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# Emergent Endovascular Repair of Ruptured Abdominal and Thoracic Aortic Aneurysms in a Single Center: Midterm Outcomes

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**Rezumat**

***Proceduri reparatorii endovasculare pentru anevrisme aortice abdominale şi toracice cu un singur centru de ruptură: rezultate postoperatorii***

*Obiectiv:* Terapiile endovasculare ar putea oferi avantaje în sindroamele aortice acute. În acest studiu, ne prezentăm experienţa legată de abordurile reparatorii endovasculare, atât pentru anevrismele aortice toracice, cât şi pentru cele abdominale şi raportăm rezultatele observate în perioada de urmărire postoperatorie înainte de externarea pacientului şi până la 36 de luni după externare.
*Metode:* Au fost înregistrate prospectiv datele de la pacienţii (n=96) trataţi prin proceduri endovasculare între 2004 şi 2012, iar rezultatele din perioada de urmărire postoperatorie în urma intervenţiilor de urgenţă (e - emergency) pentru rupturile aortice abdominale (EVAR – endovascular aortic repair), cât şi pentru cele toracice (TEVAR – thoracic endovascular aortic repair) (n=20) au fost analizate retrospectiv.
*Rezultate:* Vârsta medie a fost 65 ± 11 ani (interval 27-77 ani), iar 18 dintre pacienţi (90%) aparţin sexului masculin. Durata medie de urmărire postoperatorie a fost 28 ± 21.2 luni (interval 1-57). Treisprezece pacienţi au fost trataţi prin eEVAR (65%) şi 7 prin eTEVAR (35%). Un pacient cu ruptură de anevrism la nivelul arcului aortic a fost tratat prin procedură hibridă (eTEVAR + debranching). Rata mortalităţii în spital a fost 20% (n=4) pentru toate cazurile, 23.0% (n=3) pentru grupul tratat prin eEVAR şi 14.2% (n=1) pentru grupul tratat prin eTEVAR. În perioada de urmărire postoperatorie, pentru 3 pacienţi (15.0%) au fost necesare reintervenţii.
*Discuţii:* Necesitatea reintervenţiilor şi a controalelor la scurte perioade de timp constituie dezavantajele procedurilor endovasculare. Totuşi, considerăm utilizarea procedurilor eEVAR şi eTEVAR în cazurile acute de ruptură aortică ca fiind opţiuni valoroase şi salvatoare pentru pacienţii cu o anatomie adecvată.

**Cuvinte cheie:** sindroame aortice acute, tratament endovascular

**Abstract**

*Objective:* Endovascular therapies may offer distinct advantages in acute aortic syndromes. In this paper, we present our experience with emergent endovascular repair of both abdominal and thoracic aortic ruptures and report early and midterm outcomes.
*Methods:* Data from all patients (n=96) who were treated by endovascular procedures between 2004 to 2012 were prospectively collected and early-midterm outcomes of the emergency (e) interventions for both abdominal (EVAR) and thoracic (TEVAR) aortic ruptures (n=20) were retrospectively analysed.

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*Results:* The mean age was 65±11 years (range: 27-77 years) and 18 patients (90%) were male. Mean follow-up duration was 28 ± 21.2 months (range=1-57). Thirteen patients were treated by eEVAR (65%) and 7 by eTEVAR (35%). One patient who had a rupture of the aneurysm at arcus aorta level was treated by hybrid procedure (eTEVAR+ debranching). The hospital mortality rate was 20% (n=4) for all cases, 23.0% (n=3) for eEVAR and 14.2% (n=1) for eTEVAR. In the follow-up period, 3 patients (15.0%) had reinterventions.
*Discussion:* Reinterventions and the necessity of close follow-up are the disadvantages of endovascular procedures. Even if that is the case, we believe that eEVAR/eTEVAR in the acute setting of ruptured aorta in patients with suitable anatomy is a lifesaving option.

**Key words:** acute aortic syndromes, endovascular treatment

## Background

Acute aortic syndromes including aortic rupture still remain life threatening and represent a unique area in cardiovascular surgery, where application of the general concept of "door-to-balloon time" would be beneficial (1,2). Despite significant advances in surgical techniques, perioperative adjuncts, and critical care, the traditional open repair of acute rupture of aortic aneurysms remains a formidable challenge and is still associated with high morbidity and mortality rates. Endovascular therapies may offer distinct advantages in these situations. In this paper, we present our experience with emergent endovascular repair of both abdominal (EVAR) and thoracic (TEVAR) aortic ruptures and report early and midterm outcomes.

## Methods

Data from all patients (n=96) who were treated by endovascular procedures between 2004 and 2012 were prospectively collected and the emergency (e) interventions (n=20, 21%) with eEVAR or eTEVAR for ruptured thoracic or abdominal aorta retrospectively analysed. The diagnosis was set by computed tomography (CT) in all cases. All patients were submitted to operation within 6 hours from admission to emergency service. An acute abdominal aortic aneurysm (AAA) was only classified as ruptured in the presence of a retroperitoneal hematoma on the preoperative CT-scan. Principally, if anatomically suitable, all patients presenting with ruptured (r) AAA or rupture of the descending aorta were primarily considered as potential candidates for stent graft deployment. Anatomical suitability was defined as a proximal neck length >15 mm with <60° angulation and access vessels large enough to accommodate the introducer sheaths. Acute surgical emergencies involving the descending thoracic aorta such as traumatic aortic disruption or acute complicated Type B dissection were excluded. Patients with symptomatic or rapidly expanding, but not ruptured, descending thoracic aneurysms were also excluded. One patient who had medical and mechanical cardiopulmonary resuscitation (CPR) before and after arrival to the emergency department, but who was hemodynamically stable was also included in the study.

Evaluation and decision for eEVAR or eTEVAR was left to the discretion of the attending cardiovascular surgeon directly following CT-scan. A fully equipped operating room with a mobile C-arm imaging system trained operating staff with endovascular experience were permanently available. Graft placement was performed in this hybrid operating theatre under general or local-regional anesthesia using limited femoral surgical approach.

According to our policy follow-up after EVAR or TEVAR was scheduled at the outpatient clinic initially at two weeks postoperatively and if the patient had no suspected pathology, contrast enhanced CT scan was performed at 6 and 12 months yearly after.

Contrast enhanced axial CT demonstrates a ruptured thoracic aorta expanding into the left lung (*Fig. 1*) and post repair sagittal CT plane shows a covered thoracic aorta in the same patient (*Fig. 2*).

## Results

Demographics and comorbidities for the groups of eEVAR and eTEVAR are listed in *Table 1*. The mean age was 65±11 years (range: 27-77 years) and 18 patients (90%) were male. According to ASA classification (American Society of Anesthesiologists), 8 patients were in class IV and, 12 were in class V. Thirteen patients had abdominal and 7 patients had thoracic aortic rupture and 13 patients were treated by eEVAR (65%), 7 by eTEVAR (35%). One patient who had a rupture of the aneurysm at arcus aorta level was treated by hybrid procedure (eTEVAR+ debranching). All types of procedures and reinterventions are presented in *Table 2* and the

***Figure 1.*** *Contrast enhanced axial CT demonstrates ruptured thoracic aorta expanding into the left lung*

***Figure 2.*** *Sagittal CT plane shows covered ruptured thoracic aorta*

***Table 1.*** *The demographics of patients*

| Demographics | n | % |
|---|---|---|
| Male | 18 | 90 |
| Hypertension | 15 | 75 |
| Diabetes | 3 | 15 |
| Chronic pulmonary disease | 8 | 40 |
| Coronary artery disease | 4 | 20 |
| Chronic renal failure | 1 | 5 |
| Peripheral vascular disease | 2 | 10 |

***Table 2.*** *The types of procedures*

| Procedure | n | % |
|---|---|---|
| EVAR | | |
| Aorta Bi-iliac | 3 | 15.0 |
| Aorta Uni-iliac, fem-fem by-pass | 10 | 50.0 |
| TEVAR | | |
| Thoracic | 6 | 30.0 |
| Arcus+debranching | 1 | 5.0 |
| Totally | 20 | 100 |

***Table 3.*** *The characteristics of aneurysms in patients with rAAA*

| | Min. | Max. | Mean | St. |
|---|---|---|---|---|
| Diameter of aneurysm (mm) | 63 | 103 | 83.2 | 13.0 |
| Length of aneurysm (mm) | 110 | 180 | 126 | 26.6 |
| The length of neck (mm) | 8 | 45 | 18.8 | 13.2 |

characteristics of the aneurysm in patients with rAAA are presented in *Table 3*.

Technical success was achieved in all cases (100%). Aorto-uni iliac (AUI) endograft was preferred and combined with femoro-femoral crossover bypass and occlusion of the contralateral iliac artery in 10 patients (50 %).

The hospital mortality rate was 20% (n=4) for all cases, 23.0% (n=3) for eEVAR and 14.2% (n=1) for eTEVAR group. In one patient, acute monoparesis of left lower extremity was observed following repair of ruptured AAA.

Mean follow-up duration was 28±21.2 months (range= 1-57). One mortality related to lung cancer was observed in patients who were discharged from the hospital. During follow-up period, 3 patients (15.0%) had reintervention. Two of them needed re-reintervention and all were treated by restenting. The demographics of patients who have undergone reinterventions were listed in *Table 4*.

For statistical analysis baseline characteristics are reported as mean (±SD) and median for continuous variables, and number (percentage) for categorical variables.

## Discussion

Acute aortic syndromes require rapid intervention to obtain satisfactory outcomes. Recently, related to high mortality risk there are some centers organized to establish acute aortic treatment centers based on a clinical care pathway that expedites the care of acute aortic syndromes (2). Those hospitals provide a rapid response service infrastructure that was created to shorten the way to operation, to promote rapid intervention and provide effective management within the golden hours.

Emergency interventions for aortic rupture are still present with a high mortality rate (1). The mortality rate of the conventional open repair of (r) AAA has not improved significantly during the last 50 years and remains around 50 % (3). Ruptured thoracic aortic aneurysm occurs less frequently than rAAA; however, of the patients who do survive transport to a hospital, overall mortality rates may approach 97% (4,5). The rapid development of diagnostic modalities and EVAR or TEVAR within the realm of aortic

***Table 4.*** *The demographics of patients who required reintervention*

| Patient | Age, Sex | Primary Pathology | Primary Procedure | Type of Complication/Treatment | Re-reintervention/Treatment |
|---|---|---|---|---|---|
| 1 | 60,M | rAAA | AUI+fem-fem by-pass | Type Ia Endoleak/Stenting | Type Ib Endoleak/Stenting |
| 2 | 59,M | rAAA | ABI | Type Ia Endoleak/Stenting | Retrograde Type B Dissection/Stenting |
| 3 | 67,M | rAAA | AUI+fem-fem by-pass | Type III Endoleak/Stenting | No re-intervention |

rAAA: ruptured Abdominal Aortic Aneurysm; AUI: Aorta Uni-iliac endovascular grafting; ABI: Aorta Bi-iliac endovascular grafting

surgery has transformed the field and broadened the spectrum of patients that can be treated with minimally invasive techniques. However, to date, there are no large randomized controlled trials comparing the long term outcomes and efficacy of eEVAR/eTEVAR to traditional open repair.

According to our cohort, all patients were in ASA IV and V and hospital mortality rate was 23.0% for eEVAR and 14.2% for eTEVAR group. One of our patients had CPR before the procedure and died postoperatively. This issue brings forth the discussion that patients who had CPR before arriving to the hospital, in the emergency department or during the intervention and remain with hemodynamic instability, may not benefit from endovascular procedures. Efficient CPR may not be possible for appropriate catheter intervention and suitable graft deployment under fluoroscopy and this group of patients with hemodynamic instability may benefit from open surgery. However, even in such situations, or if the anatomy is not suitable for endovascular techniques, or in case of the absence of the endovascular experienced team, endoballoon occlusion of the abdominal or thoracic aorta to stabilize the hemodynamic conditions under fluoroscopic guidance followed by open technique may be another option and may prove lifesaving. For this reason we advocate the availability of endoballoon occlusion catheters and also the availability of three sizes of endografts on the shelf (24, 28 and 32 mm) with their extensions and iliac occluders.

In the setting of ruptured aortic aneurysm, patients who survive the initial event and present to an emergency room are often in profound circulatory shock due to hemorrhage. The subsequent mortality rate of patients who do survive the initial repair approaches 50% due to the "second hit" of systemic inflammatory response syndrome, which can later progress to sequential organ failure and multiple organ dysfunction syndrome (5). Additionally, substantial hypothermia due to prolonged periods of laparotomy, and coagulopathy due to massive transfusion also exacerbate the systemic inflammatory response (5-8). Endovascular approach may decrease the reperfusion injury by maintaining the distal circulation during the procedure. EVAR/TEVAR decrease the operational stress and inflammatory response by decreasing the duration of the operation.

In view of the still poor results of open surgery, some authors do believe that endovascular interventions will likely become the gold standard for the treatment of ruptured aorta (9). However, we believe that patient selection plays an overly important role to be able to compare both techniques properly. Anatomical suitability is crucial for endovascular intervention and it is determined by CT according to guidelines for elective EVAR. However, with increasing experience and evolving endovascular technology the indications were forced and the patients with more peculiar anatomy or pathology or with very high risk of open operation were also accepted for intervention.

rAAAs represent end-stage disease and are therefore associated with more difficult anatomy. This may result in lower suitability and, because of angulation, in more difficult access and deployment of the graft. This additional technical challenge in emergency situations could lead to less-than-optimal positioning and subsequent results. A recently published article by Hechelhammer et al which was assessing the outcome of eEVAR in a tertiary referral center demonstrated an increased cumulative secondary intervention risk in eEVAR compared with a large elective EVAR series from the literature (10). In our series, at the midterm follow-up, 3 patients underwent re-intervention and 2 of them needed re-reintervention. In one patient, type Ib endoleak was observed 24 months following type Ia endoleak and both were repaired with extension stents. Most probably the type Ia endoleak was related to short neck diameter (8 mm), which is of particular significance in endoleaks originating at the proximal aortic attachment site, where the level of the renal artery ostia may be a significantly limiting factor. The other patient, with Type III endoleak, was salvaged endovascularly by relining the stent graft, because the seal zone was intact. It is essential to characterize the site of failure to correct it. If the endoleak is junctional, then simply placing a limb to bridge the leak typically solves the problem as it was the case in our patient. If, however, the problem with device integrity is in the body of the graft, then the entire device needs to be excluded, usually requiring an AUI device with a fem-fem by-pass, because a second bifurcated device cannot be placed inside the first (11).

Hybrid surgical-endovascular reconstructive and debranching bypass procedures have been performed to create proximal and distal endograft fixation and aneurysm exclusion. Many thoracic aortic lesions are close to or involve the left subclavian artery (SCA), requiring coverage of the origin of this vessel by the endograft. Recent experience has suggested that expectant management of left SCA coverage is acceptable, with some exceptions. SCA, with or without revascularization, extends the proximal landing zone and thereby allows endograft exclusion of these more proximal thoracic lesions (12). On the other hand, despite some potential drawback of using an extra-anatomic bypass, deployment of an AUI stent graft device is still being used for the treatment of abdominal aortic aneurysms in different and complicated circumstances, such as presence of narrow terminal aorta, small diameter, tortuous, kinked, calcified or even occluded contralateral iliac artery, presence of common iliac aneurysm, treatment of rAAA, management of endoleaks of previous implanted endoprosthesis. In a study by Hinchliffe, cumulative 3- year patency rate for the femoral-femoral bypass graft was 91%. At the end of 5 years 83% of grafts remained patent. The authors outlined that femoral-femoral bypass graft used during EVAR with AUI stent grafts offers encouraging medium and long-term patency (13).

Spinal cord ischemia following intervention on the abdominal aorta is a rare and unpredictable event that is attributed to variations in the spinal cord blood supply (14). It is more or less attributed to the endovascular therapy related to maintaining of the distal circulation during the procedure. In one of our patients, acute left sided monoparesis was observed following eEVAR. Although the pathogenesis is most likely multifactorial, interruption of the hypogastric artery inflow via the endovascular prosthesis may have had the major influence.

As a conclusion, regarding durability, the question concerning whether to leave a stent in a patient's aorta for decades or not still has no clear answer. Reinterventions and the necessity of close follow-up are the disadvantages of endovascular procedures. Even if that is the case, we believe that eEVAR/eTEVAR in the acute setting of ruptured aorta in patients with suitable anatomy is the most valued option.

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