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Original Article

# Outcomes of Elective Endovascular Aneurysmal Repair for Abdominal Aortic Aneurysms in Jordan

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**Purpose:** The outcomes of endovascular aneurysmal repair (EVAR) for infrarenal abdominal aortic aneurysms (AAAs) in the Middle East have rarely been reported. We analyzed the outcomes of EVAR in a Jordanian population.

**Materials and Methods:** We conducted a retrospective review of the medical records of patients with infrarenal AAA who were treated with elective EVAR between January 2004 and January 2017 at a single center in Jordan. Patient characteristics, anatomical characteristics, procedural details, and early and late postoperative outcomes were analyzed.

**Results:** A total of 288 patients (mean age, 70 years; 77.8% males) underwent EVAR for infrarenal AAA (median aneurysm size, 64 mm). Bifurcated endografts were used in 265 patients, and aorto-uni-iliac devices were used in 22 patients. Successful endograft deployment was achieved in all patients with no open conversion. Early complications included localized groin hematoma in 15, femoral artery dissection in 4, wound infection in 3, and seroma in 3 patients. With a mean follow-up of 60 months, 50 endoleaks were detected, including 9 type I, 38 type II, and 3 type III. Seven patients had unilateral graft limb occlusion. The 30-day mortality was 1.7%, and long-term mortality was 7.0%, mostly due to non-AAA-related causes.

**Conclusion:** EVAR was safely performed in Jordanian patients with minimal complications. However, long-term surveillance is important due to the risk of endoleaks and consequent intervention.

**Key Words:** Endovascular, Stent graft, Abdominal aortic aneurysm, Endoleak

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## INTRODUCTION

Abdominal aortic aneurysm (AAA) is defined as abnormal, permanent, irreversible dilatation of the abdominal aorta of more than 50% of the normal aortic diameter [1,2]. AAA is a common condition of increasing prevalence mostly among elderly males over 65 years of age [1,2]. Given that rupture is the most ominous complication of AAA, the fundamental principle underpinning the management of AAA is the prevention of rupture [1,3]. The first successful AAA open surgical repair was performed in 1950, and Parodi et al. successfully isolated an AAA by placement of a simple homemade endograft through a minimally invasive transfemoral endovascular approach in 1991 [1,4]. Recently, endovascular aneurysmal repair (EVAR) using stent grafts gained acceptance as a primary treatment for AAA and an alternative to open repair [5,6]. However, data from large registries like RETA (Registry for Endovascular Treatment of

Aneurysms) and EUROSTAR (European Collaborators Registry on Stent-graft Technique for AAA Repair) showed the need for long-term follow-up to detect complications that require secondary interventions [7,8].

To improve the outcomes and safety of EVAR, adequate planning to fit the anatomical features of each individual aneurysm, proper selection of stent grafts based on extensive knowledge of the different varieties and characteristics of endografts, and refined techniques and experiences in managing various complications after EVAR are important [2,6]. Although there have been many improvements in endovascular graft designs, late complications of endograft thrombosis, migration, endoleaks, and ruptures are not infrequent, and long-term follow-up and surveillance are important [1,7-9].

The outcomes of EVAR for AAA in the Middle East have rarely been reported. The purpose of this study was to analyze the outcomes of EVAR in Jordanian people.

## MATERIALS AND METHODS

This study was conducted in accordance with the regulations of Jordan and international standards, and approval was obtained from Royal Medical Services Human Research Ethics Committee (approval number: 10/2019). Informed consent was waived because the data were analyzed retrospectively. We reviewed the records of all patients with infrarenal AAA who were treated with elective EVAR between January 2004 and January 2017 at King Hussin Medical Center at Royal Medical Services, Amman, Jordan. Patients who were treated on an emergency basis for ruptured or symptomatic tender aneurysms (84 patients) were excluded from the study.

Early in the study period, preoperative workup included spiral computed tomography (CT) and conventional angiography with a calibrating catheter; these procedures were performed in the vascular operating rooms using C-arm imaging. After 2007, thin-slice multidetector CT angiography (CTA) was used for the aneurysm measurements and for evaluating the suitability for EVAR (Fig. 1), and EVAR was performed in the interventional angio-suite. Patients were followed-up after EVAR, and clinical examinations and CTA were scheduled on a regular basis. Earlier surveillance was done at 1, 6, and 12 months and yearly thereafter. All patients had CTA at 30 days post-procedure, and if there was an endoleak, CTA was also performed at 6 and 12 months. In cases with good component overlap and no early leak, the next CTA was performed at 12 months. All CT scans were reviewed by a senior radiologist and a vascular surgeon for proper stent positioning, patency, endoleaks, and aneurysm diameter. Duplex ultrasonography (DUS) and radiography were also conducted, especially in patients with impaired renal function, and magnetic resonance angiography was requested for patients with a negative CT scan that was suspicious for an endoleak.

**Fig. 1.** Computed tomography angiogram with reconstruction showing Infra renal abdominal aortic aneurysm.

## RESULTS

Among the 526 patients with an AAA, 288 (54.8%) underwent elective EVAR. Their mean age was 70 (range, 54-85) years, and 77.8% were males. Comorbidities included smoking in 77.8%, hypertension in 58.0%, and coronary

**Table 1.** Demographics and characteristics of all patients who underwent elective endovascular aneurysmal repair (n=288)

| Characteristic | Results |
|---|---|
| Age (y) | 70 (54-85) |
| Male sex | 224 (77.8) |
| Smoking | 224 (77.8) |
| Diabetes mellitus | 98 (34.0) |
| Hypertension | 167 (58.0) |
| Dyslipidemia | 80 (27.8) |
| Coronary artery disease | 167 (58.0) |
| Chronic obstructive pulmonary disease | 138 (47.9) |
| ASA class | |
| I | 67 (23.3) |
| II | 126 (43.8) |
| III | 61 (21.2) |
| IV | 34 (11.8) |

Values are presented as mean (range) or number (%).
ASA, American Society of Anesthesiologists.



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artery disease in 58.0% of patients (Table 1). Two hundred thirty-seven patients had asymptomatic aortic aneurysms, while 41 had vague abdominal or back pain. Ten patients presented with distal leg ischemia due to atheroembolic events.

All aneurysms were infrarenal with an average diameter of 64 (55-128) mm. Neck anatomy was mostly favorable with a mean diameter of 26 (22-32) mm and mean length of 22 (8-38) mm, and angulations were less than 60 degrees in all cases. In 8 patients, conical necks were identified, with 5 patients having necks longer than 25 mm. Necks with severe or concentric calcification and extensive thrombus were excluded. Aneurysm extension to the common iliac artery (CIA) was present in 210 patients (72.9%). Hypogastric artery involvement was present in 26 patients (9.0%) (Table 2).

EVARs were performed under spinal anesthesia in 245 patients (85.1%) and under general anesthesia in 43 patients (14.9%). The American Society of Anesthesiologists (ASA) score for risk estimation showed class III and IV in 95 patients (33.0%). An aorto-bi-iliac stent graft was used in 265 patients (92.0%). An aorto-uni-iliac graft with a femoro-femoral crossover bypass was performed in 22 patients and a straight aortic endograft in 1 patient. Coil embolization of the hypogastric artery and extension of the stent graft to the external iliac artery (EIA) was performed in 37 cases with an inadequate distal landing zone, a CIA diameter greater than 24 mm, or an accompanying hypogastric artery aneurysm. All devices were delivered through a femoral artery cut down. Deployment of the endografts was successful in all patients with no immediate open conversion.

Different stent-graft devices included Endurant and Talent in 219 and 52 cases, respectively (Medtronic, Santa Rosa, CA, USA), Zenith in 11 (Cook Inc., Bloomington, IN, USA), Excluder in 3 (Gore, Flagstaff, AZ, USA), and TREO in 3 cases (Bolton Medical, Sunrise, FL, USA). Six patients with ASA class IV required admission to the intensive care unit. The median hospital stay after EVAR was 4 (range, 3-8) days. The average procedure time was 50 (range, 30-120) minutes, with a blood loss of approximately 150 mL. The amount of contrast used was 120±40 mL on average.

The mean follow-up period was 60 (30-120) months with 12 patients (4.2%) lost to follow-up. Early outcome analysis included procedural complications, endoleaks, and 30-day mortality (Table 3). Procedural complications at the access site included dissection with occlusion of the right common femoral artery in 4 cases. Interposition grafts with 8 mm expanded polytetrafluoroethylene were performed, and pedal pulses were regained. Furthermore, 15 patients had a small hematoma; 3, a superficial wound infection; and 3, a wound seroma, all of which were treated conservatively. The 30-day mortality was 1.7%, and the causes of 5 deaths were myocardial infarctions in 3, a mesenteric ischemia in 1, and a pulmonary embolism in 1 patient.

Regarding endoleaks, 50 cases were diagnosed: type Ia in 3, Ib endoleak in 6 (3 with limb migration), type II in 38, and type III in 3 patients. All 3 cases of type Ia endoleaks were diagnosed on the completion angiogram and treated promptly with additional ballooning. A proximal extension

**Table 2.** Anatomical characteristics of the abdominal aortic aneurysms and the procedural details (n=288)

| Characteristic | Result |
|---|---|
| AAA diameter (mm) | 64 (55-128) |
| Neck diameter (mm) | 26 (22-32) |
| Neck length (mm) | 22 (8-38) |
| Common iliac artery aneurysm | 210 (72.9) |
| Unilateral aneurysm | 171 (59.4) |
| Bilateral aneurysm | 39 (13.5) |
| Diameter (mm) | 21 (18-32) |
| Hypogastric artery aneurysm | 26 (9.0) |
| Unilateral aneurysm | 21 (7.3) |
| Bilateral aneurysm | 5 (1.7) |
| Diameter (mm) | 20 (16-24) |
| Aorto-bi-iliac stent graft | 265 (92.0) |
| Aorto-uni-iliac stent graft | 22 (7.6) |
| Straight stent graft | 1 (0.3) |
| Hypogastric coiling and external iliac artery extension | 37 (12.8) |

Values are presented as mean (range) or number (%).
AAA, abdominal aortic aneurysm.

**Table 3.** Early and late complications of endovascular aneurysmal repair (n=288)

| Complication | Results |
|---|---|
| Groin hematoma | 15 |
| Stent graft thrombosis | 7 |
| Common femoral artery dissection | 4 |
| Graft infection | 4 |
| Wound infection | 3 |
| Wound seroma | 3 |
| Endoleak type | |
| Ia | 3 |
| Ib | 6 |
| II | 38 |
| III | 3 |
| 30-day mortality | 5 (1.7) |
| Overall mortality | 24 (8.3) |

Values are presented as number only or number (%).

cuff was applied in 2 cases. No late type Ia endoleak was reported. Among the 6 patients with type Ib endoleak, 3 demonstrated proximal migration of an iliac limb with an obvious leak and sac expansion on follow-up CTA. All type Ib endoleaks were treated using hypogastric artery embolization and an extension endograft to the EIA. All of these patients had an initial CIA diameter of more than 18 mm, where flared grafts were used. Three type IIIa endoleaks due to junctional separation of the modular component were diagnosed (Fig. 2). Two were treated with iliac limb extension, and one was treated with an aorto-uni-iliac stent graft and femoro-femoral bypass. These were cases with early designed stents in which the overlapping zones of the junctions were quite short.

Type II endoleaks were detected in 38 cases, early or late after EVAR, and close follow-up with CTA or DUS was conducted. Spontaneous resolution was observed in 28 patients within 9 (range, 6-12) months. A sac expansion was observed in 3 patients, and coil embolization of the proximal inferior mesenteric artery and the sac was accomplished through selective cannulation of the superior mesenteric artery (Fig. 3). Follow-up CTA expressed complete sac thrombosis and a decrease in its diameter with none of the patients requiring a late open conversion procedure. The remaining 7 cases were stationary in size and are still being closely followed.

Seven patients presented with acute unilateral lower limb ischemia due to graft limb thrombosis confirmed by CTA. Two patients were treated with an overnight thrombolysis and stenting, while in the remaining 5 patients, a femoro-femoral bypass graft was performed because the limb was critically ischemic. In all of these patients, concomitant iliac artery stenosis was observed, and balloon angioplasty was performed just before the graft was deployed.

Four patients had a graft infection. The mean time from the procedure to presentation was 4 years (26-60 months). Three patients had diffuse abdominal pain, fever, and leukocytosis, and CTA revealed expansion of the sac and the presence of gas collection. The fourth patient presented to the emergency department with abrupt gastrointestinal bleeding 4 years after EVAR. An aorto-enteric fistula was diagnosed, and his instability mandated emergent surgery. He had been on a regular annual follow-up schedule without any abnormality. All patients with an infected EVAR underwent total explantation of the stent graft, debridement, over-sewing of the aorta, and an extra-anatomic axillobifemoral bypass. Two patients tolerated the procedure and continued their follow-up plan.

Long-term mortality was 7.0%, and 19 patients died during follow-up, including 3 patients with aneurysm-related deaths due to graft infection and 1 case of rupture. The remaining deaths were due to non-AAA-related causes, with the majority being cardiac, respiratory, and renal. The overall mortality of elective EVAR was 8.3% (24 patients).

## DISCUSSION

AAA rupture is the third leading cause of cardiovascular death following coronary disease and stroke [10,11]. EVAR has been introduced as a minimally invasive endovascular procedure that involves the placement of a stent graft to exclude the aortic aneurysm from the arterial circulation and systemic pressure [2,9]. Since Parodi et al. [4] published the first case, EVAR has been considered a revolutionary

**Fig. 2.** Type III endoleak with displacement of the extension limb (arrow).

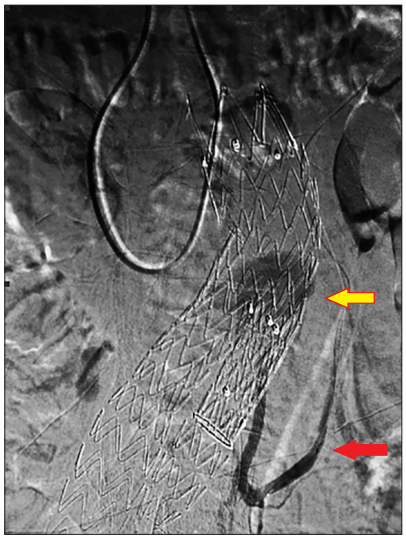

**Fig. 3.** Type II endoleak with inferior mesenteric artery (lower arrow) filling the aortic sac (upper arrow).



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development in vascular surgery [10]. The techniques of EVAR and the inventory of new devices have progressed rapidly to overcome the early device failure [12,13].

At our center, EVAR was performed in carefully selected cases according to the recommendations. As recommended, unfavorable necks including short neck length, severe proximal or distal angulations, severe calcifications, or the presence of thrombus in the neck were frequently excluded [4,11,14]. Furthermore, there is a learning curve in acquiring the skills necessary to adopt new endovascular technologies, and skilled experience will result in superior outcomes [12,15]. In our series, the operating time, amount of contrast, and blood products used improved remarkably over time. Being familiar with the same device and using it whenever anatomically suitable will again improve the outcomes and lessen the learning curve, although this may not reveal the advantages of each stent graft per se [6,16]. Aorto-bi-iliac endografts were used in most patients (92.0%), similar to other reports [2,15-17]. For patients with iliac stenosis, predilatation was performed. If dilatation failed or in cases with unilateral iliac artery occlusion, aorto-uni-iliac endografts were used [15,17].

As previously reported, approximately 20% of AAAs extend beyond the iliac artery bifurcation [16,17]. In these cases, exclusion of the hypogastric artery with extension of the graft limb into the EIA was the most common treatment of choice in 37 patients [16,18,19]. The hypogastric artery was occluded using coils at the beginning of the procedure. In contrast to other series, none of our patients complained of buttock claudication or erectile dysfunction [18,20]. To prevent pelvic ischemia when both iliac arteries were involved, iliac bifurcated devices have been reported to be useful [21].

Despite successful deployment in all patients, 50 patients (22%) showed endoleaks at the end of the procedure or during follow-up. Type Ia endoleaks were noticed in 2 patients with a conical neck and in 1 patient with an eccentric mural thrombus, which caused suboptimal placement and apposition of endografts. Type Ib endoleaks were more frequent in cases with a large initial CIA diameter. Endograft extension to the EIA should be considered in those cases. To detect any endoleaks, long-term follow-up is mandatory [15,22,23].

Current guidelines suggest that a conservative approach is appropriate for isolated type II endoleaks without sac expansion [24,25]. Intervention is recommended when there is a sac enlargement of more than 10 mm [24,25]. In this series, most type II endoleaks resolved spontaneously, and only 3 patients required intervention. Nevertheless, secondary interventions for type II endoleaks are often unsatisfactory as recurrence is common, and long-term follow-up is also mandatory [24,25].

The incidence of graft infection after EVAR has been reported in less than 1.0% of patients [26,27]. Management included conservative treatment with antimicrobial therapy in cases where there was no immediate danger to the patient's life and percutaneous drainage in the presence of infection in the cavity, especially in patients with multiple comorbidities [26,27]. In patients with active gastrointestinal bleeding and sepsis, emergent surgery remains the treatment of choice [26,27].

Originally, although EVAR was considered for patients unfit for major open repair, it has been increasingly used also for patients fit for major surgery [13,28]. The 30-day mortality rates of randomized trials have been reported to be approximately 3.0%. Our series showed a 1.7% 30-day mortality rate and a 7.0% long-term mortality rate, most of which were not related to AAA [6,17]. Following current guidelines, follow-up with CTA was done paying special attention to aneurysm size progression and endoleaks [29,30]. However, because of concerns of repeated exposure to radiation and nephrotoxic contrast, we started to include DUS surveillance during long-term follow-up. Some studies have reported that DUS showed similar detection of endoleaks as CT as well as a lower cost and avoidance of the ionizing radiation and contrast [10,12,30].

## CONCLUSION

EVAR was safely performed in Jordanian patients with minimal complications. However, long-term surveillance is important due to the risk of endoleaks and consequent intervention.

## CONFLICTS OF INTEREST

The authors have nothing to disclose.

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## AUTHOR CONTRIBUTIONS

Analysis and interpretation: MJ, JS. Data collection: KEJ, MAR. Writing the article: MAR. Critical revision of the article: KEJ, MJ. Final approval of the article: KEJ, HH. Statistical analysis: KEJ. Overall responsibility: KEJ.

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