopy.
Bleeding and hematologic dysfunction: A thoracic aortic surgery involves using large amounts of blood. The amount of blood used for depends on the bypass time. The time of deep hypothermia has an effect on the clotting system.

Aneurysms of the descending thoracic and thoracoabdominal aorta

Aneurysm of descending thoracic aorta involves diffenert parts of the thoracic aorta and may extend to the abdominal aorta too. Several techniques can be used to control upper- and lower-body blood flow during the operation.

- **Aortic cross-clamping**, This is the method for resection in a short period of time. The problems are the organ ischemia because of arterial hypertension, and metabolic acidosis. The cross clamp duration and severity of complications is directly proportional. A cross-clamping time longer than 30 minutes increases the risk of spinal cord injury
- **Passive shunts**, the most commonly used shunt is the 9-mm heparin-coated conduit (Gott shunt), which does not require systemic anticoagulation.
- **Centrifugal pump bypass flow,** the left atriofemoral centrifugal pump bypass may be useful in patients with decreased left ventricular function, coronary artery disease, renal failere.. and anticipated longer then 30 minutes aortic cross-clamping time.
- **Partial Cardiopulmonary Bypass,** it is used from the femoral vein to the femoral artery, or from the right atria to the femoral artery. This techique adds the use of oxigenator.
- **Deep Hypothermic Circulatory Arrest** has been used to protect vital organs and the spinal cord. Despite the detailed research work has not found the perfect way to protect the spinal cord. Containing a high number of patients in studies based on the present position is that hypothermic protection with CPB and DHCA may be the useful methods.

6. Endovascular procedures

Endovascular stent graft implantation is one of the most suitable alternatives to open aortic aneurysm surgery today. Aortic operations have remarkably changed since the introduction of endovascular techniques. Extremities of implantation technique have been reported in the scientific literature, from the stent-grafts implanted in the X-ray lab percutaneously toward the open stent-graft implantation procedures. Stent-graft

implantation is less invasive, more tolerable for the patients, the length of surgery is shorter, less transfusion is required and the shorter ICU and hospital stay are also the advantages of this technique. Based on our experience stent-graft implantation is considered at those patients, who are referred to be high-risk due to the large number of severe accompanying diseases. In our institute we intend to perform epidural anesthesia at abdominal aortic aneurysm stent-graft repair operations and balanced anesthesia at thoracic cases. Standards of the monitoring technique are the same as that is described at the open procedures. Monitoring improves patient's safety.
Preparation for the procedure includes setting up the following:
1. two 14 G peripheral venous line
2. laboratory exams : blood count, electrolytes , coagulation screen
3. arterial line
4. ECG monitoring from 5 different points
5. pulseoxymetry
6. urinary catheter
7. body temperature monitoring - prolonged operations
8. noninvasive blood pressure measurement (from the opposite side than the direct arterial pressure line)

At the endovascular procedures hemodynamic changes caused by the cross-clamping are not presented. The postoperative period is better tolerated, the pain is milder and the cardiovascular status is more stable. Endovascular stent-graft repair of aortic aneurysms. At present, aortic stent-grafts are most frequently used to repair infrarenal aortic aneurysms. The hemodynamic consequences of infrarenal endovascular balloon inflation are minimal compared with those of suprarenal, supraceliac, or thoracic aortic occlusion. More significant hemodynamic changes are likely to be encountered during stent-graft repair of the descending thoracic aorta.
The high-risk patients undergoing endovascular stent-graft aortic repair appear to have greater hemodynamic stability compared with for the traditional open technique was . Despite this, hypotension and hemodynamic instability could detected, especially during manipulation with expended balloon. Causes of hypotension include hemorrhage and loss of blood into the aneurysm sac after graft implantation, release of endothelial vasoactive substances, and/or an autonomic reflex in response to endovascular balloon inflation.Along the course of the operation, theres is a significant advamtage with the change int he opersation technique, and that the clamping of the aorta is left out or restricted to only a few minutes. During the positioning of the graft , the measured systemic vascular resistence increases but the value (9,2 ±3%)compared to total aortic clamping (32,8 ± 7,6 %) is significantly lower. At this point , following clamping of the abdominal aorta, we experienced a decrease in stroke volume and cardiac output which reached 38% in the cross clamping patients. In patients with stent graft technique this value remained under 9% . The decrease in venous backflow is much lower and therefore the decrease in end diastolic pressure is also lower which influences the left ventricular filling pressure. In a series of 12 patients undergoing infrarenal aortic repair with an EVT endovascular graft under neuroaxial blockade (epidural or continuous spinal), 25% of patients had sudden severe bradycardia and hypotension necessitating immediate therapy. Accordingly, blood must be immediately available, and large-bore intravenous

access must be obtained before the procedure. Because of the high incidence of CAD, careful monitoring and aggressive treatment of myocardial ischemia is essential. Conversion to open repair may be required in 2% to 20% of patients (average, 9%) due to technical difficulty with graft deployment or acute surgical complications such as aneurysm rupture or arterial injury With increasing experience, the need for emergency conversion to open repair is decreasing to approximately 2% to 5% of cases but is still associated with increased morbidity and mortality in these high-risk surgical patients (Kumar N)

In patients with significant coexisting atherosclerotic vascular disease of major organs (heart, brain, kidneys), induced hypertension should be avoided altogether or its duration minimized. A stent-graft that does not require hemodynamic manipulations for its deployment would be more desirable in such patients. The anesthetic technique may consist of general anesthesia, regional anesthesia (epidural, spinal, or continuous spinal), or local anesthesia plus sedation . The choice of technique is influenced by multiple factors, including local customs and the experience of the surgical and anesthetic teams. Consideration should be given to the potential for intraoperative hemodynamic instability and the possible need to react rapidly to surgical complications. The anesthetic goals include analgesia, sedation, anxiolysis, patient immobility, and maintenance of hemodynamic stability. General anesthesia was the most commonly used method during the initial experience with endovascular infrarenal aortic repairs because it provided the ability to rapidly convert to open surgical repair. With evolving experience, regional anesthesia (epidural or spinal) and even local anesthesia with sedation and monitoring are being increasingly used for endovascular aortic repairs A variety of drugs have been used successfully for general anesthesia, including etomidate, , propofol, potent synthetic opioids, volatile anesthetics, and muscle relaxants In patients with severely impaired left ventricular function, etomidate together with a potent opioid such as fentanyl or sufentanil provides adequate hemodynamic stability. Advantages of regional anesthesia include minimization of systemic drug use, continuation of pain relief into the postoperative period, and the improved ability to detect symptoms of myocardial ischemia in patients who can report the occurrence of chest pain. Central neuroaxial blockade was shown to reduce the postoperative hypercoagulable state, which may result in a decreased incidence of deep vein thrombosis and vascular graft occlusion .

The infrarenal cross clamping acts on kidney function only bedside refle and hemodinamic changes. In our stent graft patients we did not experienced a decrease in the renal functions . The infrarenal aortic clamping convincingly increases renin release from the kidney. The increase in plasma renin and angiotensin levels causes a postoperative increase in blood pressure, compared to preoperative values. Because of the variable and unpredictable duration of these procedures, epidural anesthesia is the most commonly used technique because it has the flexibility of providing anesthesia of indefinite duration. Careful titration of the dermatomal level helps minimize the sympathectomy-related hypotension.

Continuation of epidural blockade beyond the operating room is an excellent method of providing postoperative analgesia. A normal coagulation profile must be assured before catheter placement and removal. Continuous spinal anesthesia using an intrathecally placed epidural catheter provides a more rapid onset of a more dense neuroaxial block than does epidural anesthesia. The stent graft technique not only makes the task of the surgeon easier but eases the work of the anesthesiologists. It is important to note that considering the high risk patients we cannot lax th tight monitoring end technical equipment which encure the patient's safety and well being.

6.1 Endovascular technique for ruptured aortic aneurysm: RAAA

The decision of using endograft configuration in the RAAA depends of several factors. For the anesthesia the most important is the hypotension. We are in the position to use intra-aortic occlusion balloons in hemodinamically unstable patients, after the unsuccesfull volumen resuscitaion. It seems to be the hemodinamical instability is the most important factor of the survival in the patients with RAAA undergoing endovascular aortic aneurysm repair.

7. Hybrid solutions in aortic surgery

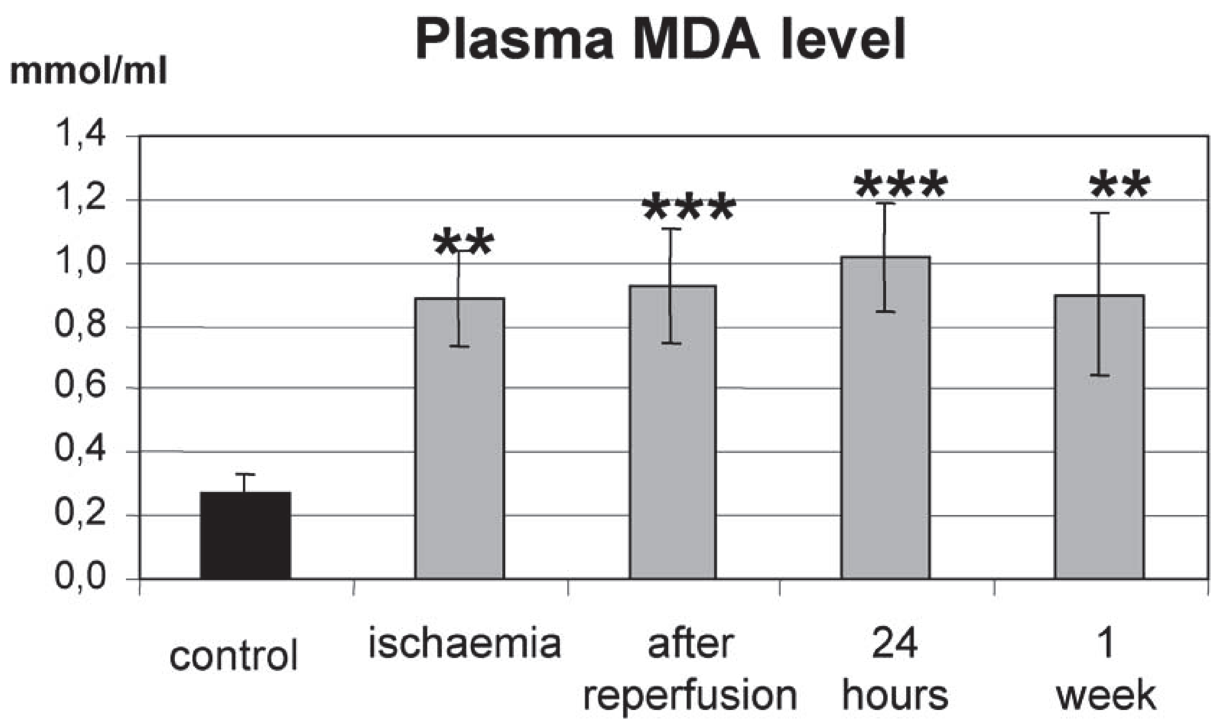
Hybrid solutions are called for vascular interventions, which are the traditional methods of open vascular surgery and insertion of the endograft are combined in order to reduce the risk of interference. The anesthesiologist must be always ready for a planned change in surgical technique, and the situation has changed to provide the surgeon and the patient to the optimal situation.

8. Reperfusion injury and inflammatory responses following acute revascularization surgery

After revascularization of an acute arterial occlusion the development of a serious ischaemic-reperfusion injury is a menacing challenge and a hard task in vascular surgery. A whale of evidences point to oxidative stress, as an important trigger, in the complex chain of events leading to reperfusion injury**.**

Arató et al . made examinations, after reperfusion in the 2nd and 24th hours, and on 7th day. Superoxide-dismutase activity, reduced glutathion concentration and leukocytes free radical production were measured. The degree of lipidperoxidation was marked with the quantity of malondialdehyde. The expressions of adhesion molecules were measured with flowcytometry. The speed and rate of free radical production significantly increased in the early reperfusion ($p < 0.05$). The level of antioxidant enzymes decreased after revascularization. The CD11a and CD18 expression of the granulocytes significantly ($p < 0.05$) decreased right after the revascularization, but with a gradual elevation until the 7th day they exceed the ischaemic value. The results showed a time specific turnover of the sensitive antioxidant–prooxidant balance after revascularization operation.

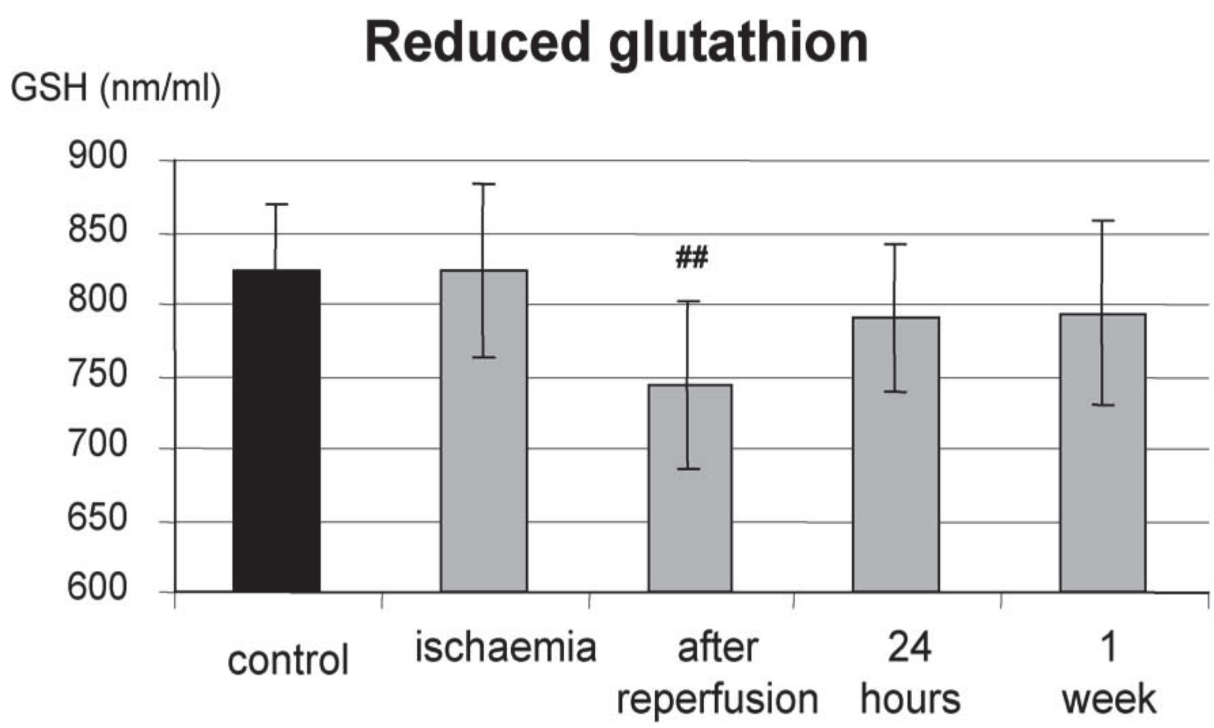
Revascularization procedures performed on acutely ischaemized extremities are accompanied by metabolic and functional derangements which may be life threatening. Determination of selected biochemical, oxidative and inflammatory parameters which belong to the most objective criteria will alert physicians reducing the reperfusion injury cascade. Malondyaldehide plasma level has shown significant elevation after the operation and during reperfusion, it remained almost constant during first post operative week, this determines lipidperoxidation and membrane impairment (Fig. 1).



(**$p < 0.01$; *** $p < 0.001$ vs. control).

Fig. 1. The malondialdehyde plasma concentration elevated significantly in all of the operated groups

During early reperfusion period GSH level dramatically diminished ($p < 0.01$) at the sam e time –SH groups levels also decreased (Figs 2 and 3).



(##p < 0.01 vs. ischaemia).,

Fig. 2. The plasma concentration of reduced glutathion (GSH) decreased significantly in the early, acute phase of reperfusion

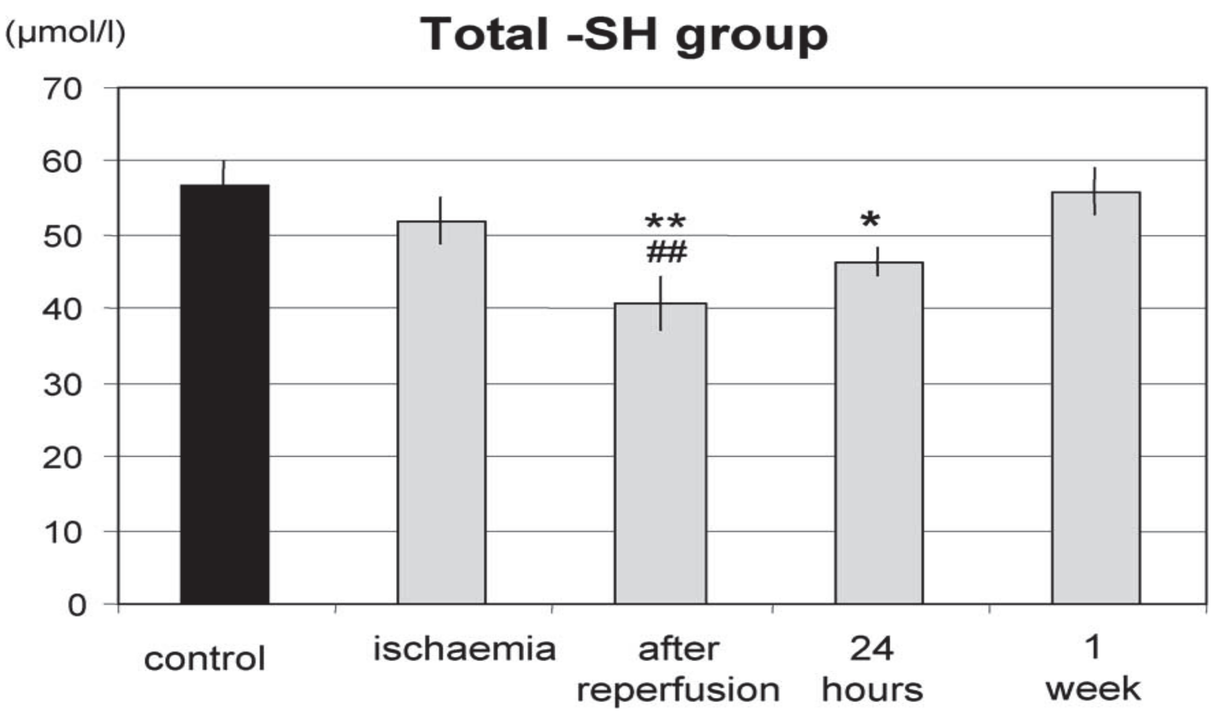


Fig. 3. Plasma concentration of –SH groups decreased significantly in the early reperfusion, then showed a slight elevation till the end of the week (##p < 0.01 vs. ischaemia, *p < 0.05 and **p < 0.01 vs. control).

Regarding SOD activation a notable difference has been noticed between the two groups (control: 894.34 ± 86.85 U/ml, study group: 415.43 ± 75.22 U/ml), and after 24 h a significant reduction has followed ($p < 0.05$) (Fig. 4).

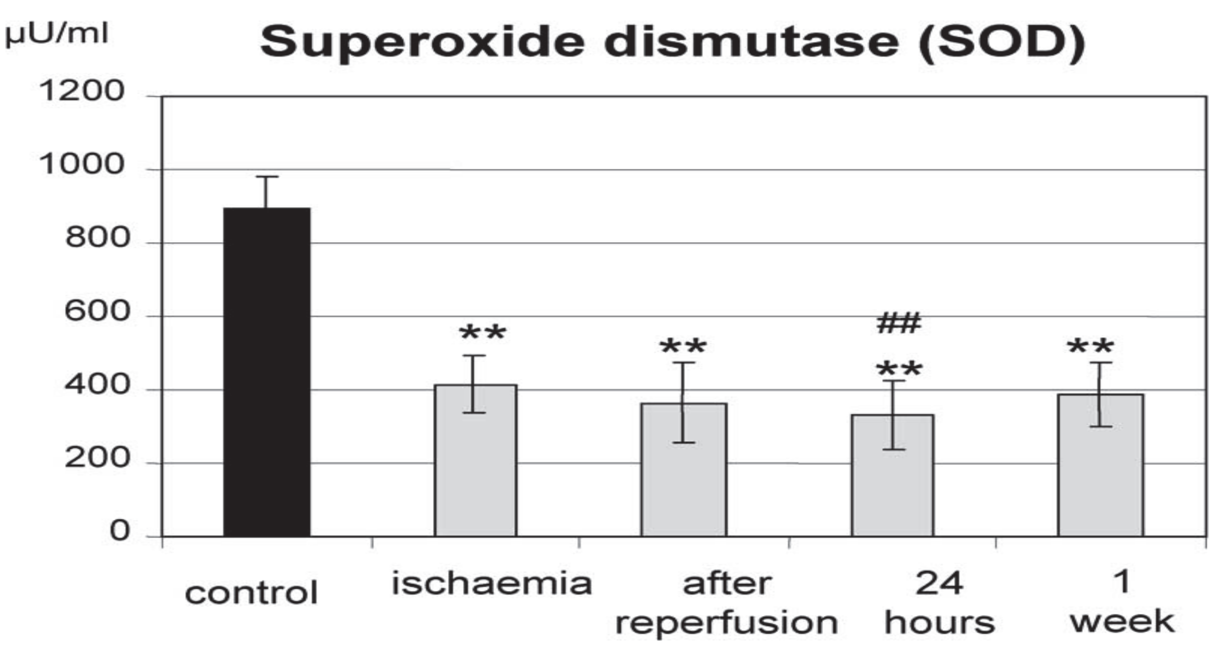


Fig. 4. Total superoxide dismutase activity was significantly lower during ischaemia versus control group, and decreased further in the 24th hour of reperfusion. Even, after a week could not reach the control value (**p < 0.01 vs. control; ##p < 0.01 vs.ischaemia).

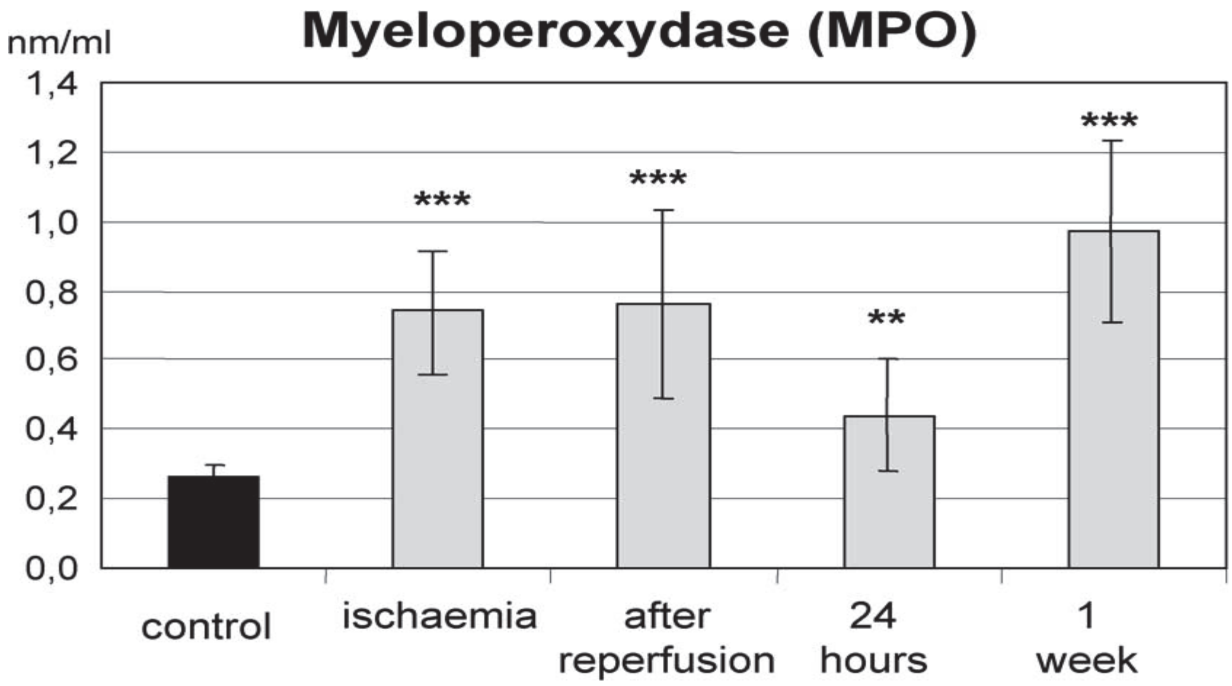


Fig. 5. Plasma myeloperoxidase (MPO) level elevated significantly after revascularization, shows a slight decrease in 24 hours,than increase further in the late reperfusion period (**p < 0.01; ***p < 0.001 vs. control)..

The results show that the reperfusion induced, prompt oxidative stress does not disappear after the early period, but persist until the examined one week postoperative period. The basic pathology in the early reperfusion injury is the oxidative burst with the generation of a mass of oxygen free radicals.

The postischaemic, immediately oxidative turnover induces a massive inflammatory response with the activation of the leukocytes after 24 hours and in the late period these tissue inflammatory responses will maintain the oxidative imbalance.

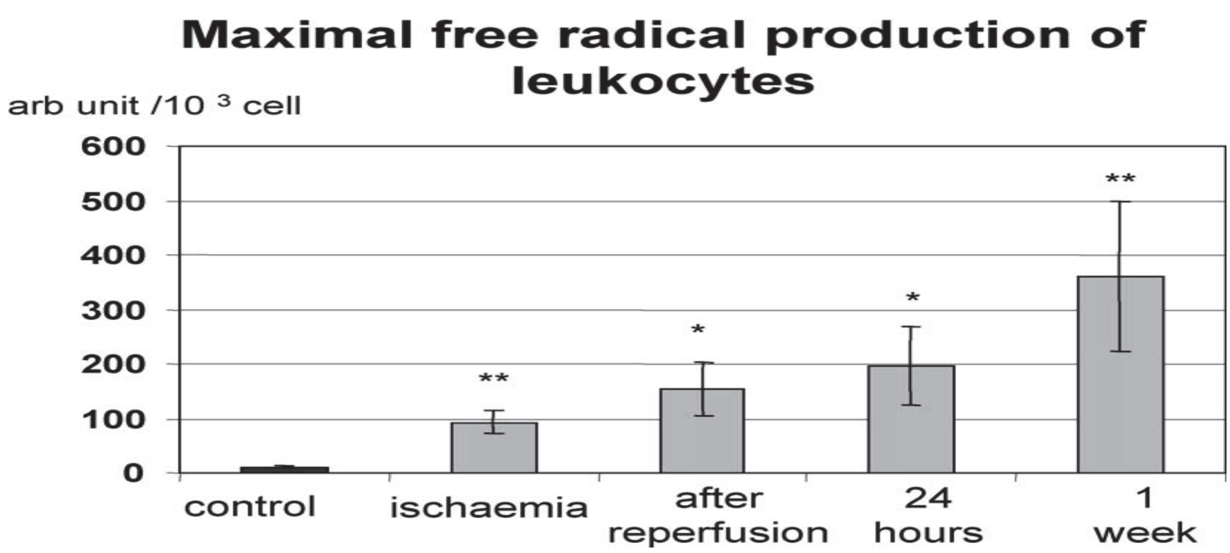


Fig. 6. Maximal free radical production of leukocytes was significantly higher during ischaemia (versus control), and continuously increased until the seventh day (*p < 0.05 and ** p < 0.01 vs. control).

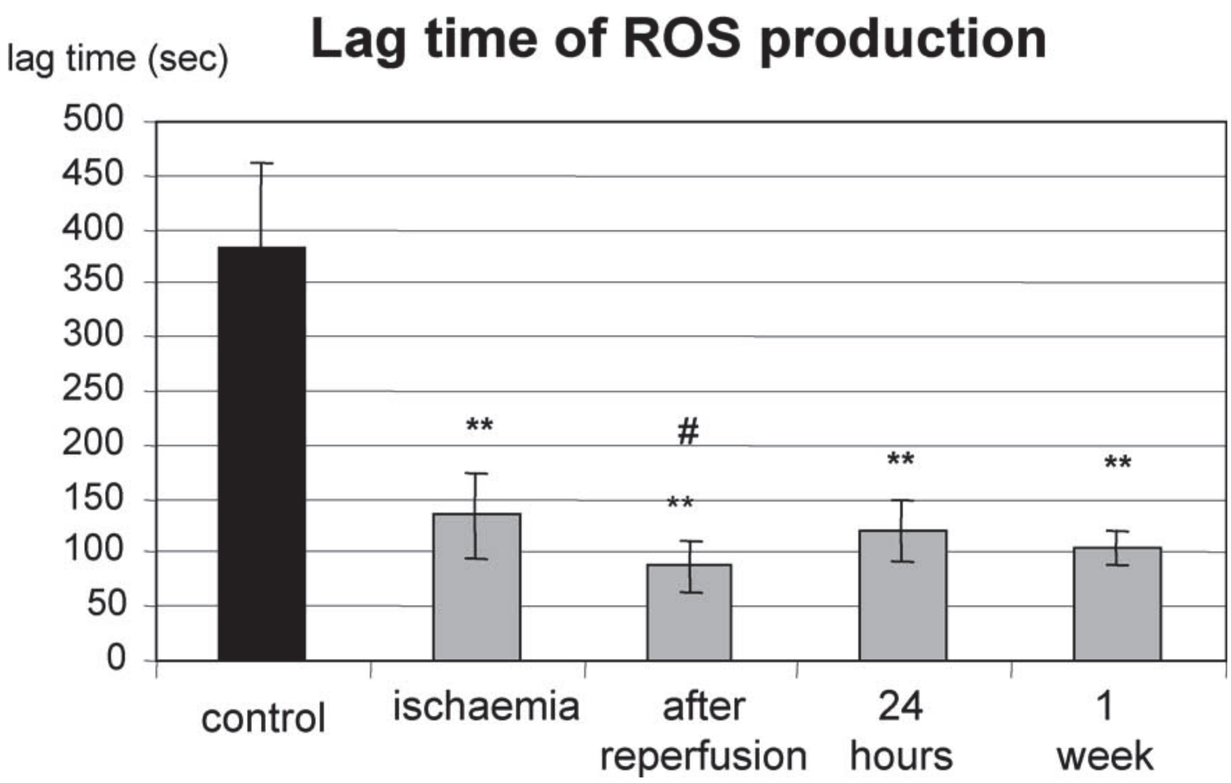


Fig. 7. The “lag time” (taking from induction until the superoxide production) decreased significantly during the reperfusion This showed the significant activation of the leukocytes (#p < 0.05 vs. ischaemia*p < 0.05 and **p < 0.01 vs. control).

The long time monitoring of the oxidative and inflammatory changes in reperfusion helps to understand the pathology and to develop a more effective therapy.

During exclusion of blood from the circulation ischemia and acidosis appear in the surrounding tissues of the occluded vessels, which try to adapt to the absence of oxygen by switching their metabolism from aerobic to anaerobic, but finally these strategy will lead to tissue damage and loss. In the chronic or acute occlusive diseases the tissue injuries depend on the duration of hypoxia, the mass of tissues involved and the blood pressure of the patients. Reconstruction of the occluded vessels is not without risk, because it can cause volume, pressure and metabolic load, with further tissue damage resulting in the so-called reperfusion injury. Peripheral arterial diseases are a seriously under-diagnosed disorder affecting up to 20 % of the adult population worldwide. Atherosclerotic involvements frequently are in the background, thrombosis or embolization can occur within the narrowed or calcified vessels, or within the aneurismal sites, resulting in serious tissue ischemia.

It is very difficult to monitor the cellular processes, which influence the outcome of the surgical manoeuvres or serve as a marker of the following events. A huge amount of data emerged for the characterization of ischemia reperfusion injury, but function of thrombocytes has been hardly investigated by Kürthy M et al. In their study showed that the duration of hypoxia basically influenced the degree of reperfusion injury in revascularization surgery, resulting in a different outcome in ADP and collagen induced platelet aggregation in whole blood even one week after surgery. Platelet aggregation highly and significantly elevated , in spite of the intensive antiplatelet and antiaggregation therapy. Sinay et al. measured in an *in vivo* animal model the serum total peroxide concentration during infrarenal aortic cross clamping ischaemia and reperfusion. Reperfusion injury is an integrated response to the restoration of blood flow after ischaemia, and is initiated at the very early moments of reperfusion, lasting potentially for days. The extent of the oxidative stress and the consecutive generalized inflammatory response depends on the ischaemic-time, the ischaemic tissue volume, and the general state of the endothelium-leukocyte-tissue functional complex (diabetes, chronic ischaemia, drugs). The pathogenesis of reperfusion injury is a complex process involving numerous mechanisms exerted in the intracellular and extracellular environments. Hypoxia leads to intracellular ATP depletion with a consecutive hypoxanthine elevation. In the early seconds of reperfusion, when the molecular oxygen appears in the cell, the – xanthine oxidase catalised –hypoxanthine–xanthine conversion will produce a mass of superoxide radicals. Superoxide radical and the other reactive oxygen intermediates will damage the membrane-lipids (through lipidperoxidation), the proteins (causing enzyme defects and ion channel injury) and the DNA. These are the main pathways of the cellular oxidant injury. The endogenous antioxidant system defends against these radical injuries .Reactive oxygen species (ROS) will also induce local and systematic inflammatory responses through the inducing of cytokine expression and leukocyte activation. Inflammatory process leads to increased microvascular permeability, interstitial edema, and capillary perfusion depletion. The oxidative and inflammatory pathways will lead to a complex reperfusion injury (Jancsó G ,Fig.8).

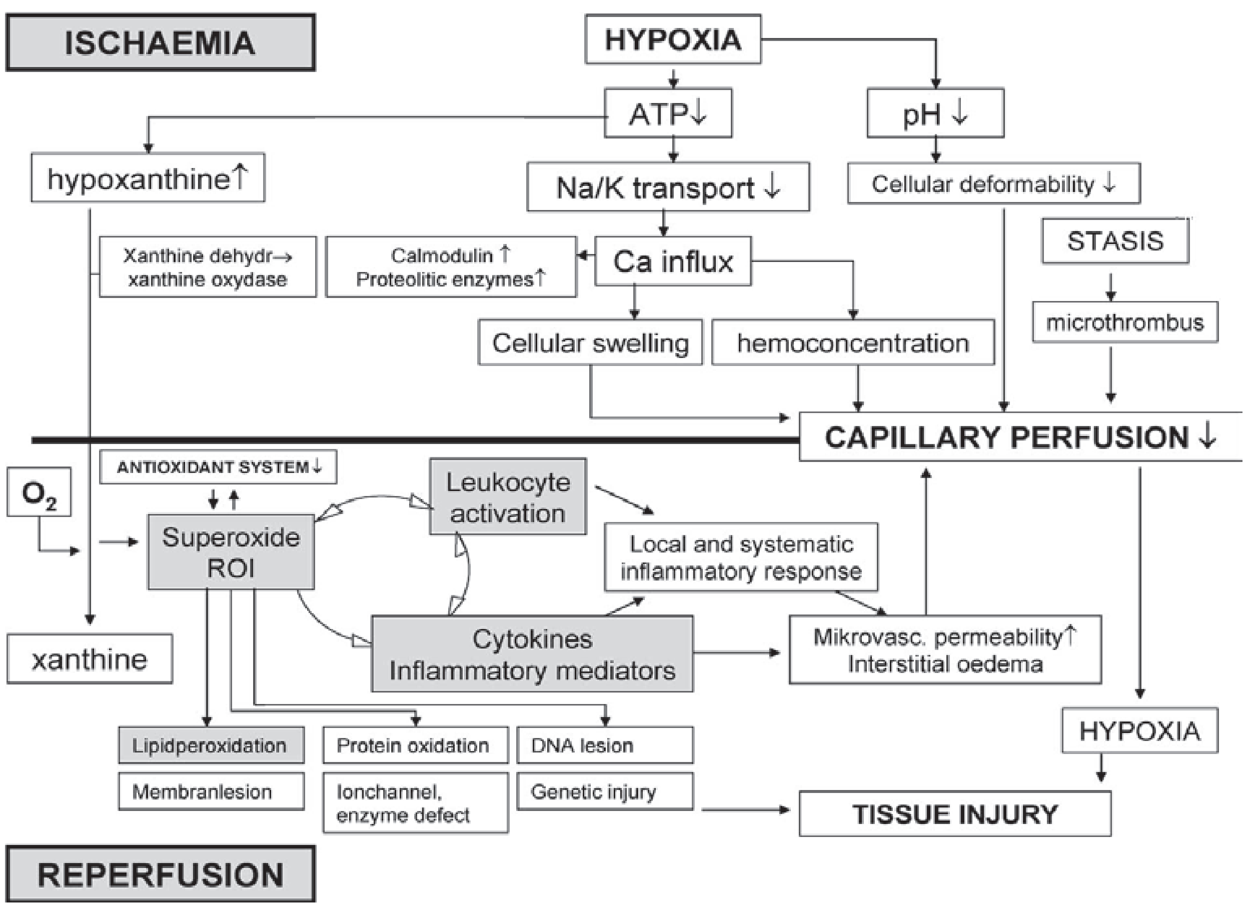


Fig. 8. Simplified presentation of the mechanism of ischaemic–reperfusion injury. Emphasizing, that the engine of reperfusion injury is the ROI–cytokine–leukocyte positive feedback circle (ROI: reactive oxygen intermediers; ATP: adenosine triphosphate; DNA: deoxyribonucleic acid).

9. Conclusions

The management of patients undergoing vascular surgery is one of the most challanging and contraversial area of anesthesiology. The high incidence of coexisting disease, the metabolic stress associated with cross-clamping and unclamping, the ischemic insults in the brain, the heart, the kidneys and the spinal cord resulting a relative high perioperative morbidity in these patients. While these pathways are well known in vascular surgery, there is no real effective tool in the hand of the operating team to treat or to prevent them. As we know how to limit ischemic damage (mostly by reducing the ischemia time via an early reperfusion, and improving O2 demand/supply balance), postconditioning might be the way to prevent or reduce reperfusion damage.

Postconditioning has the advantage of being a way to influence and modify ischaemia–reperfusion injury after it has occurred. This may open a therapeutic alternative in situations of unexpected and uncontrolled ischaemic injury, for instance in the situation where complications occur during surgery, making a simple procedure into a complicated one, and making aortic cross-clamping longer than anticipated.

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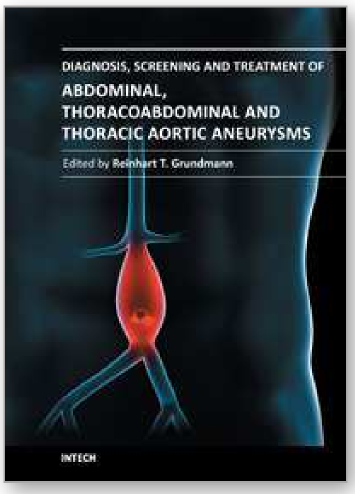

Diagnosis, Screening and Treatment of Abdominal, Thoracoabdominal and Thoracic Aortic Aneurysms
Edited by Prof. Reinhart Grundmann

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This book considers mainly diagnosis, screening, surveillance and treatment of abdominal, thoracoabdominal and thoracic aortic aneurysms. It addresses vascular and cardiothoracic surgeons and interventional radiologists, but also anyone engaged in vascular medicine. The high mortality of ruptured aneurysms certainly favors the recommendation of prophylactic repair of asymptomatic aortic aneurysms (AA) and therewith a generous screening. However, the comorbidities of these patients and their age have to be kept in mind if the efficacy and cost effectiveness of screening and prophylactic surgery should not be overestimated. The treatment recommendations which will be outlined here, have to regard on the one hand the natural course of the disease, the risk of rupture, and the life expectancy of the patient, and on the other hand the morbidity and mortality of the prophylactic surgical intervention. The book describes perioperative mortality after endovascular and open repair of AA, long-term outcome after repair, and the cost-effectiveness of treatment.