ORIGINAL ARTICLE

RUPTURED ABDOMINAL AORT ANEURSYMS AND TIMING: ONE CENTER, 20-YEARS ANALYSIS

Rüptüre Abdominal Aort Anevrizmaları ve Zamanlama: Bir Merkez, 20 Yıllık Analiz

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ABSTRACT

Objective: Early diagnosis and treatment are of great importance in the prognosis of abdominal aortic aneurysms (AAA). In this study, we aimed to discuss 44 patients who underwent surgical treatment for ruptured AAA(rAAA) in our clinic.

Material and Methods: Forty-four patients who underwent emergency surgery for rAAA in our clinic between January 2000-December 2020 (last twenty years) were evaluated retrospectively. Subgroup examinations were made according to the distance and time passed until they reached our hospital.

Results: The mean age of 44 patients was 64.61±12.13 years. 34 of the patients are male. The first application place of 29 patients is other centers. Accompanying risk factors are hypertension (72.72%), hyperlipidemia (61.36%), smoking (52.27%), coronary artery disease (47.72%), chronic obstructive pulmonary disease (34.09%), diabetes (34.09%) and elevated creatinine levels (acute renal failure-over 2mg / dl) - (20.45%). 19 patients were lost. Two of these 19 patients died during the operation and the others during their follow-up in the intensive care unit (10 ± 10.86 days). The mortality rate in rAAA, which is operated under emergency conditions, is 43.18%. However, as our hospital also serves as a regional hospital, 15 of the 29 patients (51.72%) who were transferred form surrounding provinces were lost, while 4 of the 15 patients (26.6%) who applied from the same province.

Conclusion: When rAAA are operated as soon as possible, there is a significant decrease in mortality rates. For this reason, the success of the physician who first evaluated the patient in diagnosing and quickly transporting the patient to the center where the surgery will be performed will be life-saving.

Keywords: *Ruptured Aneurysm; Timing; Abdominal Aortic Aneurysm*

ÖZET

Amaç: Abdominal aort anevrizmalarının (AAA) prognozunda erken tanı ve tedavi büyük önem taşımaktadır. Bu çalışmada kliniğimizde rüptüre AAA nedeniyle cerrahi tedavi uygulanan 44 hastayı tartışmayı amaçladık.

Gereç ve Yöntemler: Kliniğimizde rüptüre AAA nedeniyle Ocak 2000-Aralık 2020 tarihleri arasında (son yirmi yıl) acil şartlarda cerrahi tedavisi gerçekleştirilen 44 olgu retrospektif olarak değerlendirildi ve hastanemize ulaşmasına kadar geçen mesafeye ve zamana göre subgrup incelemeleri yapıldı.

Bulgular: 44 hastanın yaş ortalaması 64,61±12,13 yıldır. Hastaların 34'ü erkektir. 29 hastanın ilk başvuru yeri başka merkezlerdir. Eşlik eden risk faktörleri hipertansiyon (%72,72), hiperlipidemi (%61,36), sigara kullanımı (%52,27), koroner arter hastalığı (%47,72), kronik obsrüktif akciğer hastalığı (%34,09), diyabet (%34,09) ve kreatinin yüksekliği(akut böbrek yetmezliği-2mg/dl üzeri)-(%20,45) idi. Toplamda 19 hasta kaybedildi. Bu 19 hastanın ikisi ameliyat sırasında diğerleri yoğun bakım ünitesinde takipleri sırasında kaybedildi. (ortalama kalış süresi 10 ± 10,86 gün). Hastanemizde acil şartlarda opere edilen rüptüre AAA'da mortalite oranı %43,18'dir. Ancak hastanemiz bölge hastanesi olarak da hizmet verdiğinden çevre illerden gönderilen 29 hastanın 15'i (%51,72) kaybedilirken, aynı il içerisinden başvuran 15 hastanın ise 4'ü (%26,6) kaybedilmiştir

Sonuç: Rüptüre abdominal aort anevrizmaları zaman kaybetmeden ameliyata alındıklarında mortalite oranları düşmektedir. Bu nedenle hastayı ilk gören hekimin tanı koyma ve hastanın cerrahi yapılacak merkeze hızla ulaştırılması konusundaki gayretleri yaşam kurtarıcı olacaktır.

Anahtar Kelimeler: *Rüptüre Anevrizma; Zamanlama; Abdominal Aort Anevrizması*

INTRODUCTION

An abdominal aortic aneurysm (AAA) occurs when the aorta is permanently localized, dilated, and 50% larger than the expected and normal diameter, which may vary depending on age, gender, and body size (1). AAAs are responsible for approximately 1% of deaths in developed countries and are an important health problem. The death rate increases to 4–8% in men over 65 years of age. An increase in these rates is emphasized in the guidelines of the European Vascular Surgery Association (2). Although studies have indicated that the death rate has begun to decrease significantly in the last 10 years, it remains at very high levels. In addition, while there has been a slight decrease in death rates in patients with ruptured abdominal aortic aneurysms (rAAAs) with increased screening and elective therapy in response to asymptomatic aortic aneurysms, AAAs remain serious health issues due to their high rates of mortality (3, 4). Even when surgical treatment is applied, the perioperative mortality rate is 48% on average. Therofore, it is possible to decrease mortality due to ruptures, which are most often the first signs of aneurysms, with early diagnosis and elective AAA repair (1,5). Moreover, significant reductions in mortality can be achieved with rapid and consistent action in the diagnosis and transfer of patients to centers where the necessary treatments can be performed. This study aimed to discuss 44 patients who underwent surgical treatment for rAAAs, which have high mortality rates and high clinical significance despite advancements in medicine.

MATERIALS AND METHODS

Study Methods and Patient Selection

Forty-four patients who underwent emergency surgery at our clinic over the last 20 years were evaluated retrospectively. Patient groupings were made according to the time between the onset of initial symptoms and surgery or the health institutions where they received treatment. The cases were divided into two groups that included those who applied to our hospital after initial symptoms (Group 1; n = 15) and those who were referred to our hospital from another center (Group 2; n = 29). Among these groups, the time between the first symptom and surgery was analyzed and compared. The distance and time differences, demographic data, risk factors, and morbidity and mortality rates between these two groups were compared. Deaths within 30 days of operation were considered to represent mortality. The study was carried out in accordance with the Declaration of Helsinki of 2008. Permission was obtained from the Ethics Committee at our faculty (Atatürk University Clinical Researchers of Ethical Committee—B.30.2.ATA.0.01.00/23. 17.12.2020—Decision Number: 72).

Statistical Analysis

The Number Cruncher Statistival System 2007 (Kaysville, Utah, USA) program was used for statistical analysis. Descriptive statistical methods (average, standard deviation, median, frequency, ratio, minimum, and maximum) were used to evaluate the study data, and the distribution of the data was evaluated using the Shapiro-Wilk Test. The Mann-Whitney U Test was used to compare two groups that did not show normally distributed quantitative data. Chi-square analysis was used to determine the relationship between the qualitative data. Significance was evaluated at $p<0.05$

RESULTS

The mean of the 44 patients who underwent surgery due to rAAAs was 64.61 ± 12.13 years. In addition, the patients included 10 women and 34 men. The patients were operated on under emergency conditions. Concomitant risk factors comprised hypertension (72.72%), hyperlipidemia (61.36%), smoking (52.27%), coronary artery disease (47.72%), chronic obstructive pulmonary disease (34.09%), diabetes (34.09%), and elevated creatinine levels of 2.0 mg/dl and above (20.45%). The distribution of these risk factors among the groups is provided in Table 1.

The average aneurysm length was 50.91±8.3 mm, and the average diameter was 69.57±6.88 mm. While this value was 48.67±5.73 mm/70.2±7.06 mm in Group 1, it was 52.07±9.24 mm/69.24±6.88 mm in Group 2. Furthermore, the hemoglobin values upon arrival at the hospital were 10.54±5.06 g/dL, and the mean blood transfusion values were 6.2±1.13 units. Group 1's hemoglobin values were 11.19±7.19 g/dL, and their blood transfusion values were 6.27±1.44 units. Group 2's hemoglobin values were 10.2±3.62 g/dL, and their blood transfusion values were 6.17±0.97 units.

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The hemoglobin values and mean blood transfusion amounts were similar between the groups. According to the patients' laboratory data at the time of admission, Group 1's hemoglobin values were low and Group 2's hemoglobin levels were high. However, these findings were not statistically significant (Table 2).

Nineteen patients died in total. Two of these nineteen patients were accepted to exitus in the intensive care unit during surgery, and the others passed away within an average of 10±10.86 days. The mortality rate of rAAAs operated under emergency conditions is 43.18%. High creatinine and low hemoglobin were found to be factors associated with morbidity and mortality. Seven patients had previously been diagnosed with AAA at other centers (an average of 37.14 months prior) and did not accept surgery of their own accord or receive follow-up care. While the most common reason for presentation of AAA was severe abdominal and back pain, complaints included fainting in three cases. Diagnoses were made by computed tomography in all patients. Laparotomy was performed with median incisions above and below the umbilicus and paramedian incision in five (39 patients) of the operated patients. Infrarenal cross clamps were placed in all the patients. Aortic bi-iliac bypass was performed in 19 of the cases, and aorta-bifemoral bypass was performed in 12 of the cases. Fistula in the vena cava inferior was found and repaired in two of these cases. Tubular graft interposition was performed in seven patients, and aorta-iliac and aorta-femoral bypass were applied in two patients. Endovascular intervention was performed in three patients. Finally, intraoperative exitus occurred before the graft could be placed in a single case (Table 3).

Subgroup Analysis

The mean distance the patients had to go to our hospital from Erzurum and its districts (Group 1; n = 15) was 16.27 ± 28.64 km, and the mean travel time to our hospital was 20.33 ± 18.65 hours. The mean distance traveled by the patients from other provinces (Group 2; n=29) was 165.79 ± 87.72 km, and the mean travel time to our hospital was 41.93 ± 37.86 hours. The relationship of these values between the groups was considered statistically significant (p: 0.001 and p: 0.016, respectively) (Table 4).

The average age of the first group group (12 men and 3 women) was 64.53 ± 7.94 years. The average age of second group (22 men and 7 women) was 64.66 ± 13.94 years. Group 1's accompanying risk factors included hypertension (73.33%), hyperlipidemia (60.0%), smoking (40.0%), coronary arter disease (46.66%), chronic obstructive pulmonary disease (26.66%), diabetes (46%), and elevated creatinine levels of 2.0 mg/dl or above (20.0%). Group 2's accompanying risk factors included

Table 1. Demographic characteristics of the patients

	All patients (n:44)	Group 1 (n:15)	Group 2 (n:29)	*p value*
Age (year)	64.61±12.13	64.53±7.94	64.66±13.94	0.464
Gender				
Male (n)(%)	33 (75%)	12 (80%)	21 (72.4%)	0.435
Female (n)(%)	11 (25%)	3 (20%)	8 (27.6%)	
Diabetes Mellitus (n)(%)	15 (34%)	7 (46.7%)	8 (27.6%)	0.176
Hypertension (n)(%)	32 (72.7%)	11 (73.3%)	21 (72.4%)	0.621
COPD (n)(%)	13 (29.5%)	4 (26.7%)	9 (31%)	0.525
CRF (n)(%)	9 (20.4%)	3 (20%)	6 (20.6%)	0.685
Cigarette (n)(%)	23 (52.2%)	6 (40%)	17 (58.6%)	0.197
Hyperlipidemia (n)(%)	27 (61.4%)	9 (60%)	18 (62.1%)	0.573
CAD	21 (47.7%)	7 (46.7%)	14 (48.3%)	0.586

Chi-Square Testi **p<0,05
COPD: Chronic Obstructive Pulmonary Disease, CRF: Chronic Renal Failure(Creatinine>2,0 mg/dl), CAD: Coronary Artery Diseases

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Table 2. Blood product use and reference laboratory features.

	Group 1 (n:15)	Group 2 (n:29)	All patients (n:44)	*p value*
Erythrocyte suspension (n)	6.27±1.44	6.17±0.97	6.2±1.13	0.785
Fresh frozen plasma (n)	5.4±1.18	5.45±0.91	5.43±1	0.811
Whole blood (n)	0.87±0.74	1±0.76	0.95±0.75	0.576
WBC (K/mm$^{3)}$	12.25±5.58	13.07±5.78	12.79±5.67	0.665
Hemoglobin (g/dl)	11.19±7.19	10.2±3.62	10.54±5.06	0.901
Hematocrit (%)	27.4±5.59	28.57±6.67	28.17±6.28	0.785
Platelet (K/mm$^{3)}$	215.53±72.89	198.14±93.91	204.07±86.85	0.393
BUN (mg/dl)	66.73±41.64	56.31±31.61	59.86±35.22	0.473
Creatine (mg/dl)	1.78±1.21	1.84±1.85	1.82±1.64	0.931
Glucose (mg/dl)	201.8±115.54	187.52±64.04	192.39±84.05	0.528

Mann-Whitney U Testi p<0,05
WBC: White Blood Cell, BUN: Blood Urea Nitrogen

Table 3. Operational characteristics and features of aneurysm

	Group 1 (n:15)	Group 2 (n:29)
Diameter of the aneurysm (mm)	70.2±7.06	69.24±6.88
The size of the aneurysm (mm)	48.67±5.73	52.07±9.24
Aorta bifemoral by pass (n/%)	4 (26.66%)	8 (27.58%)
Aorta biiliac by pass (n/%)	8 (53.33%)	11 (37.93%)
Aorta-aorta greft (n/%)	3 (20.00%)	4 (13.79%)
EVAR (n/%)	1 (6.66%)	2 (6.89%)
Aorta uni femoral+uni iliac (n/%)	--	2 (6.89%)
Median incision (n/%)	13 (86.66%)	26 (89.65%)
Paramedian incision (n/%)	2 (13.33%)	3 (10.34%)

EVAR: Endovascular Aortic Replacement

Table 4. Reference distances and times between groups

	Group 1 (n:15)	Group 2 (n:29)	*p value*
Transportation distance (km)	16.27±28.64	165.79±87.72	***0.001****
First symptom - time between operations (hour)	20.33±18.65	41.93±37.86	***0.016****
Discharged time (hour)	8.78±2.44	11.07±7.12	0.451

Mann-Whitney U Testi *p<0,05

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hypertension (72.41%), hyperlipidemia (62.06%), smoking (58.68%), coronary artery disease (48.27%), chronic obstructive pulmonary disease (31.03%), diabetes (27.58%), and elevated creatinine levels of 2.0 mg/dl or above (20.68%). There were no differences between the groups in term of demographic characteristics. While 15 (51.70%) of the 29 patients from surrounding provinces and districts died, 4 (26.6%) of the 15 patients from our hospital's province passed away. This difference was statistically significant ($p < 0.05$) and is the primary focus of this study.

DISCUSSION

AAA is an important health problem due to its high risk of rupture. Detection of AAA before rupture can prolong survival, and elective repair can reduce complication rates during intervention (1). The prevalence of AAA in men over 65 years of age is 5%, and rupture of these aneurysms accounts for 1–4% of the mortality cases in this age group. This is particularly important since the first finding for AAAs is often rupture (6). The first elective surgery of AAA was performed by the Frenchman Charles Dubost in 1951 (7, 8). The aneurysm was resected, and the defect in the aorta was repaired with a homologous artery. Degenerative changes occurred in the graft within six months after the initially successful period. Voorhees et al. achieved the first synthetic graft application in 1952 (7). The 30-day mortality rate of patients who undergo elective AAA surgery ranges from 1% to 8%. However, although the operative mortality rates after the development of rupture have not significantly improved in recent years, the rates vary between 32% and 80%. Total mortality is extremely high, at approximately 80–90% (2). While our total mortality rate in operated rAAAs is below the average within the literature (43.18%), it remains at high levels.

Timing and correct diagnosis are important. Approximately 45 people per 100,000 die with the diagnosis of rAAA very year (9). For this reason, the diagnosis and elective treatment of aneurysms is critical. If the aneurysm is not recognized and treated electively, it will inevitably result in rupture. In this case, the recognition of the rupture and its early intervention become vital. In Lloyd et al.'s evaluation of 56 inoperable rAAAs, 87.5% of the cases survived more than 2 hours after admission to the hospital, and the average time to death was 10 hours and 45 minutes. The mean total time from the onset of symptoms to death was 16 hours and 38 minutes (10). In another study, 182 rAAAs were evaluated. The time between the onset of symptoms and operation was 3.9 ± 4.1 hours. However, approximately 60% of the patients were initially misdiagnosed. This finding was determined to be statistically and significantly associated with mortality.

In 1982, the Cleveland Vascular Society asserted that misdiagnosis causes 75% of the cases of mortality in rAAAs. Various radiodiagnostic methods and ample time are needed for correct diagnosis. During this time, the surgical chances of rAAA patients gradually decrease (8). Because more than half of our patients were referred to our clinic from different health institutions in other provinces, intervention may have been delayed. The patients' mean distance from the hospital was 165.79 ± 87.72 km, and the time it took them to reach the hospital was 41.93 ± 37.86 hours. These circumstances explain the higher mortality of the patients in this group than in the other group.

Suspecting a diagnosis of rAAA is the primary marker for reaching a true diagnosis. The examinations that the first physician to encounter the patient will perform and the timing of this examination will reveal critical results in terms of mortality. If there is any doubt during these investigations, the physician's primary goal should be to provide hemodynamic stabilization. Appropriate organ perfusion can be achieved with adequate volume support and vasoconstrictor therapy (11). It is thought that excessive volume overload has negative effects on mortality and increases systolic pressure (12). The physician who first encounters the patient plays an important role in maintaining this balance. In a study conducted in 2006, a significant decrease in morbidity and mortality was achieved when protocols defining the diagnosis and treatment processes of these patients were created (13). Because there were serious differences in mortality between the groups in the present study, subsequent research on these issues could prove useful.

There are also aneurysm- and patient-dependent risk factors associated with mortality in rAAAs. Four prediction-based scoring systems that detect and

measure aneurysm risk factors have been reported: the Hardman index, the Glasgow aneurysm score, the physiological and operative severity score for the enumeration of mortality and morbidity (POSSUM) and the Vancouver scoring system. The Hardman index looks for preoperative hemoglobin levels of < 9 g/dl, serum creatinine levels of > 90 µmol/L, electrocardiographic ischemia, loss of consciousness in the hospital, and patients who are > 76 years of age. If there are three or more risk factors, the mortality rate is considered to be 100%. Evaluations with the Glasgow aneurysm score are made according to age, shock, myocardial disease, cerebrovascular disease, and renal disease. In POSSUM scoring, there is an operative score consisting of preoperative information, a physiological score consisting of 12 parameters, and an operative score consisting of 6 parameters and intraoperative data. In operative scoring, the operation category includes the number of procedures, total blood loss (mL), peritoneal contamination, malignancy, and the timing of the operation. In the Vancouver scoring system, evaluation is made according to age, decreased level of consciousness, and preoperative cardiac arrest (14). It is important to identify these factors and perform risk analysis during the pre-operative period. The risk factors we identified, such as low hemoglobin and high serum creatinine levels, have been found to be associated with mortality. Volume loss has an important effect on the occurrence of either finding. Therofore, the high mortality rates in the patient group that travelled a longer distance to undergo surgery was an expected result.

Although open surgical methods remain the gold standard for patients with rAAAs, endovascular treatment (EVAR) may be considered as an initial option in patients with the appropriate anatomy (15). We were able to use the endovascular method in three of our patients. While the absence of mortality in these patients is consistent with the positive applications of EVAR in the literature, the low number of patients who receive this treatment limits our ability to comment on this issue. The most important factor in the limited use of the EVAR method is the absence of the stent graft.

CONCLUSION

An rAAA is an emergency that requires immediate surgical intervention. Even with timely surgical intervention, mortality can increase significantly due to loss of time because of the high mortality in this clinical situation. In studies where the first physicians to see these patients are involved, the loss of time can be minimized and morbidity and mortality rates can be reduced.

REFERENCES

1. Brady AR., Thompson SG., Fowkes FGR., Greenhalgh RM., Powell JT. Abdominal aortic aneurysm expansion: risk factors and time intervals for surveillance. Circulation, 2004;110(1): 16-21.

2. Moll FL, Powell JT, Fraedrich G, Verzini F, Haulon S, Waltham M et al. Management of abdominal aortic aneurysms clinical practice guidelines of the European society for vascular surgery. Eur J Vasc Endovasc Surg 2011; 41 (Suppl. 1): 1–58

3. Choke E, Vijaynagar B, Thompson J, Nasim A, Bown MJ, Sayers RD. Changing epidemiology of abdominal aortic aneurysms in England and Wales: older and more benign? Circulation 2012; 125:1617–25

4. Schermerhorn ML, Bensley RP, Giles KA, Hurks R, O malley AJ, Cotterill P et al. Changes in abdominal aortic aneurysm rupture and short-term mortality, 1995–2008: a retrospective observational study. Ann Surg 2012; 256: 651–8

5. Benson RA, Poole R, Murray S, Moxey P, Loftus IM. Screening results from a large United Kingdom abdominal aortic aneurysm screening center in the context of optimizing United Kingdom National Abdominal Aortic Aneurysm Screening Programme Protocols. J Vasc Surg 2016; 63: 301–4

6. Ulug P, Powell JT, Sweeting MJ, Bown MJ., Thompson SG., Group SC. Meta-analysis of the current prevalence of screen-detected abdominal aortic aneurysm in women. Br J Surg 2016; 103: 1097–104

7. Urbonavicius S., Urbonaviciene G., Honoré B., Henneberg EW., Vorum H.,n Lindholt JS. Potential circulating biomarkers for abdominal aortic aneurysm expansion and rupture-a systematic review. Eur J Vasc Endovasc Surg., 2008; 36(3): 273-80.

8. Brown LC, Powell JT. Risk factors for aneurysm rupture in patients kept under ultrasound surveillance. UK Small Aneurysm Trial Participants. Ann Surg 1999; 230: 289-96

9. Akata O. Initial experiences of synthetic vascular grafts in Turkey: First surgical attempt of aorta abdominalis aneurysm. Turk J Vasc Surg 2011; 20(1):022-5.

10. Treska V., Topolcan O., Vrzalova J., Molacek J., Houdek K. Osteoprotegerin Serum Levels in Abdominal Aortic Aneurysm. J Vas Surg., 2011; 53(2): 554.

11. Anjum A, von Allmen R, Greenhalgh R, Powell JT. Explaining the decrease in mortality from abdominal aortic aneurysm rupture. Br J Surg 2012; 99: 637–45

12. Lloyd GM., Bown MJ., Norwood MGA., Deb R., Fishwick G., Bell PRF et al. Feasibility of preoperative computer tomography in patients with ruptured abdominal aortic aneurysm: a time-to-death study in patients without operation. J Vas Surg., 2004; 39(4): 788-91.

13. Tchana-Sato V., Sakalihasan N., Defraigne JO. Ruptured abdominal aortic aneurysm. Revue medicale de Liege, 2018; 73(5-6): 296-9.

14. Hardman DT, Fischer CM, Patel MI, Neale M., Chambers J., Lane R et al. Ruptured abdominal aortic aneurysms : who should be offered surgery ? J Vasc Surg, 1996; 23: 123-9.

15. Mehta M., Taggert J., Darling III RC., Chang BB., Kreienberg PB., Paty PS et al. Establishing a protocol for endovascular treatment of ruptured abdominal aortic aneurysms: outcomes of a prospective analysis. J Vas Surg., 2006; 44(1): 1-8.

16. Tambyraja AL., Lee AJ., Murie JA., Chalmers RT. Prognostic scoring in ruptured abdominal aortic aneurysm: a prospective evaluation. J Vas Surg. 2008; 47(2): 282-6.

17. Chaikof EL, Dalman RL, Eskandari MK, Jackson BM, Lee WA, Mansour MA et al. The Society for Vascular Surgery practice guidelines on the care of patients with an abdominal aortic aneurysm. J Vasc Surg, 2018 Jan; 67(1):2-77.