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The Evaluation of Costs of Treating Abdominal Aortic Aneurysm

Ocena kosztów operacyjnego leczenia tętniaka aorty brzusznej

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Abstract

Background. Since 1991, endovascular stentgraft implantation has been performed alongside traditional treatment of abdominal aortic aneurysm in patients with massive internal burden.
Objectives. Comparison of the costs of traditional treatment of abdominal aortic aneurysm with those of stentgraft implantation.
Material and Methods. In 2001–2006, 637 patients were treated at this surgical ward, of whom 521 had unruptured and 116 ruptured abdominal aortic aneurysm (RAAA). Of the 521 patients with unruptured abdominal aortic aneurysm, 418 were operated in the traditional way, 65 received an inner-vascular prosthesis implant, and 38 were disqualified from surgical treatment. Only the patients with massive internal burden were qualified for treatment: 31 with respiratory failure, 29 with circulatory failure grades IV/V according to the NYHA classification, 5 who had had a stroke with spastic hemiplegia.
Results. Using data from the financial department, the overall cost of treating the patients with an endovascular prosthesis was PLN 42,487.60, the cost of traditional treatment of patients with unruptured abdominal aortic aneurysm was PLN 10,074.16, and the cost of treating a ruptured abdominal aortic aneurysm was PLN 22,589.53.
Conclusions. The high costs of endovascular treatment are connected to the price of the prosthesis used, which constitutes 90% of the total cost. Among patients with an RAAA in serious overall condition, stentgraft implantation is a life-saving procedure. The total costs of treatment of a ruptured abdominal aortic aneurysm almost doubles the regular costs of treatment in planned mode. Early recognition and instant intervention with an unruptured abdominal aortic aneurysm significantly decrease the costs of treatment. Early conclusions about the treatment are presented here. Further analysis and observation are necessary to estimate subsequent results (**Adv Clin Exp Med 2007, 16, 6, 761–768**).

Key words: abdominal aortic aneurysm, stentgraft, costs.

Streszczenie

Wprowadzenie. Od 1991 r. obok klasycznej metody operacyjnego leczenia tętniaka aorty brzusznej, szczególnie u chorych obciążonych internistycznie, wprowadzono endowaskularny sposób wszczepienia protezy samorozprężalnej.
Cel pracy. Porównanie kosztów operacyjnego leczenia tętniaka aorty brzusznej metodą klasyczną z kosztami wewnątrznaczyniowego wszczepienia protezy samorozprężalnej.
Materiał i metody. W latach 2001–2006 badaniem objęto 637 chorych z tętniakiem aorty brzusznej, spośród których 521 chorych przyjęto w trybie planowym z powodu tętniaka aorty brzusznej bez cech wynaczynienia, 116 chorych operowano w trybie ostrodyżurowym z powodu pękniętego tętniaka aorty. Spośród 521 chorych z tętniakiem aorty brzusznej, przyjętych planowo, sposobem klasycznym operowano 418 chorych, u 65 chorych wszczepiono protezę wewnątrznaczyniową, a 38 chorych nie zakwalifikowano do leczenia operacyjnego. Do zabiegu wszczepienia protezy wewnątrznaczyniowej zakwalifikowano 65 chorych znacznie obciążonych internistycznie, z których 31 miało niewydolność oddechową, 29 chorych niewydolność krążenia 4. i 5. st. w skali NYHA, a 5 chorych przebyło udar mózgu z porażeniem połowiczym.
Wyniki. Po uzyskaniu danych z działu marketingu obliczono całkowity koszt leczenia chorych z tętniakiem aorty brzusznej operowanych za pomocą endowaskularnego wszczepienia protezy wewnątrznaczyniowej, który wyniósł

42 435,60 PLN, koszt leczenia chorych leczonych w trybie planowym 10 074,16 PLN, a koszt chorych operowanych z powodu pękniętego tętniaka aorty brzusznej wyniósł 22 589,53 PLN.
Wnioski. Wysoki koszt leczenia endowaskularnego jest związany z ceną użytej protezy, która stanowi około 90% wszystkich kosztów. U chorych z TAB obciążonych internistycznie wszczepienie stentgraftu jest metodą ratującą życie. Całkowity koszt leczenia pękniętego tętniaka aorty brzusznej ponad dwukrotnie przewyższa koszt leczenia tętniaka aorty brzusznej operowanego w trybie planowym. Wczesne rozpoznanie i operacja niepękniętego tętniaka aorty brzusznej w znacznym stopniu przyczynia się do obniżenia kosztów leczenia. W pracy przedstawiono wczesne wyniki leczenia tętniaków aorty brzusznej, jest wskazana dalsza obserwacja w celu określenia wyników późnych (**Adv Clin Exp Med 2007, 16, 6, 761–768**).

Słowa kluczowe: tętniak aorty brzusznej, proteza wewnątrznaczyniowa, koszty leczenia.

Abdominal aortic aneurysm (AAA) is a pathological enhancement of the aortic which is larger by at least half its regular size, i.e. larger than 3 cm [1–3]. Abdominal aortic aneurysms are most frequently located below the renal vessels and can end up at the crossing or they can be found at the common venal vessels. Abdominal aortic aneurysms are from three to eight times more common among men than women. The progression of the aneurysm, which grows by 2–4 mm a year, might lead to rupture of the vessel [1, 4, 5]. This risk of ruptured abdominal aortic aneurysm (RAAA) correlates with the diameter of the aneurysm, although not all large aneurysms rupture and sometimes even small ones do. From the biomechanical point of view, rupture of the aneurysm is a direct result of the pressure on the vessel walls, which is higher than the maximum resistance point. In the pathogenesis of RAAA, the conditions taken into account are age, gender, hypertonia arterialis**,** lung disease, coronary disease, smoking habit, family background, and infection with *Chlamydia pneumoniae* [1, 4, 8]. Both the aneurysm's diameter and its rate of growth per year are the best predictive factors as far as rupture is concerned [4, 9–11].

The surgical procedure for RAAA is a life-saving operation because of the risks which are connected with rupture, and a diameter of 5 cm is a critical size which qualifies the patient for surgery. The death rate for the surgery of an RAAA varies from 20 to 70%; in the case of a planned procedure it is only 2–8% [7, 12]. However, in the case of endovascular stentgraft implantation the death rate is approximately 1% [12, 13]. The classical method of treatment is especially dangerous for older patients (> 70 years old) who are affected by respiratory and circulatory failure. In addition to these, other factors are taken into account when qualifying patients for stentgraft implantation, such as computed tomography and angiography [6]. In these examinations the length of the aneurysm's neck is evaluated; it should be smaller than 1 cm and its width should not exceed 3 cm [2, 14, 15]. Bending of the neck or the bag of the aneurysm by more than 60%, the presence of massive thrombosis, as well as aneurysmal changes in the venal aortic are all considered to be disqualifying as far as endovascular treatment is concerned because they make prosthesis implantation highly difficult.

The aim of this study was to compare the costs of abdominal aortic aneurysm treatment by means of the classical method in planned and in emergency mode with that of the endovascular procedure.

Material and Methods

The cases of 637 patients with AAA were submitted to prospective analysis and included 118 (18.5%) women and 519 (81.5%) men, all between 38 and 79 years of age (average: 63.5). These patients underwent treatment because of abdominal aortic aneurysm in 2001–2006 at the General and Vascular Surgery Ward (Table 1). The reasons for the planned procedures were symptoms, an increase in the aneurysm's diameter by more than 0.5 cm per year, and a diameter larger than 5 cm. Among the patients with AAA who are severely ill, in whom the aneurysm's diameter is larger than 5.5 cm and has increased in the course of the previous year by more than 0.5 cm, endovascular stentgraft implantation is strongly recommended [16–20]. In the case of an abdominal aortic aneurysm, the procedure is undertaken for life-saving reasons.

Of the 637 patients with AAA, 521 were admitted to the hospital in a planned mode and 116 in the emergency mode due to ruptured aneurysm (Table 1). Of these 521 patients, 418 were treated with the classical method and 65 patients were implanted with a prosthesis, while 38 patients were not qualified for the surgical procedure, among whom 5 suffered from stroke, 8 refused the operation, 16 remained under observation due to the small size of the aneurysm and lack of pain, and in 9 patients anatomical conditions prohibited stentgraft implantation (5 patients had a short aneurysm neck, 2 had massive thrombosis, and 2 had curvy venal vessels). Of the 65 patients in

Table 1. The number of patients with abdominal aortic aneurysm treated in 2001–2006

Tabela 1. Liczba chorych leczonych z powodu tętniaka aorty brzusznej w latach 2001–2006

Number of patients (Liczba pacjentów)	Admittance mode planned/emergency (Tryb przyjęcia)	Number of patients qualified for surgical treatment (Liczba pacjentów zakwalifikowanych do leczenia operacyjnego)	Number of operated patients (Liczba operowanych pacjentów)	Number of patients disqualified for surgical treatment (Liczba pacjentów niezakwalifikowanych do leczenia operacyjnego)
Total (Razem) 637 Female (Kobiety) 118 Male (Mężczyźni) 519	planned – 521	traditional treatment		
		447	418	29
		endovascular treatment		
		74	65	9
	emergency – 116	116	116	0

Table 2. The reasons for patient qualification for stentgraft implantation

Tabela 2. Przyczyny kwalifikacji chorych do wszczepienia stentgraftu

Type of failure (Obciążenie internistyczne)	No. of patients (Liczba pacjentów)	% (Odsetek)	Mortality rate (Wskaźnik śmiertelności)	% (Odsetek)
Respiratory failure (Niewydolność oddechowa)	31	47.91	1	2.08
Circulatory failure (Niewydolność krążenia)	29	43.37	0	0
Stroke followed by paraplegia (Udar mózgu z porażeniem połowiczym)	5	8.33	0	0
Overall (Suma)	65	100	1	2.08

whom a stentgraft prosthesis was implanted, 31 suffered from respiratory failure, 29 from circulatory failure of grade 4/5 according to the NYHA classification, and 5 suffered from a severe stroke with partial paralysis (Table 2).

Before endovascular stentgraft implantation could take place, all the patients were diagnosed cardiologically and had CT and angiography. During CT the length and width of the aneurysm's neck was evaluated as well as the aneurysm itself and changes in the venal aortic area. During angiography the course of the vessel was evaluated. The patients' abdominal aortic diameters were between 5.5 cm and 12 cm (average: 8.9 cm). Nine patients were not qualified for the procedure because the aneurysm neck was shorter than 1 cm. The patients were treated as above during their first stay at the General and Vascular Surgery Ward.

During a subsequent stay at the hospital, after the above examinations and the internal load were taken into consideration, 24 patients underwent the endovascular procedure using a Powerlic stentgraft (manufactured by Endologix), 18 with an Excluder stentgraft (by Gore), 14 with a Talent stentgraft (by Medtronic), and 9 with a Zenith stentgraft (by Cooc) (Table 3).

Table 3. The number of patients and the kind of stentgraft used

Tabela 3. Liczba chorych i rodzaj wszczepionego stentgraftu

Company (Producent)	Name of the prosthesis (Nazwa stentgraftu)	Number of patients (Liczba pacjentów)
Endologix	Powerlinc	24
Gore	Excluder	18
Medtronic	Talent	14
Cooc	Zenith	9
Total (Suma)		65

The data necessary to compare the costs of treatment were obtained from the financial department. For each patient admitted to the hospital a cost chart was set up in which the following factors were documented: the average cost of anesthesia, stentgraft, prosthesis, patient examinations, laboratory tests, materials, as well as the salaries of the medical personnel.

Results

Five hundred twenty one patients with unruptured abdominal aortic aneurysm were admitted in the planned mode, of whom 418 were qualified for the classical method of treatment. One hundred sixteen patients underwent surgical treatment in the emergency mode due to a ruptured aneurysm. Among the patients treated by means of the classical method there were 336 straight and 198 bifurcated prosthesis implanted.

Concerning endovascular procedures, in the course of the six-year observation of the 65 patients, the largest number of such procedures took place in 2005 (18 patients) and 2006 (17 patients). A clear tendency can be observed in the increasing number of this type of procedure (Table 4).

Of the 418 patients treated due to unruptured aneurysm, serious complications occurred in 84 (20%). The most frequent complications were respiratory failure in 29 patients (6.93%), circulatory failure in 21 patients (5.02%), and heart attack in 4 patients (0.95%). Of the 418 patients, 17 died (4.2%) (Table 5). The average time of stay at the surgery ward was 7 days.

Of the 116 patients treated due to RAAA, complications occurred in 25 (22%) (Table 6). The most frequent complications were respiratory failure in 54 patients (46.55%), circulatory failure in 47 patients (40.51%), and heart attacks in 8 patients (6.89%). Of the 116 patients, 27 died (23%) (Table 6). The average time of stay at the surgery ward was 12 days. It has to be pointed out that more than one complication occurred among the patients.

Out of 65 patients who had endovascular procedures, early complications occurred among 7 (10.76%) (Table 7). The most frequent complications were clotting of the stentgraft's arm in 2 patients (3.07%.), lack of stent decompression in 1 patient (1.53%), blood leakage to the aneurysm bag in 1 patient (1.53%.), and stentgraft dislocation in 1 patient (1.53%). Of the 65 patients, 1 died (1.53 %). The average time of stay at the surgery ward was 2 days.

The data for the cost analysis of the abdominal aortic aneurysm treatment by means of stentgraft implantation were obtained from the financial department (Table 8). At the moment of admittance to the hospital, a cost chart was set up for each patient in which the cost of materials, medical personnel, and the stentgraft used (PLN 38,000) were documented. All the personnel costs were also included, such as those of the diagnostic ward, the salaries of the doctors, nurses, and technicians, the average cost of anesthesia, and laboratory tests, which altogether gave the amount of PLN 42,487.60.

Table 4. The number of patients treated by stentgraft implantation in 2001–2006

Tabela 4. Liczba chorych leczonych w latach 2001–2006, którym wszczepiono stentgraft

Years (Lata)	Female (Kobiety)	Male (Mężczyźni)	Total (Suma)
2001	0	3	3
2002	0	7	7
2003	1	4	5
2004	2	13	15
2005	0	18	18
2006	5	12	17
Total (Suma)	8	57	65

Table 5. Early complications and death rates among patients who had classical surgical removal of an unruptured abdominal aortic aneurysm in 2001–2006

Tabela 5. Wczesne powikłania i śmiertelność u chorych po zabiegu klasycznego wycięcia tętniaka aorty brzusznej bez cech wynaczynienia w latach 2001–2006

Type of failure (Powikłania)	No. of patients (Liczba pacjentów)	%
Respiratory failure (Niewydolność oddechowa)	29	6.93
Circulatory failure (Niewydolność krążenia)	21	5.02
Infarction (Zawał serca)	4	0.95
Severe renal failure (Ciężka niewydolność nerek)	4	0.95
Digestive track obstruction (Niedrożność przewodu pokarmowego)	2	0.47
Exenteration (Wytrzewienie)	2	0.47
Large intestine ischemia (Niedokrwienie jelita grubego)	1	0.23
Multiorgan failure (Niewydolność wielonarządowa)	1	0.23
Hemorrhage at the place of connection (Krwotok w miejscu zespolenia)	1	0.23
Severe ischemia of the lower limb (Ciężkie niedokrwienie kończyny dolnej)	1	0.23
Lymphatic leakage (Limfotok)	1	0.23
Re-operation (Ponowna operacja)	1	0.23
Death rate (Współczynnik śmiertelności)	17	4.2

Table 6. Early complications and death rates among patients who had classical surgical removal of a ruptured abdominal aortic aneurysm in 2001–2006

Tabela 6. Wczesne powikłania i śmiertelność u chorych po zabiegu klasycznego wycięcia pękniętego tętniaka aorty brzusznej w latach 2001–2006

Type of failure (Powikłania)	No. of patients (Liczba pacjentów)	%
Respiratory failure (Niewydolność oddechowa)	54	46.55
Circulatory failure (Niewydolność krążenia)	47	40.51
Infarction (Zawał serca)	8	6.89
Severe renal failure (Ciężka niewydolność nerek)	4	3.44
Digestive track obstruction (Niedrożność przewodu pokarmowego)	4	3.44
Exenteration (Wytrzewienie)	3	2.58
Large intestine ischemia (Niedokrwienie jelita grubego)	2	2.58
Multiorgan failure (Niewydolność wielonarządowa)	2	2.58
Hemorrhage at the place of combinement (Krwotok w miejscu zespolenia)	2	2.58
Severe ischemia of the lower limb (Niedokrwienie kończyny dolnej)	1	0.86
Lymphatic leakage (Limfotok)	1	0.86
Re-operaton (Ponowna operacja)	3	2.58
Death rate (Współczynnik śmiertelności)	27	23

The Health Management Organization (HMO), in the procedure encoded 5.10.00000.10, evaluates the treatment called "Endovascular treatment of a thoracic or abdominal aortic aneurysm" by means of points, giving it 4200 points (1 point equals PLN 10–11), which in total gives the amount of PLN 42000. The classical treatment of an unruptured abdominal aortic aneurysm (which has the code 5.06.00.0000393) is evaluated at 750 points. The total calculated cost is PLN 10.074.06, and HMO pays PLN 7500. The average cost of treating a ruptured aneurysm is PLN 22.589.53. The total cost of the classical treatment of a ruptured abdominal aortic aneurysm (which has the code 5.06.00.0000382 code) is also evaluated at 750 points. The total calculated cost is PLN 22.589.53, and HMO pays PLN 7500 (Table 8).

Table 7. Complications and mortality rates among the patients who had stentgraft implantation

Tabela 7. Powikłania i śmiertelność u chorych po zabiegu wszczepienia stentgraftu

Type of failure (Powikłania)	No. of patients (Liczba pacjentów)	%
Clotting of the stent limb (Wykrzepienie nogi stentu)	2	3.07
Stent migration (Migracja stentu)	1	1.53
Lack of stent decompression (Nierozprężenie stentu)	1	1.53
Blood leakage to the aneurysm (Zaciek krwi do worka tętniaka)	1	1.53
Lymphatic leakage (Limfotok)	1	1.53
Death rate (Współczynnik śmiertelności)	1	1.53
Total (Suma)	7	10.76

Discussion

This prospective analysis was carried out in 637 patients treated for AAA, of whom 418 were treated in the classical way, 65 by means of an endovascular stentgraft, and 116 for ruptured aneurysm. Recent years have shown an increase in the use of endovascular procedures both in Poland and in western countries among patients who do not qualify for the standard surgery [21].

Patients with AAA are usually old, between 38 and 79 (average: 63.5 years). In this study the majority were male with additional health problems which might increase the risk of surgery. Patients with AAA admitted to the hospital in a planned mode are prepared for the procedure in the course of the days preceding it, which significantly decreases the risk of death. The main indicator for planned treatment of an abdominal aortic aneurysm were symptoms, an increase in the aneurysm's diameter by more than 0.4 cm per year, and a diameter larger than 5 cm. In the case of a ruptured abdominal aortic aneurysm, the procedure was undertaken due to life-saving considerations.

In the course of qualifying the patient for endovascular stentgraft implantation, respiratory failure, circulatory failure, stroke, and the localiza-

Table 8. Costs of treating a patient with an abdominal aortic aneurysm (in PLN)

Tabela 8. Koszty leczenia chorego operowanego z powodu tętniaka aorty brzusznej

	AAA	RAAA	EVAR
Average costs of laboratory examinations (Średni koszt badań laboratoryjnych)	460.00	1190.00	278.00
Average costs of imaging examinations (Średni koszt badań obrazowych)	328.00	820.00	547.00
Average costs of the surgical theater (Średni koszt pracy bloku operacyjnego)	2267.86	3263.33	1933.80
Average costs of anesthesia and recovery room (Średni koszt anestezji i sali wybudzeń)	985.00	1385.00	720.00
Average costs of the surgical procedure – physician, nurse, technician, lower personnel (Średni koszt operacji – lekarz, pielęgniarka, technik, niższy personel)	226.50	493.20	215.00
Average costs of the intensive care unit (Średni koszt pracy oddziału intensywnej terapii)	3124 (2 days)	9940 (7 days)	–
Average costs of medications (Średni koszt leków)	352.80	1268.00	282.10
Average costs of surgical ward (Średni koszt pracy oddziału chirurgii)	1610 7 days	2760 12 days	460 2 days
Average costs of complication-driven treatment (Średni koszt leczenia powikłań)	130	920.00	52.00
Average cost of a straight prosthesis, bifurcated prosthesis, and stentgraft (Średni koszt protez)	590	510	38.000
Total (Suma)	10,074.16	22.589.53	42.487.60

tion of the AAA and the venal aorta are taken into account [22]. The type of stentgraft used for the procedure is strongly connected with the anatomy of the vessels as well as the morphological scanning of the aneurysm itself, especially its neck [22–24]. This qualification procedure as well as the results of treatment at the ward in this study are similar to those presented by Polish [25–27] and international [2, 7, 19, 28–30] researchers. In the present study the most frequent complications observed among both types of aneurysm were respiratory failure, circulatory failure, and heart attack. The most common complications in the endovascular procedure were thrombus of the arm of the stentgraft, blood leakage to the aneurysm bag, and dislocation of the stentgraft. The obtained results correlate with those of other researchers [21, 22, 30–32]. Of the 418 patients treated due to AAA, 17 died (4.2%), of the 116 treated due to RAAA, 27 died (23%), and of the 65 patients treated endovascularly, 1 died (1.5%). The risk of the endovascular procedure is significantly lower than the risks of the surgical procedures for AAA and RAAA, including also the risk of complications [33–35].

In the patient cost chart, the following factors were included: average cost of the surgery theater, medications, the stay at the surgical ward, the stay at the intensive care unit, laboratory analyses, patient examinations, and the treatment of complications (Table 8). The average cost of treating an abdominal aortic aneurysm in the planned mode was PLN 10.074.16, while the average cost of treating a ruptured abdominal aortic aneurysm was PLN 22.589.53 [36]. The average cost of treatment by means of the endovascular procedure was PLN 42.487.60. The high cost of treating ruptured aneurysms was connected with the long time of stay in the intensive care ward (in this case, seven days), the increased number of examinations, and treatment of the complications. The high cost of stentgraft implantation is connected with the high cost of the prosthesis itself, which is PLN 38.000 [37, 39].

The relatively low cost of the procedure can be explained by the low salaries of the medical and technical staff. Appropriate observation of the patient and appropriate qualification for the procedure results in decreased costs. Although the present authors are not familiar with the costs of AAA treatment in other hospitals in Poland, the data obtained here are consistent with those obtained by foreign authors [32, 38]. In these times of modern noninvasive techniques in patients with AAA with other health problems, endovascular stentgraft implantation is a new and considerably inter-

esting method. Modern tools and appropriate patient selection might lead to better results in endovascular procedures.

The authors conclude that high cost of the endovascular procedure is connected with the cost of the stentgraft, which constitutes 90% of the total costs. Among patients with AAA with other severe health problems, stentgraft implantation is a life-saving procedure. The total cost of treating a ruptured abdominal aortic aneurysm is twice that of treating an unruptured aneurysm in the planned mode. Early diagnosis and immediate surgery of an unruptured aneurysm significantly decrease the total cost of treatment.

Early results of the procedures were presented in this study. Further observation of the outcomes is suggested.

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