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CLINICAL RESEARCH

Is in-hospital mortality associated with neurological outcomes in patients with endovascular aortic repair? Results from a single centre

Endovasküler aort onarımı yapılan hastalarda nörolojik sonuçlar ile hastane mortalitesi arasındaki ilişki

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ABSTRACT

Aim: Herein, we aimed to present our results of thoracic and abdominal endovascular aortic repair (EVAR/TEVAR) procedures for thoracoabdominal aortic pathologies and the relation between the post-procedural neurological adverse events and in-hospital mortality.
Material and Method: Patients who underwent EVAR/TEVAR procedures between November 2016 and May 2021 were included in this retrospective study. Patients with a history of any cerebrovascular event before the intervention were excluded. Patients were divided into two groups according to the occurrence of any early neurological complications in the postoperative period in hospital.
Results: A total of 47 patients were included in this retrospective study. Group 1 included 37 (78.7%) patients who had no neurological complications in the early postoperative period. Group 2 included 10 (21.3%) patients who had a postoperative neurological complication. The intensive care unit (ICU) stay time was significantly longer in Group 2 compared with Group 1 (1.7 ± 2.0 days in Group 1 vs 6.2 ± 5.1 days in Group 2, p = 0.021). The overall mortality rate was 19.1% (9 of 47 patients). The mortality rate of Group 2 was significantly higher than Group 1 (2 of 37 [5.4%] patients in Group 1 vs 7 of 10 [70%] patients in Group 2, p = 0.001). The American Society of Anesthesiologists (ASA) physical classification score was significantly higher in Group 2 than Group 1 (3.5 ± 0.6 in Group 1 vs 4.1 ± 0.3 in Group 2, p = 0.016). The most common early postoperative neurological complication was a lack of recovery of consciousness in the postoperative period (no postoperative consciousness).
Conclusion: The occurrence of any postoperative neurological adverse event is associated with in-hospital mortality following TEVAR/EVAR procedures.

Keywords: EVAR, TEVAR, neurological deficit, in-hospital mortality

ÖZ

Amaç: Torakoabdominal aort patolojilerinde EVAR/TEVAR sonuçlarımızı ve post-prosedural nörolojik olaylar ile hastane mortalitesi arasındaki ilişkiyi sunmak.
Gereç ve yöntem: Kasım 2016 – Mayıs 2021 arasında EVAR/TEVAR işlemi uygulanmış hastalar bu retrospektif çalışmaya alındı. İşlem öncesi herhangi bir nörolojik olay öyküsü olan hastalar çalışmaya alınmadı. Post-prosedural erken nörolojik komplikasyonların oluşuna göre hastalar iki gruba ayrıldı.
Bulgular: Toplam 60 hasta değerlendirildi. Grup 1 nörolojik komplikasyon olmayan 37 (%78.7) hasta, Grup 2 post-prosedural nörolojik komplikasyon olan 10 (%21.3) hastadan oluştu. Yoğunbakımda kalış süresi Grup 2'de anlamlı derecede uzundu (1.7 ± 2.0 gün Group 1 vs 6.2 ± 5.1 gün Group 2, p=0.021). genel mortalite oranı %19.1 (47 hastada 9) idi. Grup 2 mortalite oranı anlamlı derecede yüksekti (37 hastada 2 (%5.4) Group 1'de vs 10 hastada 7 (%70) Group 2'de, p=0.001). Amerikan Anesteziyolojistler Birliği fiziksel sınıflama skoru Grup 2'de anlamlı derecede yüksekti (3.5 ± 0.6 Group 1 vs 4.1 ± 0.3 Group 2, p=0.016). En sık erken postprosedural nörolojik komplikasyon bilinç olmamasıydı.
Sonuç: Erken postprosedural nörolojik komplikasyon oluşması, TEVAR ve EVAR prosedürlerinin hastane mortalitesini artmasına katkı yapmaktadır.

Anahtar kelimeler: EVAR, TEVAR, nörolojik komplikasyon, hastane mortalitesi

Introduction

In recent years, thoracic and abdominal endovascular aortic repair (EVAR/TEVAR) procedures have become common techniques for thoracoabdominal aortic pathologies such as aortic dissections and aneurysms. The main goal is to exclude the aortic lesion (i.e. aneurysm or false lumen after aortic dissection) from circulation by implanting a fabric-covered stent across the lesion. EVAR/TEVAR techniques are strongly recommended as the preferred treatment approach in certain patient groups with thoracic and abdominal aortic pathologies (1–3).

Neurological complications such as paraplegia and stroke rates after TEVAR procedures have been reported to be between 0.8% and 1.9% and between 2.1% and 3.5%, respectively (4). Transfer status, emergency intervention, preoperative white blood cell count (WBC), preoperative serum creatinine and

left subclavian artery (LSA) coverage have been reported as variables associated with an elevated risk of postoperative stroke after TEVAR (5).

The mortality rate after TEVAR has been reported to be between 3% and 9.5% (6,7). The 1-year all-cause mortality after TEVAR has been reported to be between 10% and 18% (8,9) and between 4% and 12% after EVAR (10,11). Age, emergency case, preoperative WBC, preoperative serum creatinine level, concurrent aortic arch debranching procedures and chronic obstructive pulmonary disease (COPD) are independent risk factors for mortality (5,6).

Messe et al. (12) reported ischaemic neurological complications in 85 (38%) of 224 patients with descending/thoracoabdominal aortic pathologies who underwent open surgery repair procedures. They also found significantly higher mortality rates in patients with neurological complications than in patients without neurological complications ($p < 0.001$).

Herein, we aimed to present our results of endovascular repair of descending thoracic aortic aneurysm (DTAA), abdominal aortic aneurysm (AAA) and thoracoabdominal aortic aneurysm (TAA) pathologies and the relation between the neurological outcomes and in-hospital mortality rates in these patients.

Material and Method

Patients who underwent EVAR/TEVAR procedures between November 2016 and May 2021 were included in this retrospective study. Patients with a history of any cerebrovascular event before the intervention were excluded. Patient data were collected from hospital records. Patients were divided into two groups according to the occurrence of any early neurological complications in the postoperative period in hospital. Mortality rates were calculated for both groups. Local ethical committee approval was obtained for the study.

The surgical procedure

All operations were performed under local anaesthesia in the angiography laboratory except concomitant peripheral arterial bypass or visceral artery bypass surgery, which were performed under general anaesthesia. The patient's heart rate and rhythm were monitored with electrocardiography and their blood pressure was monitored with invasive blood pressure monitoring. A 5000 IU bolus of intravenous heparin was administered at the beginning of all procedures and activated clotting time was monitored and maintained at over 150 seconds. All interventions were performed through femoral artery access. After proper disinfection and coverage of surgical sites, both femoral arteries were exposed with the open surgical technique if bifurcated stent graft implantation was planned. For cases in which only tubular graft implantation was planned, only one femoral artery was exposed and percutaneous access was achieved on the other side. In TEVAR, generally one-sided open surgical access and one-sided percutaneous access were achieved. In EVAR, bilateral accesses were achieved with the open surgical technique. In TEVAR, a 0.035-inch, 300-cm guidewire (Shunmei polytetrafluoroethylene [PTFE]-coated guidewire, Shunmei Medical, Shenzhen, PRC) was introduced into the femoral artery through a 6F/7F introducer sheath. Then, a 6F pigtail catheter (Dxterity 6F diagnostic catheter, Medtronic, Santa Rosa, CA, USA) was loaded over the guidewire and placed in a proper position in the thoracic aorta to get angiographic images of the descending aorta. The main body of the aortic stent graft (Valiant Captivia, Medtronic) was introduced through a 24F introducer sheath (Sentrant, 24F 28 cm, Medtronic) in the contralateral femoral artery, which was exposed with open surgical technique. The thoracic aortic stent graft was deployed according to the measurements of the angiography images taken previously in the procedure. The pigtail catheter was pulled back and replaced in the thoracic aorta through the stent graft and control angiography images were obtained to check for any signs of endoleak. If a type 1 endoleak was observed, then an extension graft (aortic cuff) was placed and balloon dilatation of the grafts was performed. The procedure was complete if no signs of endoleak were seen. The femoral artery was repaired with 6/0 or 7/0 propylene primary sutures. An open surgical bypass with an 8 mm synthetic PTFE graft was performed from the left common carotid artery (LCCA) to the LSA if coverage of the ostium of the LSA was planned at the beginning of the procedure.

In EVAR procedures, both femoral artery accesses were achieved with open surgery. Angiographic images were obtained as described above. The main body of the abdominal aortic stent graft (Endurant II, Medtronic) was placed just below the renal artery orifice to avoid renal artery occlusion through either left or right femoral artery access. Then, the contralateral limb of the graft was introduced through contralateral femoral artery access and placed in the contralateral limb of the stent graft with enough overlapping length. Large size introducer sheaths (24F Sentrant, Medtronic) were used in both femoral arterial access sites. Balloon angioplasty was performed with a balloon catheter (Reliant, Medtronic) in the proximal and overlapping sections of the graft to stabilise the graft in the aorta and to minimise the risk of endoleak (type I and III). Control angiography images were obtained to check for any signs of endoleak (especially types I and III). Finally, sheaths in the femoral arteries were removed and femoral arteries were repaired with 6/0 or 7/0 propylene sutures if there was no sign of endoleak.

All cases were completed with technical success. The patients were taken into the intensive care unit (ICU) for postoperative follow-up. A total of 3000 ml of intravenous crystalloid fluid infusion over a period of 24 hours, 100 mg acetylsalicylic acid (ASA) and 150 mg clopidogrel were administered orally to all patients in

the ICU if applicable. The patients were transferred to the ward on the second postoperative day. They were discharged on the third postoperative day if no problems had occurred during the follow-up. They received a prescription for 100 mg ASA and 75 mg clopidogrel once-a-day orally.

Statistical analysis

SPSS v13 software was used for statistical analysis. The qualitative data are expressed as a percentage (%) and the quantitative data are expressed as mean ± standard deviation (SD). The distribution of the data was tested for normality with the Kolmogorov–Smirnov test. The significance of the continuous data was tested with Student's t-test if distributed normally and the Mann–Whitney U test if distributed non-normally. Categorical variables were compared with the chi-square test. A p value < 0.05 was considered to indicate statistical significance.

Results

A total of 60 patients who underwent EVAR/TEVAR procedures were evaluated. Forty-seven patients were included according to the inclusion criteria. Group 1 included 37 (78.7%) patients who had no neurological complications in the early postoperative period. Group 2 included 10 (21.3%) patients who had a postoperative neurological complication. The preoperative characteristics of the patients are presented in Table 1.

The number of EVAR cases was 30 (63.8%), the number of TEVAR cases was 11 (23.4%) and the number of combined EVAR and TEVAR cases was 6 (12.8%). There was no significant difference in the number of aortic interventions between the groups (p = 0.104). The ICU stay time was significantly longer in Group 2 than in Group 1 (1.7 ± 2.0 days in Group 1 vs 6.2 ± 5.1 days in Group 2, p = 0.021). The in-hospital stay time was longer in Group 2 but it was not statistically significant (p = 0.160). Open surgery was not needed in the study patients. The overall mortality rate was 19.1% (9 of 47 patients). The mortality rate of the Group 2 was significantly higher than Group 1 (2 of 37 [5.4%] patients in Group 1 vs 7 of 10 [70%] patients in Group 2, p = 0.001).

The mean transverse aorta diameter was 6.2 ± 0.6 cm (range 5.5–7.8 cm) in Group 1 and 6.8 ± 1.3 cm (range 5.5–9.9 cm) in Group 2 (p = 0.151). The distribution of mean transverse aortic diameters according to aortic pathologies is presented in Table 2. One patient had an arterio-venous fistula between the abdominal aorta and the inferior vena cava; the transverse diameter of the abdominal aorta was 8.5 cm in this patient.

Table 1. Preoperative data

	Group 1 (n=37)	Group 2 (n=10)	P value
Age mean ± SD	72.7 ± 11.8	74.8 ± 8.9	0.604
Male n(%)	30 (81)	7 (70)	0.461
EF mean ± SD	48.6 ± 9.5	48.3 ± 12	0.935
Triglyceride mg/dl mean ± SD	153.7 ± 72.7	158.4 ± 88.2	0.862
LDL mg/dl mean ± SD	118.2 ± 51.6	125.0 ± 70.9	0.734
Preoperative creatinine mg/dl mean ± SD	1.2 ± 0.9	1.5 ± 0.8	0.262
Preoperative white blood cell count mean ± SD	11.4 ± 7.7	8.8 ± 2.4	0.360
Preoperative arrhythmia n(%)			0.182
None	27 (72.9)	5 (50)	
AF	9 (24.3)	4 (40)	
AV block	1 (2.7)	0	
Pacemaker	0	1 (10)	
Peripheral artery disease n(%)	6 (16.2)	0	0.078
Preoperative malignancy n(%)	5 (13.5)	1 (10)	0.762
Preoperative COPD n(%)	17 (45.9)	6 (60)	0.429
Tobacco product consumption n(%)	26 (70.2)	7 (70)	0.987
Diabetes mellitus n(%)	14 (37.8)	5 (50)	0.490

SD: Standard deviation; EF: Ejection fraction (%); LDL: Low density lipoprotein; AF: Atrial fibrillation; AV block: Atrioventricular block; COPD: Chronic obstructive pulmonary disease;

Table 2. Aortic pathology and aorta diameters

	Group 1 (n=37)		Group 2 (n=10)	
	N (%)	Mean ± SD (cm)	N (%)	Mean ± SD (cm)
Abdominal aorta aneurysm	20 (54.0)	6.3 ± 0.7	2 (20)	7.3 ± 0.5
Thoracic aorta aneurysm	5 (13.5)	6.0 ± 0.4	1 (10)	6.9
Type 3 dissection	1 (2.7)	6.1	2 (20)	5.9 ± 0.6
Abdominal aorta + iliac artery aneurysm	5 (13.5)	6.1 ± 0.6	2 (20)	6.7 ± 1.2
Ruptured abdominal aorta aneurysm	1 (2.7)	6.6	0	
Ruptured thoracic aorta aneurysm	0		1 (10)	6.7
Thoracic + abdominal aorta aneurysm	2 (5.4)	5.8 ± 0.4	2 (29)	7.7 ± 3.1
Ruptured thoracic + abdominal aorta aneurysm	2 (5.4)	6.7 ± 1.2	0	
Type 3 dissection + abdominal aorta aneurysm	1 (2.7)	6.3	0	

SD: Standard deviation

Table 3. Postoperative data

		Group 1 (n=37)	Group 2 (n=10)	P value
Emergency surgery n(%)		15 (40.5)	7 (70)	0.095
ASA risk score mean ± SD		3.5 ± 0.6	4.1 ± 0.3	0.016
ES transfusion units mean ± SD		1.2 ± 2.4	1.1 ± 1.6	0.939
ICU stay time days mean ± SD		1.7 ± 2.0	6.2 ± 5.1	0.021
In-hospital stay time days mean ± SD		7.0 ± 4.0	10.1 ± 6.1	0.160
Transvers aorta diameters (cm) mean ± SD		6.2 ± 0.6	6.8 ± 1.3	0.151
Aortic pathology n(%)				0.197
	AAA	19 (51.4)	2 (20)	
	TAA	5 (13.5)	1 (10)	
	Type 3 dissection	1 (2.7)	2 (20)	
	AAA + CIAA	5 (13.5)	2 (20)	
	Ruptured AAA	1 (2.7)	0	
	Dual AAA	1 (2.7)	0	
	Ruptured TAA	0	1 (10)	
	TAA + AAA	2 (5.4)	2 (20)	
	Ruptured TAA + AAA	2 (5.4)	0	
	Type 3 dissection + AAA	1 (2.7)	0	
Aortic intervention n(%)				0.104
	EVAR	26 (70.3)	4 (40)	
	TEVAR	6 (16.2)	5 (50)	
	TEVAR + EVAR	5 (13.5)	1 (10)	
Aortic graft diameter (mm) mean ± SD		33.1 ± 5.7	33.8 ± 7.0	0.764
Aortic graft length (mm) mean ± SD		143.3 ± 48.9	147.9 ± 44.4	0.990
Femoro-femoral bypass n(%)		6 (16.2)	1 (10)	0.189
Type of endoleak n(%)				0.869
	None	28 (75.7)	7 (70)	
	Type 1	3 (8.1)	1 (10)	
	Type 2	1 (2.7)	0	
	Type 3	3 (8.1)	1 (10)	
	Type 1 + type 3	1 (2.7)	1 (10)	
	Type 1 + type 2	1 (2.7)	0	
Embolization types				0.551
	None	24 (64.9)	6 (60)	
	Arterial coil	5 (13.5)	3 (30)	
	Balloon angioplasty	4 (10.8)	1 (10)	
	Iliac artery occluder	1 (2.7)	0	
	Coil + balloon angioplasty	3 (8.1)	0	
Access site complications n(%)		7 (18.9)	2 (20)	0.930
Mortality n(%)		2 (5.4)	7 (70)	0.001

ASA: American Society of Anesthesiologists; ES: Erythrocyte suspension; SD: Standard deviation; ICU: Intensive care unit; AAA: Abdominal aortic aneurysm; TAA: Thoracic aortic aneurysm; CIAA: Common iliac artery aneurysm; EVAR: Endovascular aneurysm repair; TEVAR: Thoracic endovascular aneurysm repair.

The American Society of Anesthesiologists (ASA) physical classification score was significantly higher in Group 2 compared with Group 1 (3.5 ± 0.6 in Group 1 vs 4.1 ± 0.3 in Group 2, p = 0.016). Left carotid-subclavian artery bypass was performed in one patient after the TEVAR procedure in Group 2. Femoro-femoral bypass was performed in six (16.2%) patients in Group 1 and one patient (10%) in Group 2 (p = 0.189). Aorta-superior mesenteric artery bypass was performed in one patient who had an AAA in Group 2. Arterial coil embolisation and/or balloon angioplasty were performed according to the type of endoleak. The postoperative data are presented in Table 3. The most common early postoperative neurological complication was the lack of recovery of consciousness during the postoperative period (no postoperative consciousness). The distribution of the postoperative neurological complications is presented in Table 4.

Table 4. Type of neurological complications

	N (%)
Cognitive dysfunction	2 (4.3)
Acute cerebral ischemia	2 (4.3)
Seizures	1 (2.1)
No postoperative consciousness	5 (10.6)

Discussion

According to the results of this study, it is possible to say that early postoperative neurological complications after EVAR and/or TEVAR procedures are strongly related to in-hospital mortality.

Periprocedural ischaemic events after EVAR/TEVAR procedures are related to dislodged multiple emboli by manipulation of catheters, guidewires, large-calibre delivery sheaths, and devices in the diseased aortic wall (13,14). The main blood supply of the spinal cord comes from the vertebral, segmental and hypogastric arteries. The anterior spinal artery is formed by the branches that come off each vertebral artery before they join together to form the basilar artery. The two posterior spinal arteries are formed by the branches of the posterior cerebellar artery (PICA) or by the branches of pre-atlantal vertebral arteries. These three arteries are fed by additional arteries throughout their course at each spinal cord level through the intervertebral foramen; these vessels are called segmental arteries. These segmental arteries branch into anterior and posterior radicular arteries and spinal medullary arteries which feed anterior and posterior spinal arteries.

Extensive coverage of the aorta by endografts (15,16), perioperative hypotension (17), covering the LSA orifice (13,18), shorter native aorta segment proximal to the celiac artery (19), previous or concomitant TEVAR and EVAR (15,20) are associated with post-procedural spinal cord ischaemia and neurological complications. We performed left carotid-subclavian artery bypass in one patient with thoracic aortic pathology because the orifice of the LSA was covered by the aortic stent graft. We avoided covering a thoracic aorta segment longer than 20 cm in a single session to prevent spinal cord ischaemia and possible neurological complications.

The incidence of pelvic ischaemic complications after open infrarenal aortic surgery is about 2% but the associated mortality rate is over 40% (21,22). The ischaemic complication rate after EVAR is between 3% and 10% (23). Interruption of hypogastric arterial circulation and limb occlusion contribute to the mechanism of post-EVAR pelvic ischaemia (24). Maldonado et al. reported that colonic and spinal cord ischaemia after EVAR is associated with high post-procedural morbidity and mortality (25).

Xue et al. (26) compared the results of patients with and without spinal cord ischaemia after TEVAR and reported that post-TEVAR ICU stay and in-hospital stay times are significantly longer in patients with spinal cord ischaemia. In our study, the mean ICU stay time was significantly longer in patients who had post-procedural neurological complications (p = 0.021). The mean in-hospital stay time was also longer in these patients but it was not statistically significant (p = 0.160).

The ASA risk score is used to evaluate the patient's status, predict perioperative risk and improve patient outcomes (27). It ranges from a healthy patient (ASA I) to a brain-dead patient (ASA VI). The ASA score was significantly higher in Group 2 patients in this study. Moreover, patients of Group 2 were admitted with a more haemodynamically unstable preoperative status. We think that these factors had an additive effect on postoperative neurological adverse events and raised the in-hospital mortality rates in this group as a result.

Limitations of the study

The study was retrospective and was conducted in a single centre. The patient number was low because endovascular treatment is expensive and most of the emergent patients could not reach a health centre on time in our region. Patients with aortic disease commonly had a peripheral arterial disease such as carotid artery disease and it was difficult to find patients without preoperative cerebral ischaemic events to include in the study group.

Conclusion

The occurrence of any postoperative neurological adverse event is associated with in-hospital mortality following TEVAR and EVAR procedures. Additional studies with more patients should be conducted on this subject.

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ETHICAL DECLARATIONS

Ethics Committee Approval: It was approved by the Ethics Committee of the Zonguldak Bülent Ecevit University.

Informed Consent: The study was conducted retrospectively so no written informed consent was needed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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