Hybrid techniques in the treatment of thoracic aortic aneurysm – own experience

Techniki hybrydowe w leczeniu tętniaków aorty piersiowej – doświadczenia własne

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Post Kardiol Interw 2009; 5, 3 (17): 123–128

Abstract

Aim: Two cases of patients with thoracic aortic dissection treated with hybrid technique consisting of surgical aortic valve graft implantation (Bentall procedure) with a transfemoral stent-graft implantation as a second stage procedure are presented.

Methods and results: In both cases thoracic aortic dissection was diagnosed. First patient underwent aortic valve graft implantation (Bentall procedure) with transposition of brachiocephalic trunk and left common carotid artery. In the second case Bentall procedure with by-pass to the right coronary artery and transposition of the great arteries to the aortic prosthesis with the use of Dacron prostheses was performed. Both patients had a stent-graft implantation to the thoracic descending aorta covering the left subclavian artery as a second stage procedure.

Conclusions: The use of stent-grafts and hybrid technique in patients with thoracic aortic aneurysms and dissections should be more frequent. It is related to the lower risk of death and neurological complications in comparison to conventional surgical treatment of the thoracic aortic aneurysms.

Key words: thoracic aorta, stent-graft, hybrid techniques

Streszczenie

Cel: Analiza 2 przypadków klinicznych chorych z rozwarstwieniem aorty piersiowej leczonych metodą hybrydową: operacyjnej wymiany aorty wstępującej i łuku z transpozycją pnia ramienno-głowowego i tętnicy szyjnej wspólnej lewej oraz przezudowej implantacji stentgraftu do aorty zstępującej w drugim etapie leczenia.

Metody i wyniki: U obu chorych stwierdzono rozwarstwienie aorty piersiowej. U pierwszego chorego wykonano zabieg implantacji zastawkowego graftu aortalnego metodą Bentalla wraz z doszyciem pnia ramienno-głowowego do protezy aorty wstępującej oraz zespoleniem tętnicy szyjnej wspólnej lewej z protezą aorty za pomocą wstawki naczyniowej. W drugim etapie leczenia implantowano stentgraft do aorty zstępującej. U drugiego chorego wykonano zabieg metodą Bentalla połączony z pomostem żylnym do rozwarstwionej prawej tętnicy wieńcowej i zespoleniem pnia ramienno-głowowego i tętnicy szyjnej wspólnej lewej z protezą aorty za pomocą protez naczyniowych. W drugim etapie, podobnie jak w przypadku pierwszym, implantowano stentgraft do aorty zstępującej. W obu przypadkach implantacji stentgraftów pokryto ujście lewej tętnicy podobojczykowej.

Wnioski: Techniki hybrydowe zastosowane w leczeniu tętniaków aorty piersiowej w porównaniu z konwencjonalnym leczeniem chirurgicznym są metodą bezpieczniejszą, o zdecydowanie mniejszym ryzyku zarówno zgonu, jak i powikłań neurologicznych. Wydaje się więc słuszne coraz szersze zastosowanie stentgraftów i leczenia hybrydowego u chorych z rozwarstwieniem aorty piersiowej.

Słowa kluczowe: tętniaki aorty piersiowej, stentgraft, techniki hybrydowe

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Praca wpłynęła 11.08.2009, przyjęta do druku 11.08.2009.

Introduction

Thoracic aortic aneurysms are an important clinical problem. Every year in the United States 43 000-47 000 patients are hospitalized because of the thoracic aortic aneurysm. A clinically significant descending aortic aneurysm is defined as a two-fold increase of the aortic lumen in comparison to the adjacent normal aortic segment. Aneurysms have a tendency to grow. This tendency is potentiated by the dissection. The increase of mean diameter of ascending and descending aneurysmatic aorta segments is 0.09 cm/year and 0.28 cm/year in case of dissection. The larger the aorta, the faster the aneurysm enlarges which is related to the higher risk of rupture or dissection [1]. Conventional surgical treatment of thoracic aortic aneurysms is an invasive procedure requiring deep hypothermia, extracorporeal circulation and having a high mortality (7-17%) or neurological complication (4-12%) burden [2]. Indications for surgical treatment include: the size of the aneurysm, trauma-related aortic wall dissection, acute type B dissection accompanied by distal ischaemia, rapture, leak, false aneurysm, bronchial compresion, aortobronchial and aortoesophageal fistulas [1]. Introduction of thoracic aortic stent-grafts created new possibilities. Endovascular treatment has a lower risk burden of cardiac, neurological or renal complications. Two-step, hybrid solutions are also possible: surgical treatment of thoracic aorta with the transposition of the brain-supplying arteries accompanied by stent-graft implantation. Current article presents two cases of patients treated for a thoracic aortic aneurysm in our institution with the use of endovascular or hybrid approach.

Case 1

Fifty-year-old man with the history of arterial hypertension, prior PTCA of the second diagonal branch in 2007, with EF of 20%, one year history of heart failure symptoms was admitted to the Institute of Cardiology for the treatment of heart failure and qualification for transplantation. Echocardiographic examination disclosed a markedly enlarged left ventricle (LVdD 7.2 cm) and ascending aorta (5.6 cm). Because of the observed abnormalities patient was referred for computed tomography (CT) of the thoracic and abdominal aorta. The study showed a dissection of the aortic arch with the ostium of dissection located distally to the left carotid artery and a retrograde contrast staining visible up to the level of brachiocephalic trunk offspring. False lumen did not include the brain-supplying arteries and continued through the descending aorta. Arteries originating from the aortic arch were departing normally, from the true lumen. Thoracic aortic dimensions were: aortic bulb 47 × 46 mm, maximal ascending aortic diameter 54 mm, aortic arch diameter proximal to the offspring of brachiocephalic trunk 43 mm, true lumen distally to the left subclavian artery in the aortic arch – 22 mm, U-shaped false lumen (transverse axis) with one arm of 25 × 6 mm and a second arm of 47 × 26 mm.

In the descending aorta the true lumen had 21 mm with the false lumen of 40 × 27 mm. CT examination demonstrated that the dissection comprises abdominal aorta up to the level of the left iliac artery. Because of the low ejection fraction, the extent of the surgical procedure and a high risk of mortality casued by a severe heart failure the patient was scheduled to undergo a two-step procedure: surgical replacement of the ascending aorta and aortic arch in the first step and transfemoral stent-graft implantation to the descending aorta in the second step.

Procedure technique

Median sternotomy was performed. The pericardium was opened. Arteries of the aortic arch were prepared. Right atrium and brachiocephalic trunk were cannulated. Extracorporeal circulation and patient cooling were started. Subsequently an aortic valve graft (St. Jude Med.) of 27 mm diameter was implanted with the transposition of coronary arteries to the graft (Bentall procedure). Next, the ostium of dissection was located distally to the offspring of the left common carotid artery. Left common carotid artery was clamped. A distal end of this artery was connected to the ascending aortic prosthesis with the use of a dacron prosthesis. Subsequently brachiocephalic trunk was connected to the aortic prosthesis. On the 14th day after the procedure patient was transferred to the cardiology department of the regional hospital for the medical treatment before the second step. Second step of treatment was initiated after 31 days from the surgery. The stent-graft (Valiant 40 mm with the Xcelerant delivery system) was implanted in the aortic arch and descending aorta through the surgical incision in the right femoral artery under general anesthesia with antibiotic prophylaxis. The stent-graft was deployed right after the offspring of the brachiocephalic trunk covering the left subclavian artery. Patient become febrile (up to 38°C) on the second day after the procedure, but was succesfully discharged to the regional hospital for further observation and medical treatment after 7 days from the stent-graft implantation (fig. 1).

Case 2

Fifty five-year-old obese (BMI 36) male with type A aortic dissection and a long history of arterial hypertension was admitted to our institution for an elective procedure. Angio-CT revealed two sites of dissection, 1 cm above the aortic ring, and second one in the aortic arch at the level of the left subclavian artery. The dissection included ascending aorta, aortic arch and descending aorta and

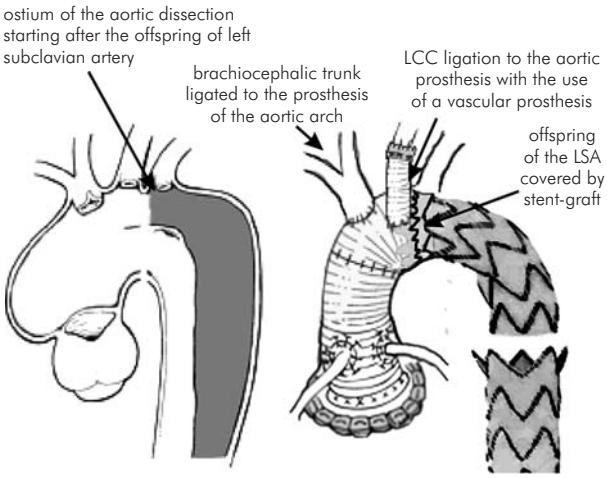

Fig. 1. Aortic dissection starting after the offspring of left common carotid artery. The condition after a second step of the procedure: graft implantation (Bentall procedure), transposition of the brachiocephalic trunk and left common carotid artery as a first step of the procedure, closure of the offspring of left subclavian artery by the implanted stent-graft as a second step of the procedure

Ryc. 1. *Rozwarstwienie aorty rozpoczynające się za odejściem lewej tętnicy szyjnej wspólnej. Stan po wykonaniu zabiegu dwuetapowego: implantacja zastawkowego graftu aortalnego metodą Bentalla, transpozycja pnia ramienno-głowowego lewej oraz wspólnej tętnicy szyjnej w pierwszym etapie, zamknięcie ujścia lewej tętnicy podobojczykowej przez stentgraft implantowany w drugim etapie leczenia*

descended through the abdominal aorta up to the level of the superior mesenteric artery. Left coronary artery and celiac trunk were originating from the true lumen. A dissected offsprings of the brachiocephalic trunk, left common carotid artery, left subclavian artery and superior mesenteric artery were found. Right coronary artery was originating from the false lumen. Aortic dimensions were as follows: aortic bulb – 39 × 32 mm, ascending aorta – 49 mm including very narrow true lumen (TL) of 3-7 mm diameter and 42 mm wide false lumen (FL). Aortic arch had 32 mm (TL – 18 mm, FL – 14 mm) descending aorta had 36 mm (TL – 17mm, FL – 18 mm) as shown on figure 2.

Procedure technique

Surgery began in a typical mode, followed by the left femoral artery and right atrium cannulation. Extracorporeal circulation and patient cooling were initiated. Aorta was cut and ostium of the dissection was located above the aortic valve with the right coronary artery torn off. Cold blood cardioplegia was administered to the coronary arteries. At first 25 mm diameter valvular aortic graft (St. Jude Med.) was implanted (Bentall method). Venous by-pass was connected distally to the right coronary artery and proximally to the graft. The aortic arch was inpected at 20°C temperature and a second

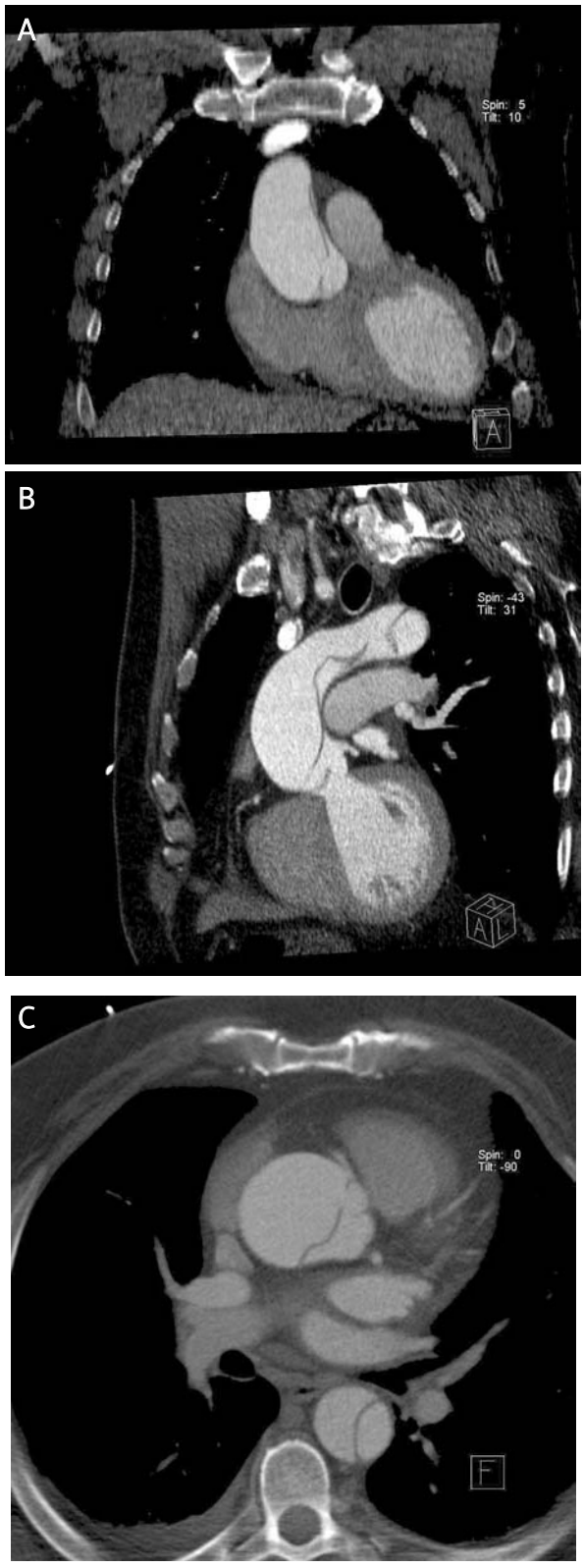

Fig. 2. Computed tomography scans show the aortic dissections – second patient. See text for details

Ryc. 2. *Zdjęcia tomografii komputerowej prezentujące rozwarstwienia aorty u chorego 2. Opis w tekście*

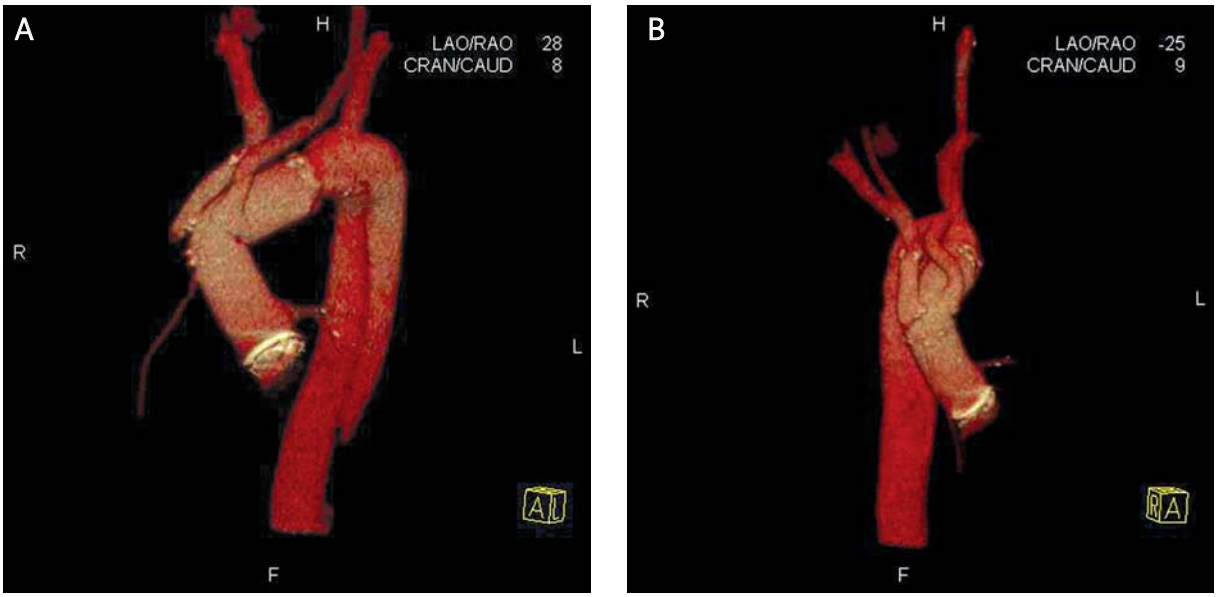

Fig. 3. Computed tomography scans showing results of the first step of treatment – Bentall procedure with aortic graft valve implantation, by-pass to the right coronary artery, transposition of the brachiocephalic trunk and left common carotid artery to the aortic prosthesis with the use of Dacron prostheses

Ryc. 3. *Zdjęcia tomografii komputerowej prezentują stan po pierwszym etapie leczenia – implantacja zastawkowego graftu aortalnego metodą Bentalla, by-pass do prawej tętnicy wieńcowej oraz zespolenie pnia ramienno-głowowego i tętnicy szyjnej wspólnej z protezą łuku aorty za pomocą dakronowych protez naczyniowych*

ostium of the dissection was found below the left subclavian artery beyond surgical access. Antegrade brain circulation was introduced through the brachiocephalic trunk. Brachiocephalic trunk and the left carotid artery were cut off and vascular prosthesis of the aortic arch was implanted proximally to the offspring of the left subclavian artery. The distal end of the latter artery was connected to the aorta through the 8 mm diameter vascular prosthesis. Subsequently a brachiocephalic trunk was connected to the aortic prosthesis with the use of a 10 mm diameter vascular prosthesis (fig. 3). Continuous brain perfusion was provided through the whole procedure. The second step of the procedure was initiated after 44 days from the surgery. The stent-graft (Valiant 32 mm with the Xcelerant delivery system) was implanted to the aortic arch and descending aorta through the surgical incision in the right femoral artery under general anesthesia with antibiotic prophylaxis. The stent-graft was deployed right after the offspring of the brachiocephalic trunk covering the left subclavian artery. The post-procedural follow-up was uncomplicated. Patient was discharged home after 3 days from the procedure with a follow-up visit scheduled after the next 3 weeks (fig. 4 and 5).

Fig. 4. Intraprocedural image of stent-graft implantation. Visible brain-supplying arteries after transposition. Elongation of the landing zone allowed a stent-graft implantation in the former location of the left common carotid artery covering the offspring of left subclavian artery

Ryc. 4. *Zdjęcie śródzabiegowe implantacji stentgraftu. Widoczne przeszyte naczynia dogłowowe. Dzięki wydłużeniu* landing zone, *stentgraft implantowano w miejscu tętnicy szyjnej wspólnej, pokrywając odejście lewej tętnicy podobojczykowej*

Discussion

Introduction of stent-grafts in the treatment of aneurysms/dissections of the descending thoracic aorta opened new possibilities. The aneurysm of the whole aorta or dissections of the aortic arch are known limitations of the endovascular therapy. Bergeron et al. [5] prefer a hybrid approach consisting of the transposition of the great arteries during the cardiosurgical procedure followed by the endovascular treatment. A margin of unaffected tissue, the so called landing zone is neccessery for the safe deployment of stent-graft. Transposition of the great

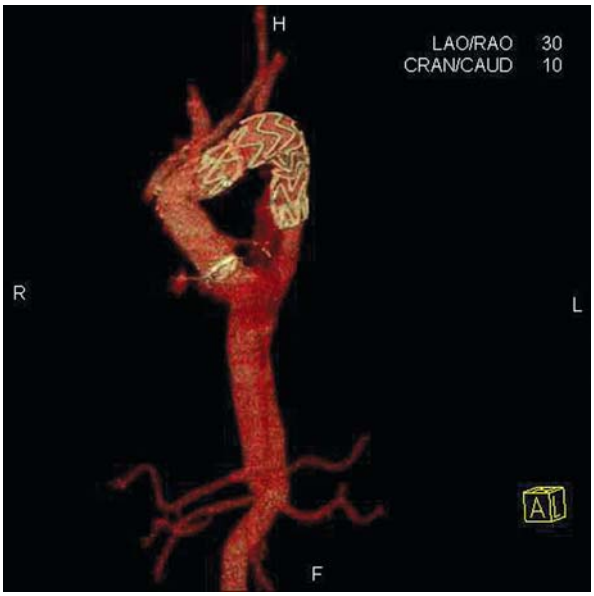

Fig. 5. Computed tomography scan showing results of the second stage of treatment. It was made one day after a stent-graft implantation to the thoracic aorta. Metal struts of the stent-graft can be seen

Ryc. 5. *Zdjęcie tomografii komputerowej obrazuje końcowy efekt leczenia dwuetapowego. Badanie wykonane dobę po implantacji stentgraftu do aorty piersiowej. Wyraźnie widoczne metalowe rusztowanie stentgraftu*

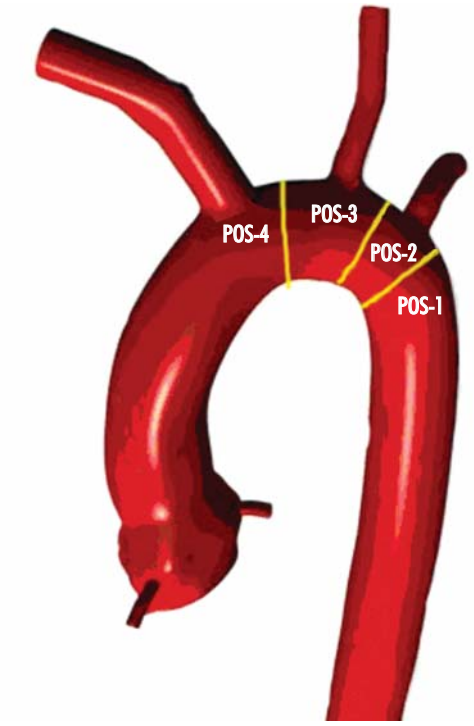

Fig. 6. Landing zones for stent-graft implantation

Ryc. 6. *Poszczególne strefy implantacji stentgraftu, tzw.* landing zone

arteries increases the landing zone allowing a more proximal graft implantation. There are 4 landing zones as presented on figure 6.

Stent-graft implantation in position 1 (POS 1) is an ideal option not requiring a surgical intervention. Patients with disease location in position 2 (POS 2) require a closure or transposition of the left subclavian artery (LSA) to increase the landing zone. In case of the symptoms of subclavian steal syndrome (LSA occlusion) such as arm claudication, acute ischaemia or critical ischaemia Byrne et al. [6] recommend a by-pass implantation between the left common carotid artery (LCC) and the left subclavian artery (LSA). Bergeron et al. [5] recommend the LSA transposition also in the case of dysfunctional coronary circulation through LIMA as well as in the case of stenotic or hypotrophic contralateral vertebral artery. In the case of dissections comprising position 3 (POS 3) a by-pass between the left common carotid artery and the brachiocephalic trunk is recommended. Subsequent transposition of the left subclavian artery and the left common carotid artery finishes the procedure. This type of procedure is frequently referred to as hemi-arch. When the disease reaches the level of the brachiocephalic trunk – position 4 (POS 4) the implanted stent-graft requires at least 3 cm of landing zone measured in the medial aortic arch line.

In this situation a preferable solution is the so-called Total Arch Rerouting. The procedure consists of a proximal ligation of the ascending aorta to the 12 mm Dacron bifurcated prosthesis followed by an end-to-end ligation between the brachiocephalic trunk and the second bifurcation. Second step consists of an end-to-end ligation between the second bifurcation of the prosthesis and the left subclavian artery. LCC and LSA connection finishes the procedure. Second step of the procedure – a transfemoral stent-graft implantation is recommended after one or two weeks (fig. 7).

Gottardii et al. [2] state that LSA transposition increses the stent-graft landing zone by about 2.2 cm, double transposition by about 2.4 cm and the Total Arch Rerouting by about 3.9 cm. What are the possible complications of the hybrid procedure? The same author presented the results of a hybrid treatment in 73 patients. LSA transposition was performed in 24 cases, double transposition in 36 cases and the Total Arch Rerouting in 13 cases. All patients underwent endovascular treatment as the second step. The author presents a total in-hospital mortality of the combined procedure of 6.8%. Bergeron et al. presented 25 patients treated with the hybrid procedure in his report. Total Arch transposition was performed in 15 patients and hemi-arch in 10 patients. All patients underwent a subsequent endovascular procedure with the use of the Talent, Excluder or Zenith endografts. Surgical transposition was complicated only by a small focal stroke caused by an occlusion of the left common carotid artery. The total frequency of stroke was 8%, 2 patients died after the second step of treatment – one due to perforation of the left ventricle caused by

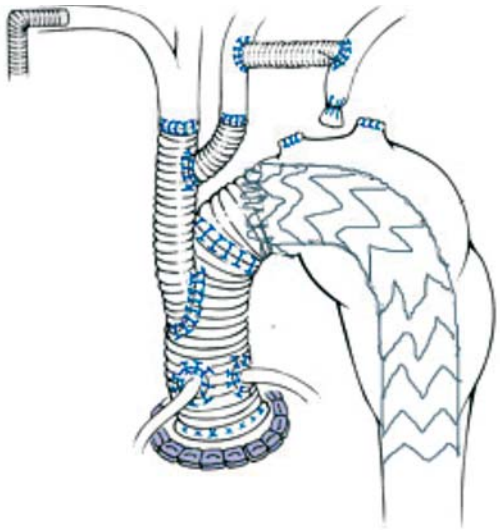

Fig. 7. Diagram presenting result of the hybrid procedure. Aortic graft implantation (Bentall procedure), transposition of the great arch arteries, and stent-graft implantation

Ryc. 7. *Schemat prezentuje stan po implantacji zastawkowego graftu aortalnego metodą Bentalla, całkowitej transpozycji naczyń dogłowowych oraz implantacji stentgraftu do zstępującej aorty piersiowej*

a delivery catheter and a second due to MOF. There were no fatal cases or neurological complications related to the surgical transposition of the arteries [5].

Surgical procedure increases the area for the second step of treatment by creation of the landing zone. As stated by the authors cited above the optimal landing zone is 2 cm [2]. In cases presented in this paper landing zone was 2 cm in the first patient and approximately 3 cm in the second patient. Gottardi et al. performed a second step of the procedure after mean 7 days from the surgery [2]. The rehabilitation period in our institution was 4 to 6 weeks. It was influenced by several factors. In the first case those included: a low ejection fraction, increased body temperature in the post-surgical period caused by a bacterial infection. The second patient required 4 weeks of treatment with intravenous antibiotics. The procedure of stent-graft implantation performed as a second step of treatment in our institution was safe, free from complications and fully successful – the ostium of dissection and flow in the false lumen were eliminated. After a few days of hospitalization both patients were discharged from the institution in a good condition. A continuous detailed follow-up of patients after this kind of procedures in necessery. A follow-up CT examination is scheduled after 3 months post discharge. As we mentioned in the introduction section a conventional surgery of thoracic aortic aneurysms is a highly invasive procedure related to high mortality (7-17%) and neurological complications (4-12%) [2]. Hybrid treatment is a safe alternative with a lower risk of mortality and neurological complications. It seems resonable to increase the use of stent-grafts and the hybrid treatment in patients with thoracic aortic dissection.

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