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Results of surgical treatment of ruptured abdominal aortic aneurysms (rAAA) in our own material

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Abstract

Introduction: *Aortic aneurysm rupture is defined as bleeding beyond tunica adventitia of a dilated aortic wall. The incidence of ruptured abdominal aortic aneurysm (rAAA) varies between 5.6 and 17.5 per 100,000 inhabitants per year and seems to have decreased over the past two decades.*
The aim of the work was to assess the results of treatment of patients with ruptured abdominal aortic aneurysm.
Material and methods: *Analysis encompassed patients who had undergone surgery for ruptured abdominal aortic aneurysm between 2011 and 2017. A total of 140 patients were operated on due to ruptured abdominal aortic aneurysm. Evaluation of treatment outcomes was based on a retrospective analysis of patients' medical records, assessing the results of treatment based on the following parameters: peri- and postoperative mortality, serious peri- and postoperative complications (acute coronary syndrome, gut ischemia, renal failure, respiratory failure, lower limb ischemia).*
Results: *Results confirm that peri-and postoperative mortality due to ruptured abdominal aortic aneurysm remain high despite continuous progress. Further development of intravascular repair techniques (EVAR) and anesthesiologic management may facilitate better treatment outcomes. However, this requires a great deal of organizational effort to ensure 24/7 availability of multi-specialist teams (vascular surgeon, anesthesiologist, radiology technician, nursing staff) capable of performing intravascular procedures.*
Conclusions: *Surgical management of patients with ruptured abdominal aortic aneurysm continues to be associated with high mortality rates and a significant number of postoperative complications.*

Key words: ruptured abdominal aortic aneurysm, surgical treatment of abdominal aortic aneurysms, endovascular repair (EVAR)

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Introduction

According to the guidelines of the European Society of Vascular Surgery, the incidence of ruptured abdominal aortic aneurysm (PTAB) in Western countries varies between 5.6 and 17.5 per 100,000 inhabitants per year and appears to have decreased over the past two decades [1]. In the United States, it decreased from 18.7/100,000 in 1994 to 13.6/100,000 in 2003 and according to data from the Swedish Vascular Registry over the years 2008-2012 it amounted to 6.07–8.15/100,000 inhabitants [2, 3]. According to data from 1990s, the overall mortality rate in case of a rupture of aortic aneurysm is very high and reaches 80–90%. Subsequent reports demonstrated that it remains high and ranges from 32% to 80%, although according to data from

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specialized centers from the years 2002–2015, in the United States it varied from 20% to 46%, and between 21.6% and 29.6% in Sweden [1, 3–5].

A ruptured aortic aneurysm is defined as bleeding beyond the tunica adventitia of a dilated aortic wall. It can be classified as a rupture into the free peritoneal cavity or as retroperitoneal rupture, where peritoneal tissues cause temporary tamponade and limit blood loss. An aneurysm is considered symptomatic when it is painful, but no breaking of the aortic wall is noted. Inclusion of "symptomatic" aneurysms in the "ruptured" group by some researchers might have improved the outcomes of studies [1]. The incidence of urgent surgeries has decreased with an increase in the number of routine screenings. A patient with a previously diagnosed abdominal aortic aneurysm, who is admitted to hospital with hemorrhagic shock and other symptoms of an aneurysm rupture, does not require further diagnostics and should be taken to the operating theater as soon as possible. Depending on availability, only an urgent ultrasound examination for confirmation of the diagnosis is sufficient. However, Lloyd et al. [6] conducted a study in patients with PTAB who have not undergone surgery for various reasons; they noted that 87.5% of patients survived more than 2 hours, concluding that the majority of patients who arrived at hospital remained hemodynamically stable enough to perform a CT scan to decide on further treatment.

"Permissive hypotension" is recommended in perioperative management, as aggressive fluid therapy intensifies bleeding. In 1991, Crawford [7] published a trial including 180 patients noting significant improvement in survival with systolic blood pressure being maintained at 50–70 mm Hg with fluid restriction. Van der Vliet et al. [8] were the first to publish the results of application of a protocol for maintaining systolic blood pressure between 50 and 100 mm Hg, with potential use of nitrates and limiting fluid supply to 500 ml during the preoperative period. In addition to obvious "surgical" factors, such as: duration of surgery, blood loss, aortic cross-clamping time, the presence of "abdominal compartment syndrome" is also important. It is observed in 10–55% of patients operated on due to rAAA, contributing to multiorgan failure and postoperative mortality [9]. This parameter should be monitored in the postoperative period; finding of intraabdominal pressure over 20 mm Hg is an indication for decompression of the abdominal cavity using temporary closure techniques [10].

Development of endovascular techniques has contributed to improved treatment outcomes, but endovascular procedures, such as implantation of stentgraft in place of abdominal aortic aneurysm (EVAR) in the treatment of rAAA, are still not widely available [1]. The widespread use of intravascular techniques in the treatment of rAAA still faces many barriers related to both patient's condition (hemodynamic instability) and aneurysm morphology, as well as logistic challenges: 24/7 availability of personnel qualified in performing intravascular techniques (vascular surgeon, radiology technician, anesthetics team, nursing staff), "hybrid" operating theater, a wide choice of stentgrafts. Reports confirming the undoubted benefits of endovascular rAAA treatment relate to a selected patient group [11]. It is estimated that around 60% of cases of rAAA are suitable for EVAR due to aneurysm anatomy (between 18% and 83% according to various authors) [12]. The randomized Amsterdam Acute Aneurysm Trial included 83 patients, 46% of whom were eligible for EVAR, and eventually 35% of patients were treated with this method [13]. Discrepancies in reports on the utility of EVAR are caused by application of various systems as well as different anatomical criteria. Most authors apply the same anatomical criteria for rAAA as in elective treatments. However, assuming that in cases of emergency when saving patient's life is a priority, increasingly more liberal anatomical criteria are acceptable, especially when it comes to the length of the neck of the aneurysm. It is accepted that use of EVAR in the first stage of treatment with a possibility of converting to open surgery results in better mortality rates than primary open treatment. Further progress associated with introducing new stentgraft systems will make the use of EVAR in rAAA more accessible.

According to the guidelines of the European Society for Vascular Surgery, endovascular treatment (EVAR) of rAAA should be considered if the anatomy of the aneurysm allows and if the center has the staff and access to equipment required to perform intravascular procedures.

The aim of the work is to present the results of treatment of patients with ruptured abdominal aortic aneurysm in our own material in the context of the current European guidelines, as well as under the conditions of the Polish health service.

Material and methods

We performed a retrospective analysis of the medical records of patients treated between 2011 and 2017 due to a ruptured abdominal aortic aneurysm at the vascular surgery department, which provides services to patients from the entire province. A significant group consisted of patients referred from other hospitals, sometimes more than 100 km away. One hundred and forty patients, 18 women and 122 men, were treated over that period. Average age of patients was 74.2 years (39 to 94 years), the average age of women was 79.8 years,

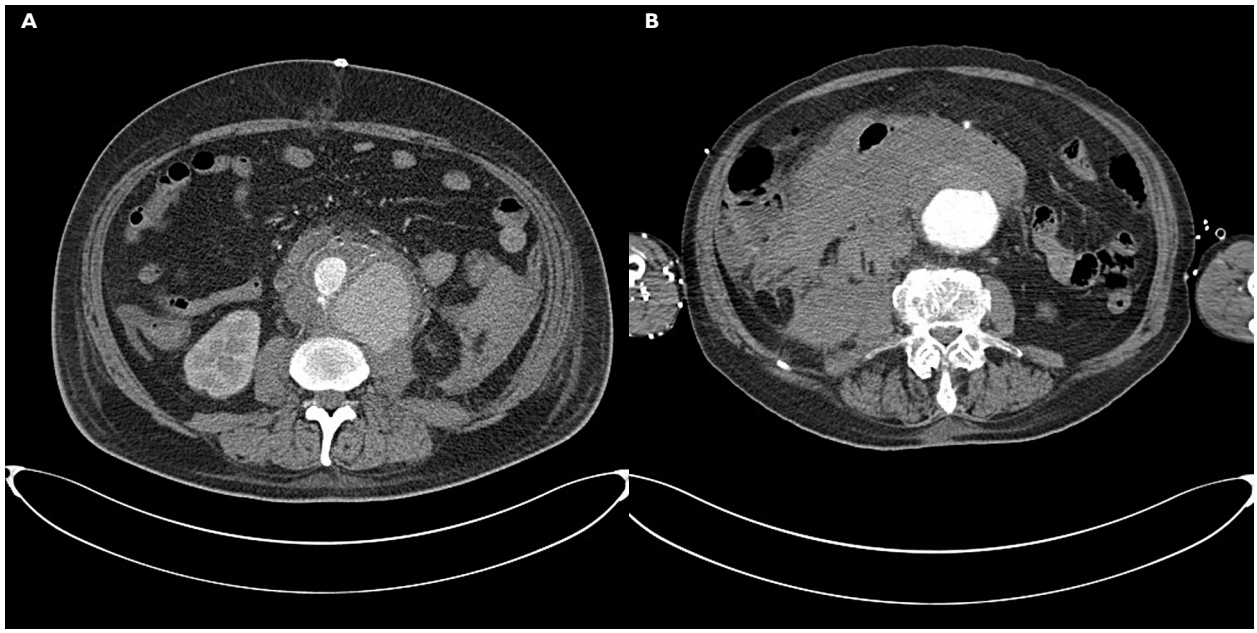

Figure 1A, B. Angio-CT of ruptured abdominal aortic aneurysm (horizontal plane)

the average age of men — 73.8 years. Among men, 27 (19.3%) did not exceed the age of 65, there were no cases of rAAA among women below 65 years of age.

Patients' condition was assessed on admission according to the ASA scale as well as based on complete blood counts and creatinine levels.

We analyzed the time it took for a patient diagnosed with rAAA to reach the operating theater, under the operative conditions of the Hospital Emergency Department and Clinical Department of Vascular Surgery of the 4WSKzP, measured as the time from patient registration at the Emergency Department (ED) to the beginning of the operation according to the surgical protocol. Despite the progress in diagnostics, patients without prior imaging (CT and/or ultrasound), who required ultrasound or angio-CT to confirm the diagnosis of rAAA at the ED were still referred to our center, which increased the time of transition to the operating theater (Figs 1, 2). This only concerned patients, who were hemodynamically stable, as patients diagnosed with AAA and symptoms of hemorrhagic shock were sent directly from the ED to the operating theater without further diagnostics, unnecessary in such cases. CT scan was performed on admission in 72 patients (51%), 43 patients had CT imaging performed at the referring center, 25 patients went directly to the operating theater without further diagnostics.

Evaluation of treatment outcomes took into account such parameters as: peri- and postoperative mortality, duration of stay in the ITU, duration of hospital stay, and complications such as: bowel ischemia, lower limb ischemia, respiratory failure, kidney failure.

Figure 2. Angio-CT of ruptured abdominal aortic aneurysm (frontal plane)

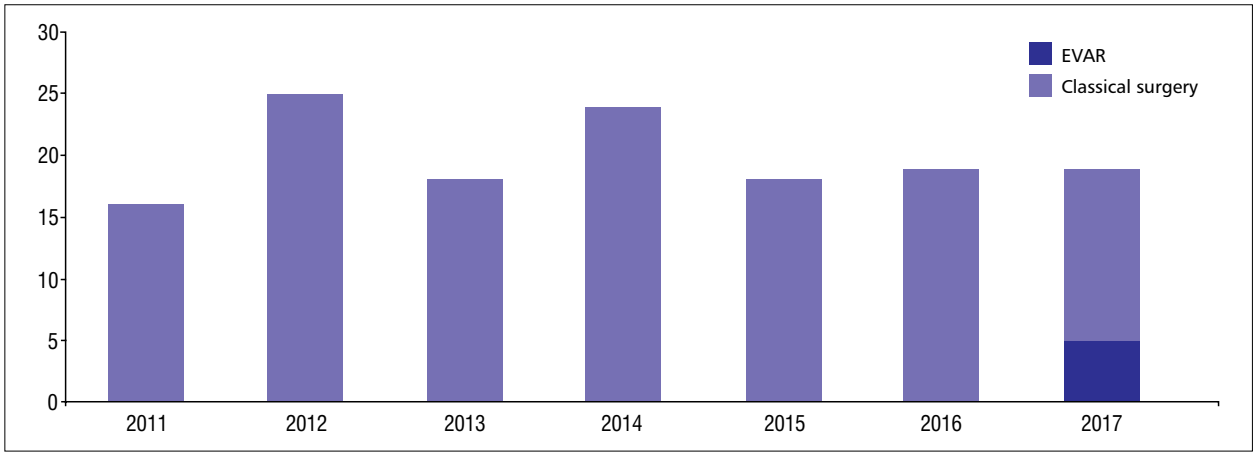

Figure 3. Numbers of surgical procedures due to ruptured abdominal aortic aneurysm in subsequent years

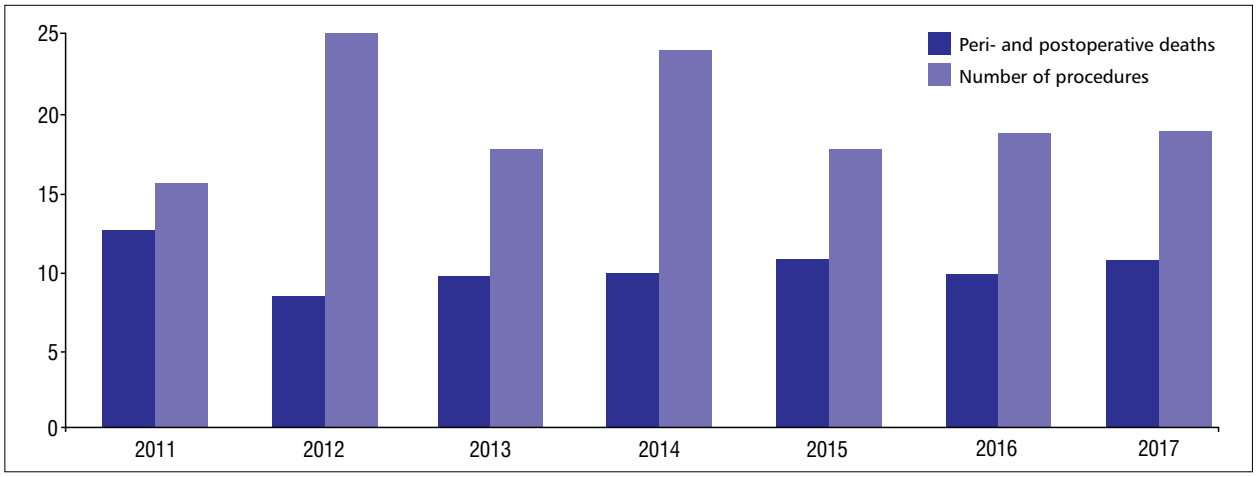

Figure 4. 30-day mortality after surgical treatment of rAAA

Statistical analysis

Analysis of the collected data was performed using Statistica v. 13.3 for Windows. Quantitative data was presented as means and standard deviations or medians and compared using Student's t-test and Mann-Whitney U test. Test results with $P < 0.05$ were considered statistically significant.

Results

One hundred and forty patients were treated for ruptured abdominal aortic aneurysm between 2011 and 2017. The only criterion disqualifying from treatment of ruptured aneurysm was lack of patient's consent and one such a case was reported. The number of surgeries in the subsequent years was similar and ranged between 16 and 25 per year. Classic surgery was performed in 135 cases. Procedures were performed by vascular surgery specialists, all via midline laparotomy, obtaining intraoperative confirmation of rupture of aortic aneurysm and/or iliac arteries. A total of 39 patients were diagnosed with aneurysms involving iliac arteries, and in 7 patients aneurysm involved the ostia of renal arteries, which required clamping the aorta above the renal arteries. A straight dacron prosthesis was implanted in 100 patients, an aortobiiliac prosthesis in 7 patients, aortobifemoral in 32 cases, and one patient died after general anesthetic introduction before the beginning of surgery. Five patients were treated endovascularly, EVAR was performed in 4 cases and extension of stent-graft aortic extension was done in one patient (Fig. 3).

Of the 140 operated patients, 67 died during the peri- or postoperative period (the overall 30-day mortality rate was 47.8%) (Fig. 4), including 17 patients

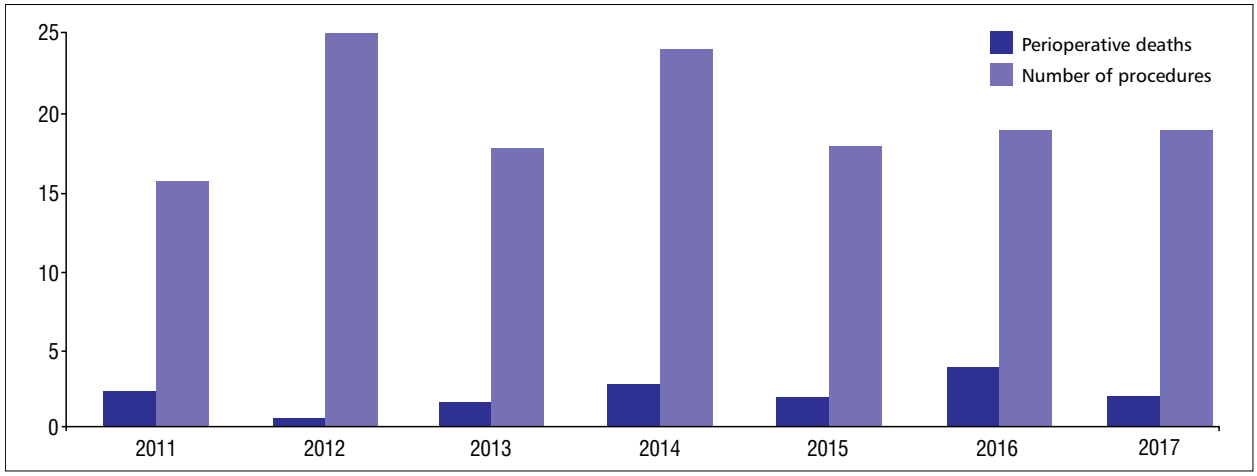

Figure 5. Number of perioperative deaths

who died during or on the day of surgery (mortality rate 12.1%) (Fig. 5). The average age of patients who died was 73.9 years and did not significantly differ from the average age of patients who survived the procedure — 74.57 years (P = 0.7008). The average time to the operating table, measured from the time of patient registration in the ED until the beginning of the procedure was 139.6 minutes, ranging from 30 to 335 minutes and was significantly shorter for patients who died: 100.3 min compared to 186.2 minutes in patients who survived the procedure. The differences can be explained by the fact patients from the second group were in better general condition, which more often allowed performing an angio-CT study. Among 72 patients who had CT examination performed at the ED 44 patients survived (61%). Patients' condition assessed according to the ASA scale was 3.7 on average; 4.1 for group one (patients who died) and 3.4 for group two — this difference was statistically significant (P = 0.0022). In patients from group 1, mean blood hemoglobin concentration was significantly lower at 10.1% compared to group two — 11.5% (P = 0.0134). With respect to renal function, serum creatinine concentrations averaged 1.70 mg%; 1.83 mg% (range 0.56—5.72 mg%) in group one and 1.58 mg% (range 0.62—5.30 mg%) in group two, without statistically significant differences between groups (P = 0.2542). Patients operated on due to ruptured abdominal aortic aneurysm required an average of 3.7 units of red blood cells; significantly more blood was transfused intraoperatively in patients from the first group — 4.6 units of RBC per patient on average, compared to the second group — 2.9 units of RBC per patient on average (P = 0.0123).

Mean duration of hospitalization in patients who were discharged from hospital was 14.2 days and ranged from 6 to 65 days. The mean duration of stay in intensive care was 6.1 days and ranged between 1 and 64 days. Typical complications described in the literature, such as: intestinal ischemia, lower limb ischemia, respiratory failure, renal failure, acute coronary syndrome, and psychosis (Table 1) were observed postoperatively. Complications were observed in 35 of the 73 patients (48%) who survived the procedure and were discharged from hospital. Among this group, 41 patients required intensive care; mean time of stay at the ITU was 11.9 days (the longest stay of 64 days), the most common cause of prolonged stay at the ITU was respiratory failure requiring mechanical ventilation. Of the 67 patients who died, only 36 (53.7%) were admitted to the ITU. In our opinion, more patients should have been admitted to the ICU, at least on the first day after surgery, but this was not always possible due to the lack of ITU beds. Furthermore, the main criterion qualifying for ITU admission was the need

Table 1. Complications of surgical treatment of rAAA

Type of complication	Number
Renal	8
Intestinal necrosis	8
Acute lower limb ischemia	2
Endoleaks after EVAR	1
Acute coronary syndrome	5
Psychosis	5
Respiratory failure	12
Number of patients in total	**73**

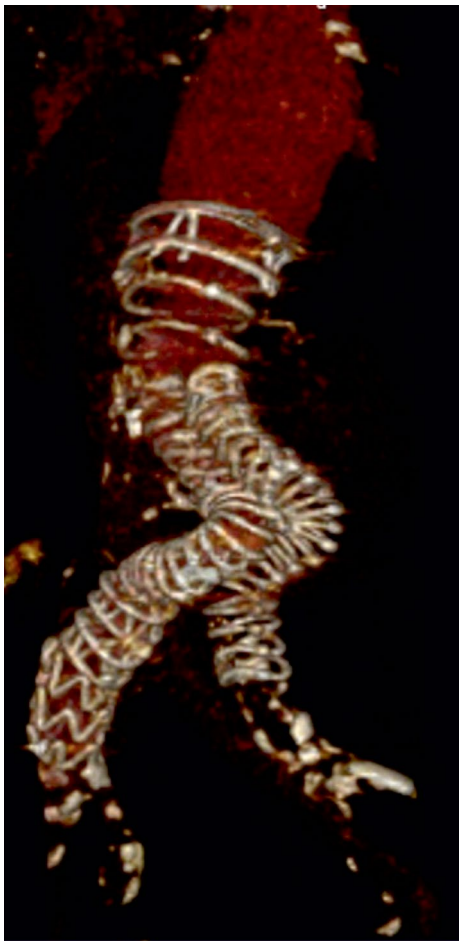

Figure 6. Ruptured abdominal aortic aneurysm after EVAR

for mechanical ventilation due to respiratory failure; patients who did not require mechanical ventilation were sometimes not admitted to the ITU despite their poor general condition, i.e. requiring catecholamine infusions or multiple transfusions of blood products.

Twenty-three patients required repeated surgery, 14 patients (60.9%) died in the postoperative period. In 8 patients, resection of the sigmoid or small intestine was performed due to ischemia (6 of them died during the postoperative course), 7 patients were reoperated due to acute lower limb ischemia (5 died during the postoperative course), 7 patients were reopened due to symptomatic hematoma/bleeding of the operated area (3 died), one patient had a second-look surgery with the removal of the previously applied packing.

With development of endovascular surgery, a new group of patients with ruptured abdominal aortic aneurysms after previous stentgraft implantation arose. There were 4 such patients in our material. Three of them underwent classic surgery, two of them had a vascular prosthesis implanted (Figs 6, 7) after removal

Figure 7. Stentgraft removed during surgical repair of ruptured abdominal aortic aneurysm after EVAR

of a stentgraft, in one patient aneurysm wall was sutured and sealed around the graft with a piece of the prosthesis ("banding"). In one patient, aneurysm rupture was observed in the course of type I leak after EVAR. In the first stage, an attempt was made at endovascular treatment – a stentgraft extension, but an angio-CT performed to symptoms of renal failure showed obstruction of the left renal artery (despite the fact that it was patent in DSA performed during the endovascular procedure) with a persistent leak. Ultimately the patient also required classic surgery — removal of the stentgraft with implantation of a vascular prosthesis.

In one case of a morbidly obese patient with aneurysm rupture into the peritoneal cavity, only aneurysm closure (aneurysmorrhaphy) was performed in the first stage of treatment due to severe general condition and difficult anatomical conditions. Ultimately, deferred endovascular procedure (EVAR) was used to treat the aneurysm after patient's general condition had stabilized.

Discussion

Demographic data confirm that the problem of abdominal aortic aneurysm rupture mainly affects men (they represented 87.1% of patients) and elderly people (mean age 74.2 years) [14–16]. It is worth noting that 27 patients were under 65 years of age (19.3%) and they were all men, i.e. 22.1% of men were below the age generally accepted as an indication for screening [17]. In the analysis conducted by Laine et al. [18] on a group of 585 patients with rAAA , 486 of subjects were men (83.1%) and 18.3% of patients were below 65 years of age (21.4% of men and 3.0% of women). The above data may suggest that the age of men included in AAA screening programs should be lowered.

Results obtained in our material confirm that management of patients with ruptured abdominal aortic

aneurysm continues to be associated with high mortality rates and a significant number of postoperative complications.

Poor general status according to ASA scale, low blood count as well as high serum creatinine levels can be considered risk factors for postoperative mortality. Undoubtedly, the need to repeatedly transfuse blood products (RBC) is also an important risk factor for death.

The number and nature of reported complications corresponds to those reported in the literature on rAAA. In a publication by Gawenda et al. [19], the occurrence of intra- and postoperative bleeding was observed in 12–14% of patients, intestinal ischemia in 3-13%, respiratory failure in 26–47%, and renal failure in 26–42%. A particularly dangerous complication is intestinal ischemia requiring gut resection. In our material, out of 123 patients who survived the procedure, it occurred in 8 patients, representing 6.5% of the study population. Six of them died in further postoperative course, representing an 80% mortality rate, which is comparable to the literature data, e.g. 73–100% according to Gawenda [19].

Effectiveness of treatment depends on many factors. Increased health awareness among the public and greater availability of basic diagnostic tests, including abdominal ultrasound, may be a significant factor limiting the incidence of abdominal aortic aneurysm rupture. Early diagnosis and elective treatment, especially in the age of development of endovascular surgery, can protect the patient from the disaster of the "aortic rupture". Management at the primary care level seems important, so that a patient with a "pulsating tumor in the abdomen" would not wait too long for necessary treatment [14].

At the level of emergency medical services, it is important that patients with suspected or diagnosed ruptured abdominal aortic aneurysm should be sent to centers specialized in the operative management of rAAA as soon as possible. At the level of preoperative management, it is important to remember the principle of "permissible hypotonia" to limit blood loss until surgery.

Peri- and postoperative anesthetic management is an extremely important aspect of treatment, from the moment of admission to hospital, through management in the operating theater, to the treatment of early and late complications of rAAA in the Intensive Therapy Unit. Further developments in this area may contribute to improving treatment outcomes [15].

Further improvement of treatment outcomes is possible due to the application of endovascular techniques in the treatment of patients with rAAA. The available literature data concerning the results of endovascular treatment of rAAA indicate lower mortality rates compared to classic surgery, ranging between 18% and 53%, and according to some researchers even less than 20%. It should be mentioned, however, that a selected group of patients is referred for intravascular treatment and a group of patients undergoing classic surgery includes cases that are much more difficult, such as those with pararenal aneurysms that have been disqualified from EVAR, or patients in poor general condition. The possibility of intravascular treatment of ruptured aneurysms requires a significant organizational and financial effort, which is not easy under today's conditions of the Polish health service. Qualification for EVAR in urgent cases requires access to rapid imaging diagnostics (computer angiotomography). Surgical treatment in such cases is possible in a fully-equipped hybrid operating room, dedicated to intravascular procedures, offering the possibility of immediate conversion to open surgery and accessibility to the equipment needed in EVAR. Endovascular treatment of rAAA also requires 24-hour availability of staff specialized in performing such procedures (vascular surgeon specialized in EVAR, radiology technicians, nursing staff) [16].

Summarizing, it is worth presenting the work of Swedish authors, where Gunnarson et al. analyzed the results of treatment of ruptured abdominal aortic aneurysms included in the Swedish Vascular Register between 2008 and 2012 [3]. They compared centers where endovascular treatment is the primary practice strategy (EVAR in more than 50% of patients with rAAA) with centers preferring classic surgery. A total of 1,304 patients were enrolled. Two hundred and thirty-six patients were treated in three "endovascular" centers (EVAR in 74.6% of cases), while 1068 patients were operated on in 26 "classic" centers (EVAR in 15.6% of cases). There was no significant difference in the 30-day mortality rates, which amounted to 28.0% in the "endovascular" group and 27.4% in the "classic" group. Overall, patients undergoing endovascular surgery (regardless of the center) were older (76.4 vs 74 years) and were characterized by lower mortality rates (21.6% vs. 29.6%). It can be, therefore, concluded that in order to achieve such good results of treatment among patients with rAAA, it is necessary to improve the entire health care system, from the level of primary care, through the emergency response system, to specialized vascular surgery centers with access to modern endovascular techniques [16].

Conclusions

1. Surgical treatment of patients with ruptured abdominal aortic aneurysm continues to be associated with high mortality rates and a significant number of postoperative complications.

2. The following can be considered as unfavorable prognostic factors in rAAA: poor general condition according to the ASA scale, low baseline complete blood count values, high baseline serum creatinine levels, the need for multiple transfusions of blood products (RBC).
3. Effective surgical treatment of patients with ruptured abdominal aortic aneurysm is possible if patients are efficiently referred to centers specialized in the treatment of rAAA with access to intravascular treatment and possibility of providing comprehensive perioperative care in intensive therapy units.
4. Further improvement of treatment outcomes is possible thanks to the use of intravascular techniques in a fully equipped hybrid operating room dedicated to intravascular procedures with the option of immediate conversion to open surgery and accessibility to the entire equipment needed for EVAR.

Conflict of interest:

None.

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