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Open repair of juxtarenal aortic aneurysms: 10-years of experience in a single center

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ABSTRACT

Objectives: This study aims to evaluate the long-term surgical outcomes of juxtarenal aortic aneurysms (JAAs).

Patients and methods: We retrospectively analyzed a total of 21 consecutive patients (20 males, 1 female; mean age 64.8±11.8 years; range, 31 to 80 years) who underwent open repair of JAAs using a suprarenal clamp between May 2009 and May 2019. Data including baseline demographic and clinical characteristics of the patients, preoperative risk factors, radiographic images, and postoperative data were recorded.

Results: Of all patients, six had a failed endograft. The median time to the completion of surgery was 286 (range, 192 to 628) min and the median renal ischemia time was 42 (range, 20 to 82) min. Renal artery endarterectomy (n=5), reimplantation (n=2), and an extension graft interposition (n=2) were the additional procedures to ensure kidney perfusion. During a follow-up of 48 months, six patients required dialysis and three were permanent, and the overall mortality rate was 33.3%.

Conclusion: The results of JAA repair become steadily worsened due to the changes in the rate and severity of constitutional risk factors during the last decade. The increasing number of failed endovascular procedures increases the need for a suprarenal clamp. Therefore, failed endograft should be considered an etiological factor and a risk factor for the open repair of JAAs currently.

Keywords: Abdominal aortic aneurysm, dialysis, renal artery, surgery.

As the endovascular methods have been used extensively for the repair of infrarenal abdominal aortic aneurysms (AAAs), surgical procedures have been limited to only complicated aneurysms.[1,2] One of the complicated aneurysms which limit the use of endovascular procedures is juxtarenal aneurysms (JAAs) with a hostile neck having the risk for renal artery compromise (Figure 1a, b).[3-5] Open repair of a JAA requires a cross-clamp at the suprarenal level, and there may be a risk for postoperative renal dysfunction. Some reports have suggested that the need for dialysis after JAA surgery is about 3.3%, and newly developed kidney injury is associated with a higher mortality.[6] It is, therefore, important to identify and prevent different causes of renal dysfunction.

In the present study, we aimed to evaluate the long-term surgical outcomes of JAAs and to identify perioperative risk factors affecting the results of the open repair of JAAs.

PATIENTS AND METHODS

In this study, we retrospectively analyzed a total of 21 consecutive patients (20 males, 1 female; mean age 64.8±11.8 years; range, 31 to 80 years) who underwent open repair of JAAs using a suprarenal clamp at Gaziantep University, Faculty of Medicine, Department of Cardiovascular Surgery between May 2009 and May 2019. A JAA was defined as an AAA which extended to the origin of the renal arteries and required clamping of the aorta above one or both renal arteries due to either the absence of a proximal neck or an endovascular stent/stent-graft endangering infrarenal clamping. Data collection was performed by scanning the electronic surgical records of patients

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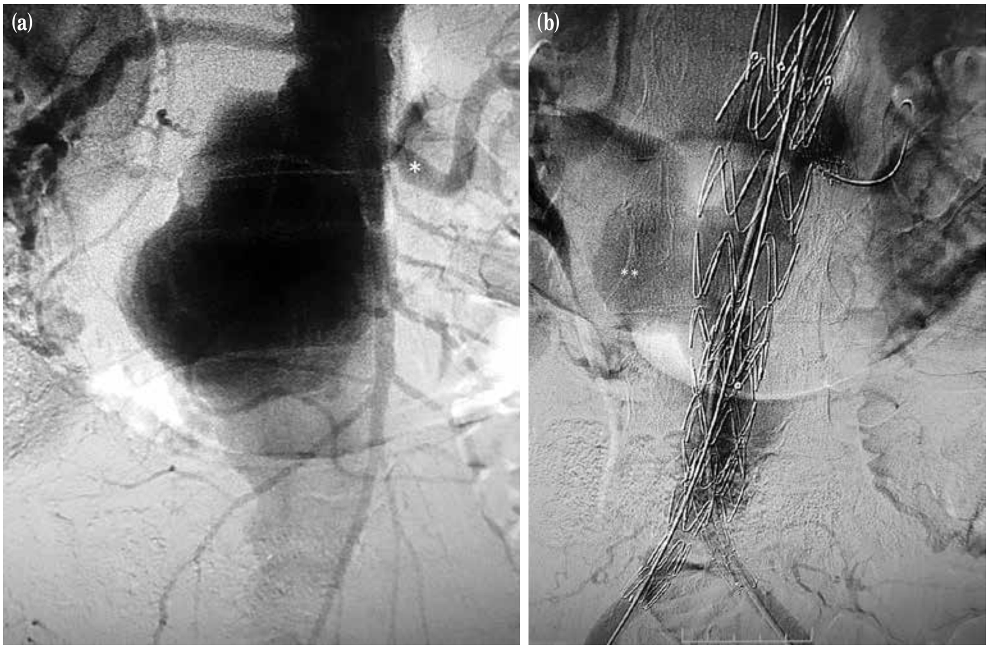

Figure 1. An example of an unsuccessful chimney-endovascular aneurysm repair. A low-rising right renal artery (*) originates from aneurysm wall **(a)**. Final radiographic image **(b)** shows a type 1 endoleak (**) even after serial ballooning of proximal endograft. EVAR: endovascular aneurysm repair.

hospitalized for an AAA. The demographic data, perioperative, and follow-up data of the patients who required aortic clamp proximal to the renal artery were recorded for the study. A written informed consent was obtained from each patient. The study protocol was approved by the Gaziantep University Şahinbey Research and Application Hospital Ethics Committee (2019/431). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Preoperative variables, operative measures, and postoperative variables

The patients followed by the nephrology department due to steadily high serum creatinine levels (above 2.5 mg/dL) or those on maintenance dialysis were considered as chronic renal failure. Coronary artery disease was defined as having the diagnosis with previous coronary angiography or coronary artery bypass graft surgery. Chronic obstructive pulmonary disease, diabetes, hypertension, previous peripheral vascular procedures (surgical and endovascular), and cerebrovascular disease (transient ischemic attacks, or carotid artery intervention) were extracted from the computerized database with the patients' demographics. Besides, we used the radiographic images to assess the maximum diameter of the aneurysm and anatomic considerations for the suprarenal clamping.

All patients were operated under general anesthesia and through a median laparotomy. The bolus dose of heparin (100 to 150 U/kg) was administered after dissecting retroperitoneal tissue and renal arteries. The supra-/interrenal clamp was placed accordingly at a single attempt, followed by distal clamping at the level of iliac arteries. The aneurysm was opened longitudinally, stent graft was removed if present, and bleeding from the origins of lumbar arteries were controlled by sewing with silk sutures. The aorta was transected just distal to the clamp, while leaving a skirt for anastomosis. Freeing of the renal artery origin from the aneurysmal segment, renal artery endarterectomy, removal of renal artery stent, or a graft anastomosis to extend the renal artery to the midline in selected cases were done at this stage, if needed (Figure 2). Each renal artery was perfused immediately with a cold crystalloid solution (20 g mannitol / 1,000 mL lactated Ringer's solution). The proximal end of the graft was anastomosed to the aortic skirt using 3/0 prolene suture as quickly as possible and the proximal clamp was, then, transferred onto the graft. The anastomosis of the free end of the renal artery or the extension graft was performed with a side-clamp. Cold crystalloid perfusion for renoprotection was used in every 15 min throughout the suprarenal clamping. We finished arterial reconstruction by performing anastomosis the distal part(s) of the graft to the distal aorta, iliac or

Figure 2. Right renal artery injury during removal of a stent was extended onto aortic graft using an 8-mm Dacron graft (*).

common femoral arteries. Inferior mesenteric artery anastomosis to new aorta was performed, only if sufficient retrograde bleeding was present, and was ligated, otherwise.

Intraoperative variables included renal ischemia time, duration of operation, additional renal artery procedures (i.e., reimplantation, extension graft, endarterectomy), type of aortic reconstruction (i.e., tubular graft, aorto-biiliac or aorto-bifemoral bypass), and level of aortic clamping (suprarenal or interrenal).

The primary outcome measure was mortality, until the last control visit, and the secondary measure was the need for dialysis. Postoperative evaluations included extubation time, and the length of intensive care unit (ICU) and hospital stay.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 20.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were expressed in mean ± standard deviation (SD) and median (min-max), while categorical variables were expressed in number and frequency. The continuous variables with a normal distribution were assessed using the Shapiro-Wilk test. The mean survival time after index surgery was estimated using the Kaplan-Meier survival analysis (95% confidence interval [CI]). A *p* value of <0.05 was considered statistically significant.

RESULTS

In all patients, the mean size of JAAs treated in our department over 10 years was 6.3±1.1 cm. Failed or unsuccessful endovascular AAA repair

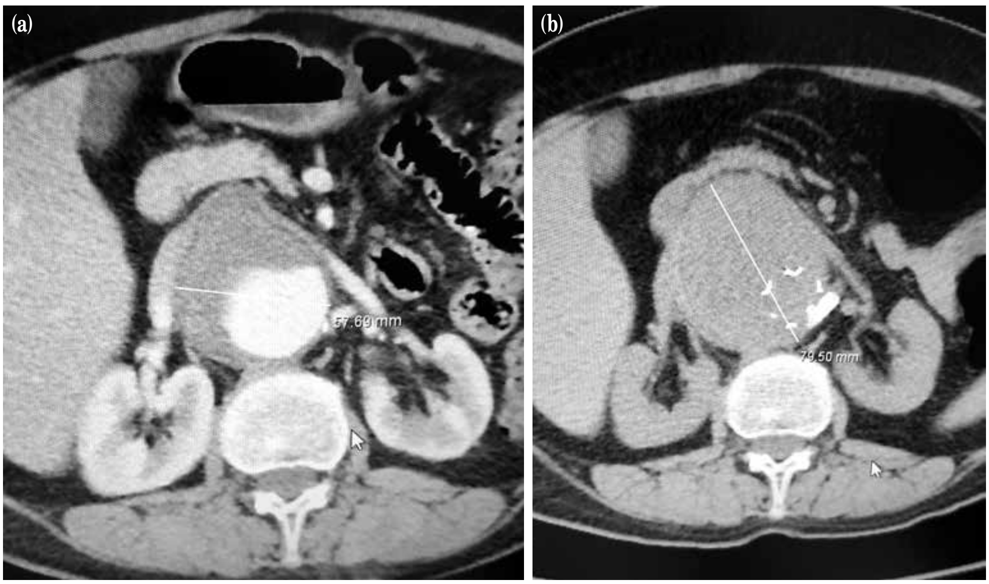

Figure 3. The maximum diameter of an aortic aneurysm measured at same the level (middle of both kidneys) before **(a)** and six months after EVAR **(b)** in a patient with chronic renal failure.
EVAR: Endovascular aneurysm repair.

Table 1. Baseline demographic and clinical characteristics of patients

	n	%	Mean±SD	Median	Min-Max
Age (year)			64.8±11.8		
Gender					
Male	20	95.2			
Female	1	4.8			
Body mass index (kg/m^2)			25.8±2.1		
Diabetes	9	42.9			
Hypertension	16	76.2			
Hyperlipidemia	8	38.1			
Chronic obstructive pulmonary disease	12	57.1			
Coronary artery disease	11	62.4			
Coronary stent	1	4.8			
Coronary bypass surgery	3	14.3			
Ruptured juxtarenal abdominal aortic aneurysm	3	14.3			
Renal insufficiency	3	14.3			
Previous vascular procedures					
Endovascular abdominal aortic repair	6	28.6			
Thoracic endovascular aortic repair	1	4.8			
Femoral-femoral bypass	1	4.8			
Femoral-popliteal bypass	2	9.5			
Carotid stent	2	9.5			
Serum creatinine (mg/dL)				1.0	0.6-5.4

SD: Standard deviation; Min: Minimum; Max: Maximum.

(EVAR; Figures 1a, b and 3a, b) with ongoing symptoms was present in six patients (28.6%). Baseline demographics and comorbidities of the patients are shown in Table 1.

Table 2 shows the operative variables. All patients were operated through a median laparotomy and the median time to the completion of surgery was 286 (range, 192 to 628) min and the median renal ischemia time was 42 (range, 20 to 82) min. A tube graft was used in three patients (14.3%), while a bifurcated graft was implanted in 18 patients (85.7%): an aorto-biiliac graft and aorto-bifemoral graft in 16 (76.2%) and 2 (9.5%) patients, respectively. Seventeen patients (81%) were subjected to simple clamping at the suprarenal aorta; however, in four patients (19%), the aortic clamp was between the renal arteries originating from different levels (Table 3). Additional procedures to ensure postoperative renal perfusion were renal artery re-implantation to the new aorta (n=2, 9.5%), interposing an extension graft (n=2, 9.5%, Figure 2), and endarterectomy (n=5, 23.8%).

Table 4 presents the follow-up data. The median postoperative ventilation time was 12 (range, 5 to 31) hours and three patients (14.3%) were lost during the hospital stay. The overall mortality rate was 33.3% (n=7) during a mean follow-up of 47.9±33.6 months.

Table 2. Operative data of patients requiring a suprarenal clamp

	n	%	Median	Min-Max
Operation time (min)			286	196-628
Renal ischemia time (min)			42	20-82
Simple suprarenal clamp	17	81		
Interrenal clamp	4	19		
Additional renal artery procedure				
Extension graft	2	9.5		
Reimplantation	2	9.5		
Endarterectomy	5	23.8		
Type of aortic procedure				
Tubular graft	3	14.3		
Aorto-biiliac graft	16	16.2		
Aorto-bifemoral graft	2	9.5		

Min: Minimum; Max: Maximum.

According to the Kaplan-Meier analysis, the mean survival was 75.6±10 months (95% CI: 56.1-95.2; Figure 4). Hemodialysis was required in six patients including two on maintenance dialysis preoperatively. Only one new patient continued routine dialysis program after discharge, other two were lost in the ICU and one was followed by the nephrology department after six hemodialysis sessions for the hypervolemic state.

Table 3. Reasons for suprarenal clamping

	n	%
Short neck	8	38.1
Renal artery arising from aneurysm	7	33.3
Endovacular abdominal aortic repair	6	28.6

Table 4. Follow-up parameters of patients (during 48 months)

	n	%	Mean±SD
Extubation time (h)			12.9±5.8
Intensive care unit stay (day)			2.9±1.2
Hospital stay (day)			9.4±2.9
Need for dialysis			
Temporary	3	14.3	
Permanent	3	14.3	
Hospital mortality	3	14.3	
Total mortality	7	33.3	
Highest creatinin (mg/dL)			2.9±1.3
Follow-up time (month)			47.9±33.6
Complications			
Pulmonary	5	23.8	
Distal embolism	2	9.5	
Mesenteric ischemia	1	4,8	
Amputation	2	9.5	
Graft infection	1	4.8	
Wound infection	3	14.3	

SD: Standard deviation.

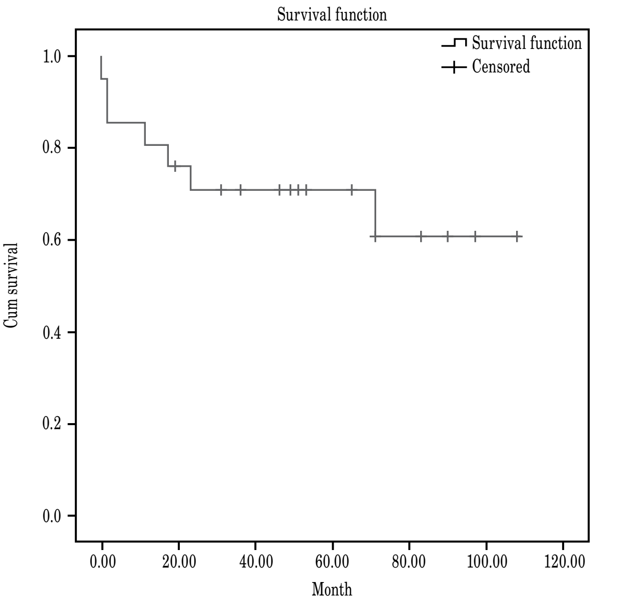

Figure 4. The diagram showing the estimated survival rate of the patient cohort.

DISCUSSION

The AAA is seen in 5 to 7% of individuals over age 60 years and, 2 to 20% are JAAs or extend to the renal arteries.[7] Surgical repair for symptomatic AAAs has been well-described and effective procedure, although its main disadvantage is the high operating risks, particularly in patients with significant comorbidities.[8-11] Besides, the treatment of JAAs remains more challenging due to inevitable renal ischemia.[10,12] The patients included in our study consisted of elderly patients with comorbidities potentially complicating surgery such as coronary artery disease (33.3%), chronic obstructive pulmonary disease (57.1%), and failed EVAR procedures (28.6%). The hospital mortality was as high as 14.3%; however, it included one early death after ruptured aneurysm repair.

The largest series including 257 patients concluded that open surgery of JAA could be performed with low mortality rates (5.8%), but with increased renal morbidity (41%).[13] However, the authors noted a mean

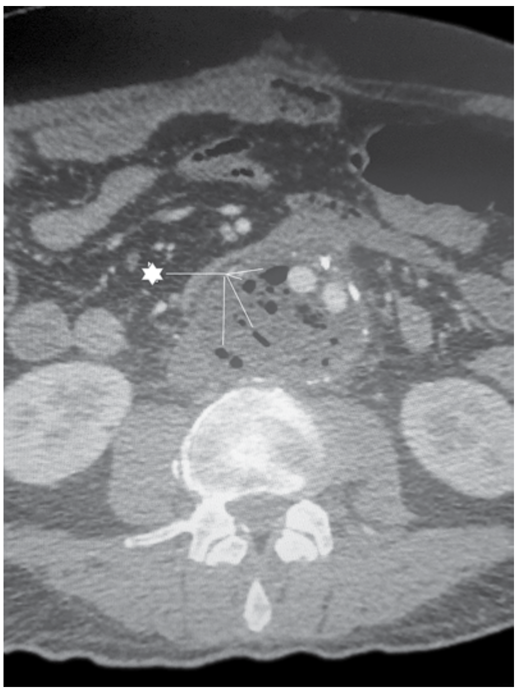

Figure 5. Air bubbles (*) around an infected graft implanted for treatment of juxtarenal aortic aneurysm.

renal ischemia time of 28 min during JAA repair, and none of the patients required reconstruction procedures for a troublesome renal artery. A more recent study including 126 patients who required suprarenal cross-clamp was conducted by Knott et al.[7] and they found an operative mortality of 0.8%, renal insufficiency (creatinine increase >0.5 mg/dL) of 18%, and new hemodialysis in 4% of patients. Notably, they used cold renal instillation (i.e., heparin, mannitol, and lactated Ringer's solution) during suprarenal clamping in 100 patients and the mean duration of renal ischemia was 23 (range, 3 to 90) min that is almost half of our experience. Although the demographics of our patient cohort were almost similar to those in the aforementioned studies, the renal artery ischemia time was remarkably longer. The main differences from these reports are the number of failed EVAR patients requiring suprarenal clamp and the number of additional procedures performed to the renal artery.

Over the last decade, EVAR has become the preferred method of treatment for the infrarenal aortic aneurysms.[14,15] Progressive improvement in endograft technology are associated with improved short-term outcomes, but with a considerable amount of late reinterventions, and widespread use in a higher number of eligible patients.[16,17] The quality of the results is related to individual experience, knowledge about the capacity of special equipment, adequacy and diversity of clinical resources, and appropriate patient selection. Therefore, simple EVAR to infrarenal aneurysms with a hostile neck rather than fenestrated EVAR or chimney/snorkel procedures should be considered to increase the risk of failure (Figure 5). One of the treatment options of failed EVAR is akin to the open repair of JAAs. However, removal of the aortic stent graft and/or concomitant renal stents may require additional interventions to the renal arteries and consequently increase the duration of the renal ischemia. We believe that the high failed EVAR rate in the patients in our study would help to explain the increased mean renal ischemia time, which is reported as 27 min in the literature, and the higher rate of patients requiring dialysis.[6]

Renal perfusion with cold crystalloid perfusate during suprarenal clamping (median: 42 min) was applied in all patients, but a median rise of 1.3 mg/dL serum creatinine level and 28.6% dialysis requirement were yielded. An ideal level of aortic cross-clamp placement (suprarenal or interrenal) and strategy of renal perfusion remains controversial with conflicting reports in the literature.[7,18,19] Some authors have suggested that postoperative renal dysfunction is not related to renal ischemia time, preoperative renal function, or renal revascularization but cold saline perfusion provides considerable benefits with 0% postoperative azotemia.[18] In addition to superior results of cold crystalloid perfusate considering renal morbidity, perfusion with isothermic/cold blood seems to be effective to supply oxygen and buffers, prevent cell membrane damage, and reduce cell swelling.[20-22] Others have also reported that the decrease of the estimated glomerular filtration rate is significantly lower in the interrenal clamp than in the suprarenal clamp.[23] Nonetheless, several authors have advocated a simple clamp-and-sew technique which provides approximately 25 min shorter renal ischemia time than renal perfusion approaches.[7,24] The common opinion in the literature is that renal ischemia exceeding 45 min, with or without renal perfusion strategies, is associated with an increased risk of renal damage.[13,14,25]

In our study, renal morbidity, hospital mortality, and mid-term (48 months) mortality seem to be higher compared to previous reports. The reasons that we can infer from this study are the high rate of preoperative comorbidities, the failed EVAR procedure complicating surgery, the concomitant vascular pathologies reflecting diffuse atherosclerosis, and the high rupture rate at presentation. Although many have indicated significant potential advantages of endovascular procedures as a reason to avoid open surgery to treat complex AAAs, the true benchmark for open surgery still remains unclear.[26-28] However, dialysis requirement and mortality for open reconstruction seemed similar to those reported for complex endovascular repairs.[29,30] Indeed, we believe that unsuccessful endovascular procedures tend to increase the complexity of open surgery and, hence, the negative consequences, due to the disproportionate increase in the frequency of use and experience. Also, complications such as pulmonary infections, mesenteric ischemia, limb amputation, peripheral embolism, graft infection are more commonly seen in our patient cohort than those with infrarenal aneurysms.

The present study has several limitations. This single-center study is limited by the relatively small number of patients, and the 10-years interval represented. During this long period, improvements in the operative and perioperative care have been made, which are possible to have improved patient outcomes. We believe that no prospective randomized trials would be obtainable with this small volume of patients in a single-center, and studies with a retrospective design could serve valuable information for the near future. Secondly, this study did not show significant effects of some potential factors such as renal perfusion, renal ischemia time, and renal revascularization on renal failure. The reason for this may be due to our strategy which necessitates cold perfusion application in all patients that further prolonged renal ischemic time. Therefore, a sufficient statistical power obtained from a larger sample size could be required to define more predictors. Finally, we did not have complete data including the medical management of comorbidities during follow-up and, thus, the relationship between renal failure and medical management still remains to be elucidated.

In conclusion, the results of this study are consistent with previous reports, showing less favorable outcomes after JAA repair considering renal injury. The discrepancy in prognosis rates seems to be worsened by more extensive pathology, and an increasing number of failed EVAR procedures. As the procedural complexity increases by additional renal artery interventions, ethical considerations before endovascular procedures should be revised individually for low-volume centers. The complexity of surgical procedure due to changing etiological factors requires an accurate preoperative assessment of morphology and operative strategy.

Declaration of conflicting interests

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