CASE STUDY

# ISCHEMIC SPINAL CORD INJURY FOLLOWING AORTIC STENT GRAFT IMPLANTATION – CASE STUDY

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**SUMMARY**
Morbidity and mortality associated with aortic aneurysm remains high. Aneurysms involving the thoracic and lumbar part of the aorta (TAAA) are particularly burdened with mortality. They are also one of the biggest challenges that vascular surgeons can face. Despite several dozen years of progress in surgical techniques, as well as the constant development of accompanying methods of spinal protection, ischemic spinal cord injury with subsequent paresis or pareresis is still one of the most serious complications of both open and closed surgical treatment of aortic aneurysms. Ischemic complications of the spinal cord occur immediately after the procedure, when the patient wakes up with a neurological deficit (according to some authors within the first day after the procedure) or in a deferred manner. In the case of open surgery, immediate damage is more common, in the case of endovascular surgery - deferred. Factors such as low blood pressure, arrhythmias, cardiovascular failure, sepsis and anemia due to anemia contribute to an increased risk of deferred complications. The rehabilitation of a patient with limb paralysis as a consequence of vascular spinal injury is laborious and requires a comprehensive approach. Proper treatment and prompt intervention in the form of rehabilitation is a great therapeutic challenge.
**The aim** of the paper was to present the importance of the ischemic injuries of spinal cord following aortic stent graft implantation through a case report.

**KEY WORDS:** ischemic spinal cord injury, aneurysm, aorta, graft

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## INTRODUCTION

Despite several dozen years of progress in surgical techniques, as well as constant development of accompanying methods of spinal protection, ischemic spinal cord injuries with subsequent paresis or pareresis are still one of the most serious complications of both open and closed surgical treatment of aortic aneurysms. The risk of ischemic spinal injury according to various sources ranges from 2-10% and is similar for both open and endovascular surgical techniques [1]. It is recognized that the pathogenesis of spinal injury during the procedure is multifactorial, however, its mechanism has not yet been fully explained. The two most frequently considered theories are insufficient remodeling of collateral circulation designed to maintain the life of the spinal cord and closure of nutrient vessels caused mechanically by the operator during clamping, with graft material or other (e.g., material derived from atherosclerotic plaque) [2]. Morbidity and mortality associated with aortic aneurysm remains high. In the United States, death associated with aortic aneurysm is estimated to be 14th among people over 55 and 17th among all age groups, European statistics remain equally high. Aneurysms involving the thoracic and lumbar part of the aorta (TAAA) are particularly burdened with mortality. They are also one of the biggest challenges that vascular surgeons can face.

## ABDOMINAL AORTIC ANEURYSMS (AAA)

The incidence of abdominal aortic aneurysms increases with age [3]. In addition to age, risk factors for the development of an aneurysm in this area include male sex, smoking [4-8] hypercholesterolemia and hypertension [5, 9, 10] as well as family history of the disease. It is assumed that the risk of abdominal aortic aneurysm increases by 6% for 10 years after exceeding the age of 65 [11]. In animal models, the association of initiation and development of abdominal aortic aneurysms with inflammatory processes is noteworthy. This is confirmed by human studies [12, 13]. Also, diseases associated with a high inflammatory response such as asthma or psoriasis - are associated with a high percentage of abdominal aortic aneurysms [14,15]. Animal models also show the important role that the renin angiotensin system plays in the development of AAA [16]. Interestingly, the occurrence of diabetes reduces the risk of developing AAA [17], and high hemoglobin A1C levels is inversely correlated with the development of abdominal aortic aneurysms [18].

## THORACIC AORTIC ANEURYSMS

Thoracic aneurysms (TAAs) are less common than those located in the lumbar region. Their incidence reaches

6-10 cases per 10,000 population. In contrast to lumbar aneurysms, they are approximately 20% associated with the 98 LU pacific genetic variants. Among the mutations associated with this type of aneurysms, min. mutations of fibrillin-1 (Fbn1) and changes associated with the TGF-beta receptor 99-103. This has also been confirmed by experimental animal studies. In addition to genetic factors, the development of aortic valve aortic valve is associated with the development of thoracic aortic aneurysms [19].

## THORACOLUMBAR ANEURYSMS:

Thoracolumbar aneurysms (TAAA) are defined as 1.5 x dilatation of the thoracic and lumbar part of the aorta compared to its initial diameter. Most often occur in old age (average age of 66) [2]. Although lumbar and descending aortic aneurysms are more common than these, descending and thoracolumbar aneurysms are gaining in importance. This is not only related to the expansion of diagnostic options - enabling detection, but also to the permanent aging of societies. Their incidence reaches a total of over 16 cases in 10,000 men and over 9 in 10,000 cases in the female population [20]. The natural course leads to a constant widening of the aneurysm size up to the rupture of the vessel wall. TAAAs are classified according to the division proposed by Crawford [1]. The four-grade classification is based on anatomical coverage. Type 1 (25%) covers most of the descending thoracic aorta, from the left subclavian artery (LSA) to the renal arteries. Type II (29%) can start anywhere below LSA and extends to the splitting of the aorta. Type III (23%) starts below Th6 and can reach up to split. Type IV (23%) is limited to the abdominal part below the diaphragm. The Crawford classification correlates with the difficulty of performing the procedure as well as the risk of complications. Type II is associated with the highest rates of death, paraplegia, renal failure and other complications [2].

## SURGICAL TREATMENT

### *OPEN SURGICAL TREATMENT*

Since the 1950s it has been the gold standard of TAAA treatment. Initially, homographs were used in the treatment, followed by vascular prostheses [21, 22]. Stanley E. Crawford began the era of modern TAAA treatment. His pioneering surgical technique resulted in a decrease in mortality during procedures from 26 to 8% and a risk of paraplegia to 16% (in a series of over 1,500 procedures performed) [2]. Modern data give mortality ranging from 6.2 to over 20% depending on the experience of the center, the surgeon conducting the procedure and the situation in which it is performed (elective or emergency surgery) [23, 24]. In the analysis of 797 planned open TAAA procedures performed in California, mortality within 1 month was 19%, within 1 year 31% [25]. The consequence of treatment is also often prolonged hospitalization and long, painstaking rehabilitation. Contraindications for open procedures are: advanced age, serious pulmonary diseases, circulatory failure, renal failure, complicated aortic morphology and a high risk of aneurysm wall rupture. In studies analyzing the consequences of endovascular procedures performed in patients disqualified from open surgery due to excessive operational risk, mortality during the first month was 4.8-5.5%, and complications in the form of permanent paraplegia in 2.7-4%) [26, 27]. This shows that endovascular procedures give results comparable to those achieved during open procedures performed in highly specialized centers, even taking into account that in the analyzed cases the most burdened disqualified patients from open procedures were taken into account.

## ENDOVASCULAR SURGERY

Precursors of endowasculation were scientists from Eastern Europe, who in the 1980s provided traumatic injury to the thoracic aorta with a stentograft of their own design [28] a few years later, the same team undertook to stent an abdominal aortic aneurysm from the same access, but the attempt proved unsuccessful. This obstacle was overcome in 1991 [29]. A few years later, the procedures began to be applied successfully with regard to the thoracic aorta [30]. Since then, constant technical progress has been noted in both modernizing operational techniques and the equipment used at the time. In Poland in 1998, the first surgery to establish a stentograph was made by Professor M. Szczerbo-Trojanowska in Lublin [31]. It is a safe procedure, which does not require closing the vessel lumen and virtually no blood loss (max 200ml). Today, this is the standard procedure in the treatment of acute and chronic thoracic aortic aneurysms. This treatment eliminates the dissection site, restores normal blood flow to the tissues, protects the vessel walls and excludes the aneurysm from the bloodstream. It is also used in emergency or traumatic situations, where there is no possibility of surgical treatment because of the patient's general health [32-34]. The main limitation in the use of endovascular procedures is the need to anchor grafts to the healthy wall of the vessel, without closing the vessels departing from the aorta. In the case of aneurysms involving the aortic orifices, special graft, fenestrated or branched models must be used [35]. In a large study evaluating the effect of TAAA treatment with branched stents. Studies conducted on 185 patients showed a good technical effect in 98%, mortality within the first month at 9% and complications in the form of vascular trauma in 6% [36].

## ISCHEMIC SPINAL INJURIES

Ischemic spinal injury is a complication dramatically affecting the quality of life of patients. In addition to dramatic changes in quality of life, this complication also increases the risk of death for affected patients [37]. In a study comparing patients affected and not affected by a spinal cord injury in over 570 patients undergoing surgery for aneurysm, a significantly higher first-month mortality (23 to 8%) was observed, lower

5-year survival (25 to 51%) in patients with perioperative trauma spinal cord [38]. This is confirmed by the results of studies comparing patients with transient spinal dysfunction to those with definitive damage [39]. Blood supply to the core and mechanisms of damage during aneurysm surgery:

The frequency of spinal cord vascular injuries is due to its blond supply system. The spinal cord is provided with vertebral artery branches: the anterior vertebral artery supplying the motor areas of the spinal cord and the two posterior spinal arteries supplying its sensory areas. The anterior spinal artery is supplied by segmental branches of the aorta by radicullar medullary arteries. During aneurysmal surgery, many of these vessels may be lost, resulting in immediate or delayed ischemic injury. During open surgery, it is necessary to use a cross clamp to temporarily reduce blood flow to the spinal cord to allow surgery. In addition to reducing blood supply to the spinal cord, it contributes to an increase in venous pressure and cerebrospinal fluid, ultimately contributing to ischemia and the release of neurotoxic substances. Secondary restoration of circulation (revascularization) may, contrary to appearances, worsen this condition by reperfusion injury [40]. During endovascular surgery, the mechanism of injury is the segmental artery closure by a stentographer, especially in the absence of revascularization techniques available during open surgery. Mechanisms such as vascular embolization, hemodynamic destabilization with subsequent hypotension, and insufficient collateral circulation are also considered [39, 41]. Many strategies have been developed to prevent this complication from Cerebrospinal fluid drainage and permissive hypertension as binders. Security factors also include proper postoperative care with monitoring to prevent hemodynamic disorders and the operator's knowledge of not only the mechanisms of spinal perfusion but also the possibility of collateral circulation with subclavian and hypogastric artery, and thus ensuring their activity, especially for more extensive procedures and early intraoperative reperfusion of the lower limbs and pelvis. Ischemic complications of the spinal cord occur immediately after the procedure, when the patient wakes up with a neurological deficit (according to some authors within the first day after the procedure) or in a deferred manner. In the case of open surgery, immediate damage is more common, in the case of endovascular surgery - deferred [42]. Factors such as low blood pressure, arrhythmias, cardiovascular failure, sepsis and anemia due to anemia contribute to an increased risk of delayed complications. The rehabilitation of a patient with limb paralysis as a consequence of vascular spinal injury is laborious and requires a comprehensive approach. Proper treatment and prompt intervention in the form of rehabilitation is a great therapeutic challenge.

## THE AIM

The aim of the paper was to present the importance of the ischemic injuries of spinal cord following aortic stent graft implantation through a case report.

## A CASE REPORT

A 66-year-old patient was admitted to the Vascular Surgery Department of the Independent Clinical Hospital No. 4 in Lublin due to an aneurysm just above the T-Branch stent graft implanted in May 2019 due to dissection of the thoracic-abdominal aorta involving the visceral and renal vessels. After surgery in 2019, a complication of generalized sepsis occurred. In 1999, the patient underwent laryngectomy due to larynx cancer. In February 2010, based on the clinical picture and angiography, the patient was qualified for re-implantation of the stentograft due to the progressive aortic dissection above the prosthesis. In addition, the patient suffered from hypertension and gout. He was in full logical contact during the admission to the ward. The functional condition was assessed as very good. Before the surgery, in the initial functional assessment (balance and gait assessment - Tinnetti scale) a maximum of 10 points was obtained (full physical fitness, independence and no risk of falls). In the Barthel scale the maximum of 100 points was obtained, indicating complete independence in everyday life activities. The surgery was carried out correctly. In the postoperative period, complications in the form of deep flaccid paralysis of the left lower limb and deep paresis of the right lower limb occurred. In the following days there was a neurological and neurosurgical consultation and CT scan of the lumbosacral and thoracic spine (Fig.1). The study showed degenerative changes of the spine, protrusion of the L4/5 disc, no signs of bleeding into the spinal canal. The clinical picture supported vascular spinal cord injury in the area of anterior spinal artery vascularisation. In the neurological assessment a negative Babinski reflex, no tendon reflexes, no pain sensation were found, with a untouched skin sensation. In the following days the patient was qualified and transferred to the Department of Neurological Rehabilitation in order to continue treatment and rehabilitation. Upon admission to the Rehabilitation Ward the patient was lying down, unable to sit down on his own, barely maintained a sitting position with his legs down outside the bed when seated passively. On the Barthel scale 15 points was obtained so the patient's condition was assessed as "very severe" (required help in most everyday activities). On the Tinnetti scale, he scored 0 points. In Lovett muscle strength assessment, the lower left limb was rated 0 - no movement, there was a trace of movement in lower right limb in the hip and knee flexors as well as a trace of knee extension and a trace of flexion and extension in the ankle (1+ in Lovett scale). From the first day after admission, a rehabilitation program was performed included: active exercises with upper limb resistance, active and passive exercises of the right lower limb, exercises according to neurodevelopmental methods (PNF), isometric exercises of active muscle groups and gradual passive uprighting (Fig.2). Due to the treatment of thrombosis in the left lower limb, passive exercises of that limb were contraindicated until the end of treatment. Active standing and learning of motion-related activities began after obtaining

**Fig. 1.** 3D computer tomography reconstruction of the graft.

**Fig. 2.** Exercises according to the neuromuscular pathway (PNF) method.

**Fig. 3.** Equilibrium exercises.

**Fig. 4.** Locomotive training with the help of a high balcony.

**Fig. 5.** Orthopedic equipment in the form of drop foot ankle orthosis.

medical permission. Then the scope of physiotherapy was expanded to equilibrium exercises and priopriocеption exercises in high positions, such as sitting and standing (Fig.3). After a period of 16 weeks of rehabilitation in the ward, the patient obtained a significant improvement in the strength of the muscles of the lower right limb (hip flexors 4, knee flexors 4, ankle flexors 3 in Lovett scale). The left lower limb was still functionally weaker (hip flexors 3, knee flexors 3, ankle flexors 2 in Lovett scale). The stabilization of the torso improved significantly, which enabled the patient to sit and stand independently with the help of a high walker or another person (Fig. 4). To protect the feet while walking, orthopedic equipment in the form of ankle drop foot orthosis was used (Fig. 5). When performing self-service activities, e.g. dressing, toilet, he no longer required the assistance of "third parties. On the Barthel scale he obtained 65 points. After 18 weeks of rehabilitation, the patient is able to cover a distance of 150 meters, still supplied with orthosis and high walker. He describes his state as satisfying.

## CONCLUSIONS

Factors increasing the risk of developing aortic aneurysm include: age over 55, male gender, family history of aneurysms, smoking, atherosclerosis, chronic obstructive pulmonary disease (COPD), hypertension, high blood cholesterol, ischemic heart disease.

Intravascular prosthesis insertion is a method increasingly used all over the world, enabling safe interference and repair of damaged vessels. Endovascular treatment allows therapy at an early stage of disease development. Complications of endovascular treatment include: leakage of blood into the aneurysmal sac, migration of the stent graft, stent graft breakdown or stent graft thrombosis [43] Jargiełło. A sharp increase in blood pressure during the stentograph expansion, poor placement associated with advanced atherosclerosis, can also cause a thrombus within the stentograph or lead to a fracture. Endovascular complications requiring long-term and comprehensive rehabilitation are stroke (4- 6.7%) or permanent or transient spinal cord stroke (0-3%) [44, 43]. In order to avoid the above complications after surgery are used: the shortest aortic clamping time, not exceeding 60 minutes, avoiding drops in blood pressure during the procedure, monitoring of cerebrospinal fluid pressure, and if necessary cooling through epidural infusions of saline and the use of opioid receptor antagonists [44, 45].

Effective treatment of postoperative complications of aneurysms and aortic wall dysfunction as well as rapid recovery of the patient from before surgery depends on early and comprehensive rehabilitation. Physiotherapy should be carried out in the first postoperative days and carried out in a safe manner for the patient, under full medical supervision. Then we have a better chance of returning the patient to optimal mobility and independence in life.

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