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# Preoperative Care, Anesthesia and Early Postoperative Care of Vascular Patients

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## 1. Introduction

The changes in the operation technic in the last twenty years may reduce morbidity and mortality of traditionally high - risk vascular surgical procedures. (White CJ&Gray WA, 2007) The indrease of median age, the number of elderly patients will also elevate the number of vascular procedures. 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, anesthesiologists 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 (2007) 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 colleagues, 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. In the last few years, the **American College of Cardiology Foundation/American Heart Association** focused on beta-blocker therapy. Based on this update beta-blockers should be continued in patients, who are receiving them for treatment of conditions with ACC/AHA indications (Class I)

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.

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 vascular 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 increase 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 intraabdominal 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 inhaling 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 abdominalis aneurysm**

The anesthesia and surgical technique despite the development of the aorta during surgery thoracoabdominalis 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 (follow the protocol), 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. Preoperative 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 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 physiotherapy would improve the patients' condition. One to two days prior to surgery preoperative pulmonary function test should be performed. Decreased FEV1/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<sub>2</sub> pressure monitoring is important, since the probability of developing hypercapnia is high, as well as the postoperative CO<sub>2</sub> 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 perioperative renal complications. All the anesthetic and operative techniques and perioperative events that decrease blood pressure and cardiac output have the potential to alter renal function. The blood flow redistribution in the kidney can decreased the glomerular filtration.

#### **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. pulseoxymetry
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 intraoperative 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.

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 ulcer 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 precense, FFP and platelets ordered for the patient, and heparin is omissions. 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. pulseoxymetry
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
5. Positioning the double-lumen tube can be helped by bronchofiberoptic intubation.
6. Ten units of red blood cell transfusion, FFP and platelet transfusion.
7. Monitoring of SSEPs (somatosensory evoked potentials)
8. Body temperature monitoring: core and peripheral temperature.

The Type A - when 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.

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. Despite the fact that 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 different part 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 atriolfemoral centrifugal pump bypass may be useful in patients with decreased left ventricular function, coronary artery disease, renal failure. and anticipated longer than 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 technique adds the use of oxygenator.
- 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.

### 5.4 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 be detected, especially during manipulation with expanded 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, there is a significant advantage with the change in the operation 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 resistance increases but the value ( $9,2 \pm 3\%$ ) compared to total aortic clamping ( $32,8 \pm 7,6\%$ ) 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

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 anaesthesia (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 reflex and hemodynamic changes. In our stent graft patients we did not experience 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.

Endovascular aortic stent repair, especially of the infrarenal segment, has also been performed under monitored anesthesia care. **Drake** et al. used general anesthesia in 103 patients undergoing endovascular repair of the descending thoracic aorta. The procedure was performed with the patient in the right lateral decubitus position, and TEE was used to guide proper stent placement. General anesthesia provides greater patient comfort when adenosine is used to induce sinus arrest and temporary interruption of CO during thoracic aortic stent deployment. 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 the tight monitoring and technical equipment which ensure the patient's safety and well being.

### **5.5 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 hemodynamically unstable patients, after the unsuccessful volumetric resuscitation. It seems to be the hemodynamical instability is the most important factor of the survival in the patients with RAAA undergoing endovascular aortic aneurysm repair.

### 5.6 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.

### 5.7 Peripheral vascular disease

1. Acute arterial obstruction: most commonly caused by thrombosis and embolisation.

The majority of patients are elderly people with chronic atrial fibrillation. Operation must be performed within 4 -6 hours after the acute ischemia, revascularization must be made as soon as possible. The longer the ischemic period, the less chance for limb survival. Preoperative lab test should routinely contain liver and kidney function and the creatine phosphokinase value (CK). Trends of CK level can indicate the length of ischemia. In case of significantly high level of CK, careful attention should be paid to the subsequent myoglobinuria and adequate fluid intake should be provided. Monitoring hourly diuresis is essential. Acid waste metabolites released from the ischemic, necrotic area impair the circulation, and upsets the acid-base and electrolyte metabolism of the body. Type of anesthesia is determined by the site of obstruction, which can range from narcosis to local anesthesia. If the patient is anticoagulated (e.g because of chronic atrial fibrillation), the regional technique cannot be performed. After the revascularization the impaired circulation is restored, which is followed by the release of large amount of acid waste metabolites from the necrotic areas which were accumulated during the ischemic period. Necroenzymes and myoglobin from the necrotized muscle are also released. These can results in further kidney failure and circulatory impairment. Thus, careful monitoring and lab control is necessary. In case of delayed revascularization, the so called revascularization syndrome develops, which can be life-threatening. Fast decision making becomes essential to determine whether to save the limb or the life. In case of revascularization syndrome despite the anatomically perfect revascularization, further increase of CK level, and rapid progression of kidney failure caused by the myoglobinuria are presented. Hypokalemia also develops. If CK level, during the monitorization reaches the 10.000 U/l , repeated surgical consultation should be organized to determine the further steps. Based on clinical experiences immediate amputation can save the patient's life in these cases. Hemodialysis becomes necessary if CK level exceeds the above mentioned value and if hourly diuresis decreases despite the forced diuretic therapy.

2. In case of chronic obstruction, the patient is referred to the operation after having performed an angiography, thus selecting the most appropriate anesthetic technique is easier. The principles are the same with the acute operation.

In case of peripheral vascular surgeries the anesthetic technique can be take into consideration. In patients with no anticoagulation, neuroaxial technique is widely used. Epidural cannulation at the level of L4 - L5 vertebrae provides appropriate anesthesia for peripheral vascular procedures and has great significance in postoperative analgesia.

Epidural anesthesia has several advantages in the preoperative period, as well, since it can use not only to alleviate the ischemic pain, but it can improve the impaired perfusion of the

affected limb by its vasodilation causing effect. Intra-operative systemic heparinization does not increase the risk for epidural hematomas in case of preoperatively inserted epidural catheters. Nevertheless, particular care must be taken when administering unfractionated or low molecule weight heparins. According to the latest guidelines in case of LMWH therapy insertion and removal of the epidural catheter should be performed 12- 24 hours later after the last administration of heparin i.e. before the repeated dose. Significance of catheter removal should not be neglected, since in the formation of epidural hematoma, removal has the same role than the insertion. Intra-operatively 0.5 % bupivacain solution supplemented with opiates is administered, while postoperatively 0.125 % bupivacain can be used as continuous infusion or bolus doses.

Conditions of spinal anesthesia are similar to the epidural and this technique can also be effectively used in peripheral vascular procedures. Both neuroaxial techniques are particularly advantageous in patient with chronic bronchitis and impaired pulmonary function. As previously mentioned the majority of patient with generalized vascular disease smoke, thus these conditions are often presented in the preoperative examination.

Our patients are usually polyglobulic, has high blood viscosity and slow circulation, thus the risk for early graft occlusion is high. Monitored parameters at each anesthetic techniques are the same. These are the following: 5 leads ECG with ST segment analysis, pulse oximetry, hourly diuresis and in case of known renal dysfunction or oliguria central venous pressure.

### **5.8 Carotid artery revascularization**

Indications for carotid artery operations:

Significant stenosis of the common and internal carotid artery and the carotid bifurcation, significant poststenotic flow reduction, in case of an ulcerated plaque which holds increased risk for embolisation, flow direction inversion, subclavian steal syndrome

Patients undergoing carotid artery surgery like other vascular surgical patients suffer from generalized vascular disease. The ACC/AHA 2007 guidelines consider carotid artery endarterectomy an intermediate risk procedure. Since the incidence of ischemic heart disease among these patients is 28 - 32 % the operative risk is also remarkably high. An international study (GALA -General Anesthesia contra Local Anesthesia ) covering large patient population has been being performed to determine whether local or generalized anesthesia is preferable for patients requiring carotid endarterectomy. Careful preoperative examination and evaluation of the preoperative neurological status is important. Preexisting medication of the patient should not be changed, even the platelet aggregation inhibiting therapy should be maintained in the preoperative period. Establishing arterial line and registering blood pressure beat by beat is necessary for the monitoring of carotid operations. Pressure fluctuation should be treated by administering short-acting agents (ephedrine, phenylephrin or nitroprussid, urapidil). Increasing mean arterial pressure before carotid clamping is essential to ensure adequate blood flow in the opposite carotid and vertebral artery. Target pressure during operation should be 15 - 20 percent higher than the preoperative blood pressure.

Features of the cerebral circulation:

- Cerebral perfusion is determined by the mean arterial blood pressure
- The carotid stenosis is usually bilateral, only the extent of it may vary between the opposite sides
- 3. The blood distribution is unequal due to the stenosis
- The capacity of compensatory collateral circulation is difficult to estimate.
- The vascular response for alteration in perfusion is impaired due to the diseased vascular wall, which fact can further aggravates the inequality of circulation between areas with normal and abnormal blood supply.
- Intra-operative blood supply during carotid clamping cannot be estimated

Infiltration the carotid body with 1 % Lidocaine after the exposition can prevent blood pressure fluctuation caused by the mechanical manipulation (baroreflex response). Blood pressure elevation can increase the risk for myocardial ischemia.

Numerous studies have been carried out to determine the most suitable drug for induction and maintenance the anesthesia during intubation narcosis, however, after comparison the data, providing adequate perfusion pressure and oxygenation seems to be the most important factor.

Intraoperative monitoring:  
Cooperation test

Carotid stump pressure  
Stump pressure index  
(Carotid stump pressure x 100/mean arterial pressure)  
Transcranial Doppler (TCD)  
Cerebral perfusion  
(CBF) Xe133  
EEG

Somatosensory Evoked Potential  
Conduction Time (SSEPS)

Near-infrared spectroscopy

Continuous Jugular Venous oxymetry

Criteria for shunting:

Uncertain responses,  
unconsciousness

< 50 mmHg

< 33

MCAV drop by 60 -70%

< 18 ml/100 g/min

Reduction of the  $\alpha$ ,  $\beta$  activity by 50%,  
increased  $\delta$  activity, asymmetry

> 1 ms, reduction of amplitude by >  
50%

drop of cerebral saturation is more  
than 5%

SJVO<sub>2</sub> < 50%

The above scale describes the different options for intra-operative monitoring and criteria for shunting. Continuous jugular venous oxymetry and near-infrared spectroscopy in patient undergoing general anesthesia are the most commonly used techniques, but none of them are sensitive enough to determine cerebral hypoperfusion, thus combination of several techniques is necessary. Applying surgical criteria for shunting is widely accepted, but it is worth to mention that besides it can prevent the intra-operative hypoperfusion, shunting can cause complication, as well. During general anesthesia numerous drugs can be used for induction. Formerly the barbiturates were administered preferably because of its oxygen demand decreasing effect, but either propofol or etomidat can be used effectively. During induction care must be taken of maintaining the hemodynamic stability of the patient. For maintaining the anesthesia oxygen 50% and isoflurane or sevoflurane with low MAC value is recommended. (ischemic EEG abnormalities were registered during administration of

enflurane). During ventilation particular attention must be paid to the PaCO<sub>2</sub> value, since the cerebral CO<sub>2</sub> reactivity is an important part of the cerebral autoregulation. This is because hypocapnia can decrease, whilst cerebral vasodilatation caused by hypercapnia can increase the cerebral perfusion. In case of patients with preexisting significant cerebral stenosis hypercapnia can further diminish the perfusion in the already hypoperfused area because of steal phenomenon. Thus maintaining normocapnia or minimal hypocapnia is recommended during carotid operations.

The best monitorization can be achieved in case of awake patient and administration of locoregional anesthesia. In these patients preoperative evaluation should include the determination of the dominant brain hemisphere, which is usually corresponds with the patient's handedness. It can be different among elder people, since formerly left-handedness was unacceptable. Determination of the dominant hemisphere is important because of the localization of the speech center. During locoregional technique C2 - C4 spinal roots are deeply whilst the dermatomes are superficially anesthetized by infiltrating them with 7.5 % naropin or 0,5 % bupivacain solution.

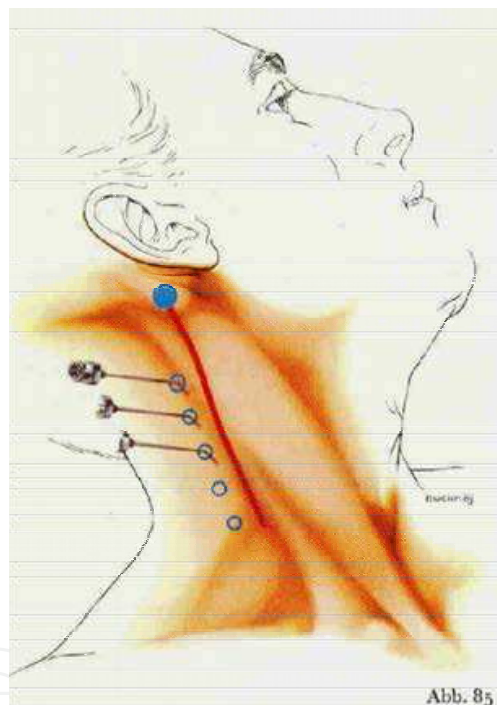


Fig. 1. Infiltration sites of cervical roots

During locoregional anesthesia blood pressure fluctuation is less remarkable. After carotid clamping continuous talking with the patient for 3 minutes should be performed during which the patient should continuously move his/her extremities. If no abnormalities of the sensory or motor function are registered the essential part of the operation can be commenced. If the patient's level of consciousness begins to decrease, aphasia or disability of limb movement develops immediate shunting becomes necessary.

What are the advantages of local anesthesia?

Cerebral ischemia can be early recognized. With the use of intra-operative shunt: patients' consciousness gives a chance for continuous neurological monitoring. Shunting is used only



if needed. Blood pressure drops that are dangerous for cerebral and coronary perfusion are less likely to develop than in case of narcosis due to the maintained regulation. Consciousness facilitates the post-operative observation.

What are the disadvantages of local anesthesia?

Hoarseness, difficulty swallowing, numbness of the hand at the opposite side, movement difficulties, dysarthria, confusion, loss of consciousness (if the local anesthetic diffuses or directly gets into the epidural space). Preparation must be made to handle the complications. Local availabilities must be taken into consideration.

### **5.9 Carotid artery stenting technique**

Requires minimal moderate sedation and standard monitoring technique. In both technique we have to listen to the postoperative stroke, it mostly embolic origin. The increase sensitivity of the baroreceptors after the plaque removal can cause bradycardia and hypotension. At the other hand hypertension can lead to hyperperfusion – hyperperfusion syndrome – which may lead to intracerebral hemorrhage. So the neurological and haemodynamical control of these patients are very important.

## **6. Postoperative evaluations**

### **6.1 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. The clinical phenomenon with increase in the lower limb compartment pressure leading to circulatory deterioration and therefore inadequate tissular oxygenation is known as compartment syndrome of lower limb

The most frequent causes of acute compartment syndrome would be classified as:

- 1.1. Decrease in the volumetric size of the compartment: tight bandages or casts, tight closure of the fascia, burn or frostbite injuries.
- 1.2. Increase in the size of the compartment: (a) as a result of edema: arterial injuries, arterial thrombosis and embolization, reconstructive vascular operations, replantation (revascularization), long tourniquet time, arterial spasm, angiography, ergotamin intoxication, prolonged immobilization with limb compression, narcotic influence, high strain, venous insufficiency, snake bite; (b) as a result of a hemorrhage. According to the progression, compartment syndrome can also be classified in the following manner:
  - First degree: pain, swelling, paresthesia.
  - Second degree: neurological changes, absence of pulse and early focal necrosis in muscles..
  - Third degree: complete muscular and dermal necrosis.

To set the diagnosis of classic compartment syndrome, the observation of the following six signs and symptoms are of great importance.

- Disproportional higher pain compared to clinical findings.
- Pain in the affected compartment with passive movement of the limb.
- Paralysis or paresis of the muscles of the concerned compartment.
- Hypaesthesia or paresthesia in the affected compartment.
- Induration and inflammation in the affected compartment.
- Absence or diminished distal pulse.

To prevent neuromuscular ischemia and necrosis, fasciotomy must be performed, in order to decompress the rigid osteofascial compartments of the lower limb, thus, to relieve the muscles and neurovascular bundles. Revascularization syndrome is undoubtedly one of the most common causes of compartment syndrome requiring urgent fasciotomy.

## 6.2 Pathomechanism of compartment syndrome

Interruption of circulation in muscle tissue results in a series of biochemical changes, starting with cellular dysfunction, followed by cellular and tissular edema, leading to reversible and then irreversible impairment of the cells. Ischemic injury to tissue leads to decreased energy supply needed for membrane function and electrolyte homeostasis, leading to enzyme system impairment and finally irreversible changes at the cellular level. Therefore, the fine balance between homeostasis and microcirculation becomes upset. Anaerobic metabolism then starts in muscle tissue due to ischemia resulting in accumulation of acidic metabolites including lactic acid. Due to the impairment of membrane functions, among the others,  $\text{Na}^+/\text{K}^+$  pump dysfunction is the most important as it causes intracellular uptake of  $\text{Na}^+$  and water and release of  $\text{K}^+$ . Intracellular  $\text{Na}^+$  and water will generate swelling and edema and, therefore, the compartment pressure increases (above 40 mmHg). This leads to secondary arterial compression, thus, despite established patency, the oxygen transport remains disturbed. Many authors reported on necessity of amputation after successful embolectomy because of serious, generalized life-threatening symptoms]. In a revascularized limb reactive hyperaemia is one of the first signs, which occurs due to dilation of capillaries and arteriovenous shunts. Capillary dilation along with products of anaerobic metabolism causes increase in the permeability of capillaries and worsening edema, leading to a secondary hypovolaemia.

Apart from the vascular lesion, impairment of circulation is one of the most important factors by which a series of hemodynamic disorders can be started, leading to capillary nutritional impairment and muscular edema. Muscle fiber swelling and edema causes elevation of compartment pressure. Then retention of intracellular fluid and microbleedings will develop, leading to further impairment in circulation as the process rapidly advances. At this level fasciotomy must be performed immediately to prevent serious myopathy and muscle necrosis. Arterial or venous occlusion alone, cannot explain the pathogenic background of compartment syndrome, since this complex of signs of vascular occlusion may develop even in the absence of vascular injury. Phenomenos as “chronic exertional compartment syndrome” or “overuse syndrome” are pieces of evidence proving that many other mechanisms are also involved in the development of compartment syndrome. Irrespective of origin of injury and ischemia, the end point of this process is swelling of muscle bundles in the compartment space and elevation of intracompartmental pressure (ICP). If intracompartmental pressure exceeds the critical level of 35–40 mmHg, the nutritional function of capillaries would cease and perfusion of muscles fail. If this process is

not interrupted by performing fasciotomy, ischemic changes will ultimately develop resulting in irreversible injuries.

### **6.3 The role of oxidative stress in the pathogenesis of compartment syndrome**

At the beginning of compartment syndrome, ischemic-reperfusion signs are present only at the cellular level. The reasons behind elevation of capillary permeability are not well known yet, though many biochemical changes observed may give partial explanation. During ischemia-reperfusion, well-known reactive oxygen-derived intermediators are formed. Toxic action of free radicals would affect intracellular matrix and cell membranes. Due to the above mentioned mechanism, antioxidant enzymes and different types of scavengers like allopurinol, mannitol, catalase, dimethylsulfoxide and superoxide dismutase (SOD), which block cytotoxic free radicals procreation, may also play an important role in stopping compartment syndrome evolution.

By monitoring ischemia-reperfusion, Lee et al. have presented further proves about the role of free radicals. During ischemia, the calcium transport in the sarcoplasmic reticulum of skeletal muscles is significantly depressed. Lee has monitored physiologic alterations during and after ischemia by strangulation of back limbs in rat models. These observations have shown that in the group of rats treated previously by superoxide dismutase and catalase, calcium uptake in the sarcoplasmic network is appreciably higher comparing to the non-treated group, though, treatment by antioxidant enzymes does not elevate the calcium uptake level to non-ischemic range. This might lead to conclusion that, possibly other mechanisms are also involved in development of compartment syndrome.

### **6.4 Main points**

Indications for surgery for compartment syndrome, used to happen decisively on the basis of clinical findings, which was mostly subjective, and therefore leads to delayed surgical intervention in many cases. By monitoring of elevated compartment pressure, microcirculation impairment and tissular oxygen saturation (StO<sub>2</sub>), we tried to observe the progression of compartment syndrome. We also tried to choose a fast, practical and reliable method that can also be performed at bed-side, providing us with objective data supporting the foregoing subjective indication of fasciotomy. Using a non-invasive oxygen saturation detector and by minimally invasive measurement of compartment pressure, the stage of the disease progression and its reversibility can be assessed objectively. Using literature references, we measured intracompartmental pressure (ICP) and tissular oxygen saturation (StO<sub>2</sub>) to evaluate the circulation of the extremity. We applied these two methods abreast, in patients suffering from clinically proved compartment syndrome, thus, our data might help in diagnosing of compartment syndrome due to reperfusion injury and deciding whether the patient should undergo conservative versus surgical treatment.

### **6.5 Determination of tissue oxygen saturation**

For determination of tissular oxygen saturation, we used InSpectra Tissue Spectrometer (Model 325; Hutchinson Technology Inc., Arnhem, The Netherlands). InSpectra tissue spectrometer can detect light absorption characteristic of hemoglobin in a near-infrared range (near-infrared spectroscopy-NIRS; wavelength: 680–800 nm). Deflected light from

tissues and its absorption by sensor device decisively indicates the level of oxyhemoglobin and deoxyhemoglobin concentration. We placed the detector part on gastrectemius muscle, and after calibration a continuous monitoring of saturation values could be obtained. NIRS is a non-invasive method for monitoring tissular perfusion. Former studies also intended to apply tissular oxygen monitoring methods like as Doppler, thermometry and application of optochemical oxygen sensors. The detector part is able to emit near-infrared light, and absorb deflected rays from different layers of tissues. Tissular Hgb-oxygen saturation would appear in 4 dissimilar wavelengths. Near-infrared light can easily penetrate skin, muscles and even bones, thus it would be absorbed in distinct ways in layers containing different concentration of blood and Hgb. The near-infrared emitter and the deflected light absorber optical cable are placed 25 mm away from each other. Depth of measurement can be set on 12, 15, 20, 25 and 35 mm. These will be the depths of the tissue where we received our data from. (Emitted light, minus absorbed light is equal to reflected light.) During measurement by NIRS we could register arterioles, capillaries, veins and tissular bed Hgb concentrations of different depth. This is the main difference between NIRS and pulsoxymeter, which can only detect Hgb-concentration of pulsating layer. This technique is appropriate for single or continuous non-invasive monitoring of tissular perfusion]. It is therefore very convenient to detect perfusion alterations occurring in the area under detector, and practically can be used to diagnose peripheral obliterative atherosclerosis (measurement of perfusion changes under strain), operative perfusion and reperfusion perception. And finally, it can be used as a reliable tool in making correct diagnosis and treatment.

## 6.6 Results

The cut-off ICP pressure was 40 mmHg above which fasciotomy was considered to be an absolute indication- we assumed normal oxygen saturation level to be 87%. (Arató et al) Undoubtedly, clinical diagnosis and surgical treatment of compartment syndrome in a timely manner requires a great attention and co-evaluation of many parameters. Complications are usually due to a delayed or inadequate fasciotomy ("too little and too late" phenomenon). Measurements performed in limited numbers are not suitable for statistical analysis. According to literature data and our experiments, measurement of limb saturation significantly correlates with compartment pressure alterations.

We emphasize that only a parallel observation of the patient's clinical status, laboratory data, ICP and limb StO<sub>2</sub> may lead to correct and reliable diagnosis resulting in determining the optimal time of fasciotomy and proper evaluating of efficiency of surgery. We believe that measurements of compartment pressure and tissular oxygen saturation both can be helpful in making accurate diagnosis, indication of fasciotomy and also during postoperative follow-up. A novel method of our team that we used objective parameters as basis of a new interventional indication strategy in making decision for fasciotomy along with empirical treatment guidelines applied generally in clinical practice (evidence-based medicine). We were the first to study lower limb compartment syndrome by parallel monitoring of non-invasive tissular oxygen saturation and by minimal invasive measurement of compartment pressure. The pressure and oxygen saturation cut-off values defined by our team can be beneficial in making decision regarding operative versus conservative treatment.

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. (Jancsó et al) 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 (Fig.2).

While these pathways are well known in vascular surgery, there is no real effective tool in the hand of the surgeons 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 O<sub>2</sub> 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.

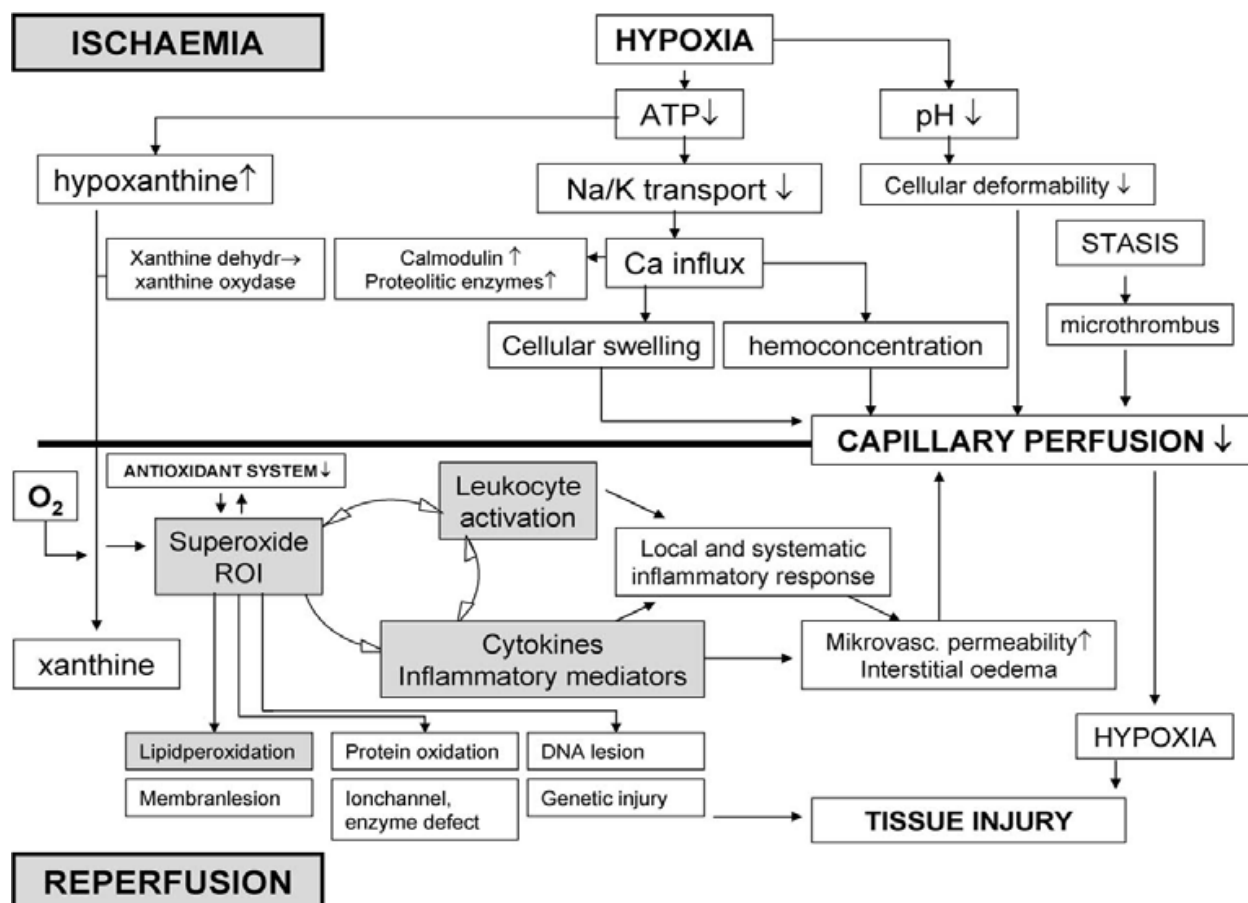


Fig. 2. Simplified presentation of the mechanism of ischaemic-reperfusion injury.

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).

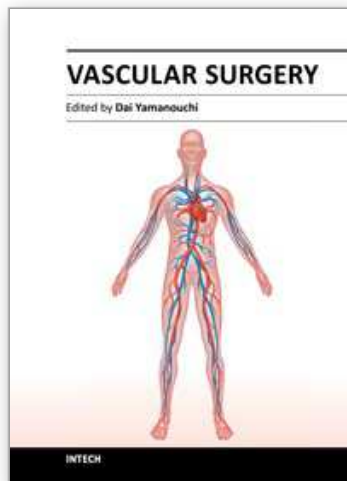
## 7. Summary

In the postoperative period the most important factor is the stress response. This includes preventing the triggers for myocardial ischaemia. These triggers are the pain, the anemia, haemodynamic instability, hypothermia and the oxygen demand. The important task of the anesthesiologist is optimization of cardiac risk, implications of anesthetic technique, diagnosis and prevent the myocardial ischaemia. It is a great challenge to keep balance on a relative elderly patients with high incidence of coexisting disease. Our job is to do everything for vascular surgery patients to reduce the morbidity and better overall outcome.

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## **Vascular Surgery**

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This book aims to provide a brief overview of conventional open vascular surgery, endovascular surgery and pre- and post-operative management of vascular patients. The collections of contributions from outstanding vascular surgeons and scientists from around the world present detailed and precious information about the important topics of the current vascular surgery practice and research. I hope this book will be used worldwide by young vascular surgeons and medical students enhancing their knowledge and stimulating the advancement of this field.

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