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Original Article

Abdominal revascularization patency outcomes of thoracoabdominal aortic aneurysm and mesenteric ischaemia

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Abstract

Aim: Thoracoabdominal aortic aneurysm (TAAA) and Mesenteric ischemia (MI) are multifactorial and hereditary diseases which also have associations with systemic atherosclerosis and genetic factors. As it is known, mortality and morbidity rates are very high for open surgery; therefore, hybrid approach, with better outcomes, has become more popular as a new alternative treatment option for TAAA patients. The aim of the study was to compare the graft patencies of all patients who underwent visceral revascularization with different aetiology.
Material and Methods: 34 patients who underwent visceral revascularization, either for MI (n:16) or TAAA hybrid procedure(n:18) were included in this study. All data was collected retrospectively and was analysed with SPSS 21.0 software program. Chi-square and Fischer tests were used in the analysis of qualitative data; and results with a p value below 0.05 were considered as statistically significant.
Results: There was no significant difference between two patient groups in terms of graft patency rates. All type 2 endoleaks were resolved spontaneously in control CT angiography and no migration was observed in patients.
Conclusion: In line with the results obtained, it has been revealed that visceral revascularization surgery can be used not only for the final treatment of MI, but also as a step in the hybrid approaches of TAA.

Keywords: Thoracoabdominal aortic aneurysm, mesenteric ischemia, visceral revascularization, TEVAR

INTRODUCTION

The incidence of thoracoabdominal aortic aneurysm (TAAA) accounts for only 10% of all aortic aneurysms. As presented by Crawford and modified by Safi, TAAA's are classified in 5 groups, depending on the origin and aneurysm [1]. Although aetiology of TAAA is still indefinite, systemic atherosclerosis resulting in degeneration is thought to be the major cause. TAAA is also associated with inflammatory disorders and vasculitis (giant cell arteritis, Takayasu's aortitis), aortic infections (mycotic aneurysm), bicuspid aortic valve disease and inherited connective tissue disorders (Marfan, Loeys-Dietz, vascular type Ehlers-Danlos syndromes). Most of patients with TAAA remain asymptomatic.

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Although indications for repair in asymptomatic patients are still controversial, the risk of rupture of the aneurysm, according to the Laplace law, is directly related to the increase in the transverse diameter of the aneurysm. The risk of rupture in TAAAs increases by 2 fold, for every 1 centimetres increase after exceeding 5 centimetres in diameter [2].

Although open surgical repair of TAAA has evolved significantly throughout the history, perioprative and post-operative mortality and morbidity rates are still high because of the complex nature of the disease [3]. Due to the challenges of complete endovascular repair of TAAA and the inherent risks of major morbidity from open repair, research teams have developed and implemented a hybrid approach to TAAA repair [4,5]. Hybrid approach could be divided into two stages; open debranching of the visceral arteries (via first performing transabdominal or retroperitoneal approach) and endovascular stent graft implantation to exclude the aneurysmal sac. Thus, the number of endovascular treatments that cannot be performed due to anatomical incompatibility would be reduced.

Hybrid methods are still being developed, and studies showing late-term results and long-term patency rates, especially of extranatomic bypasses to the renal and visceral arteries, are limited [6]. Early-term results of endovascular treatment are known to be better than surgery; but, the most important disadvantage is long-term endoleaks. A different clinical entity that is treated with visceral debranching is mesenteric ischemia (MI). MI is caused by a reduction in intestinal blood flow and is classified as acute (sudden onset of intestinal hypoperfusion) or chronic, depending on the extent of symptoms. While chronic mesenteric ischemia constitutes 5% of all mesenteric ischemia, 90% of this is atherosclerosis-based. The most important risk factors are hypertension, renal disease, diabetes and cardiovascular causes. Chronic MI, also named as intestinal angina, typically presents with multivessel mesenteric stenosis or occlusion. The typical presentation includes postprandial pain, weight loss due to fright of eating or unexplained diarrhea. The aim of revascularization is to prevent future bowel infarctions. Surgical endarterectomy, vascular bypass surgery and endovascular interventions are the treatment options along with the medical treatment, in the presence of arterial pathology. A limited number of studies demonstrate that the long-term results of surgical treatment options have a better prognosis [7,8].

In this study, the results of the patient group in which hybrid surgery was performed and visceral debranching was applied due to TAAA and the results of the patient group who underwent visceral debranching due to MI were compared. The aim of this study was to compare the graft patency's results of two groups that underwent visceral debranching, as a stage of aortic aneurysm or as a final treatment of mesenteric ischemia, in order to demonstrate that visseral revascularization is not only the final treatment of MI, but can also be used as a step in the hybrid approaches of TAAA.

MATERIAL AND METHODS

Patient Population

34 patients who underwent visceral revascularization between March 2009 and January 2015 were included in this study. The study was designed retrospectively and was conducted in accordance with high ethical norms. Ethical approval was obtained from our university's ethical review board with the following number; 15-5.1/44. While 16 of 34 were patients who underwent visceral revascularization due to MI (Group I), 18 (Group II) were patients who underwent hybrid surgery for TAAA. While 1 of the Group I patients was diagnosed with acute MI, 2 had acute MI with chronic background and the remaining 13 were diagnosed with chronic MI. Classification of Group II patients according to their diagnosis was as follows: 2 patients were type 5 aneurysm, 5 patients were type 4 aneurysm, 3 patients were type 3 aneurysm, 1 patient was type 2 aneurysm and 7 patients were type 1 aneurysm. Of the Group I patients, 12 (75%) were female and 4 (25%) were male, with a mean age of 58.3±11.0 (32-70). Of the Group II patients who participated in the study and underwent hybrid intervention, 13 (72.2%) were female and 5 were male (27.8%), and the mean age was calculated as 68.4±10.3 (39-81) years. Patient data was scanned retrospectively by using the file scanning system. Radiological images were accessed from the hospital database. Diagnosis of patients was made with through physical examination and radiological investigations. Contrast-enhanced CT angiography was the most informative radiological investigation (Figure 1). CT angiography images were evaluated by the interventional radiology team. All procedures were carried out by the same expert team. All patients were followed for one year after the surgery.

Surgical Procedure

All patients were evaluated by the anesthesia team preoperatively; routine biochemistry and complete blood count analyses were performed. Since the essential underlying cause of the diagnosis was atherosclerosis, cardiac evaluations of all patients were performed and the recommendations of the cardiology team were followed. Many patients with TAAA pathology were not suitable for endovascular treatment alone and were combined with visceral revascularization procedure. In this method, which is called the hybrid procedure, intra-abdominal revascularization was performed primarily using the same technique as the one reported in our previous study [9]. After the standard midline incision, transperitoneal approach was performed in all patients. Celiac artery (CA), hepatic artery (HA) and superior mesenteric artery (SMA) were dissected subsequently, and special care was

given to getting adequate length of SMA for optimal anastomosis. Visceral bypass can be made directly from the aorta (if there is no occlusion and the section is not present in the aneurysmal sac) in the direction of anterograde flow, or it can be performed from the iliac arteries in the direction of retrograde flow, as applied in this study (Figure 2). After heparin administration, a side clamp was placed on the iliac artery and extra-anatomical bypass was performed using polytetrafluoroethylene (PTFE) and dacron grafts instead of saphenous vein in order to prevent intraabdominal compression to the grafts and to reduce the possible risk of size mismatch between arterial structures and saphenous vein. After bleeding control, the abdomen was closed in accordance with anatomical planes. In the hybrid procedure, endovascular stage was performed depending on the general condition of the patient after laparotomy; it was applied either on the same day or a few days later in the interventional radiology department.

Unilateral femoral artery was explored surgically, and the contralateral femoral artery was cannulated percutaneously; endovascular stent grafting procedure was applied with the standard technique.

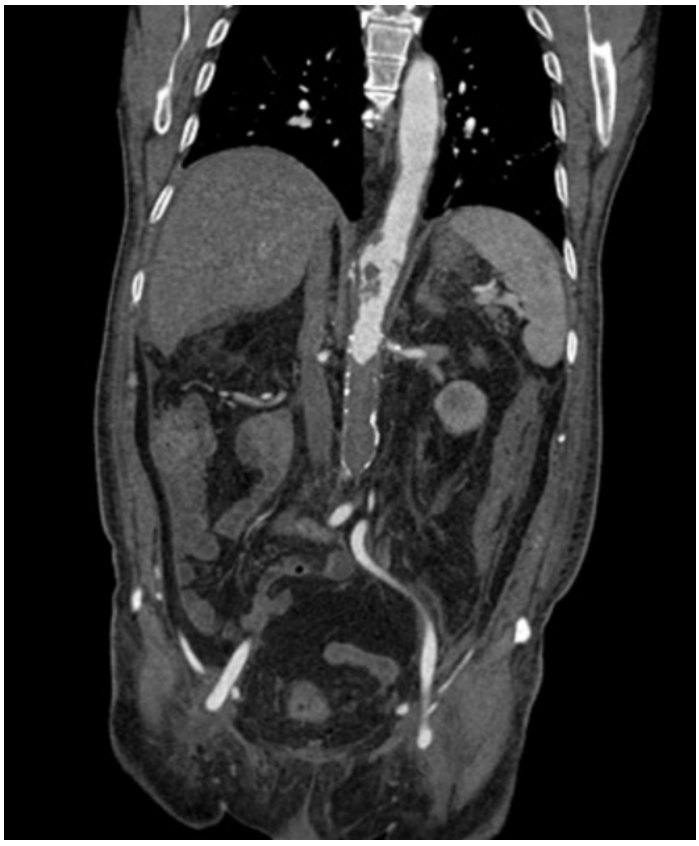

Figure 1. Contrast-enhanced CT angiography for accurate diagnosis and procedural evaluation

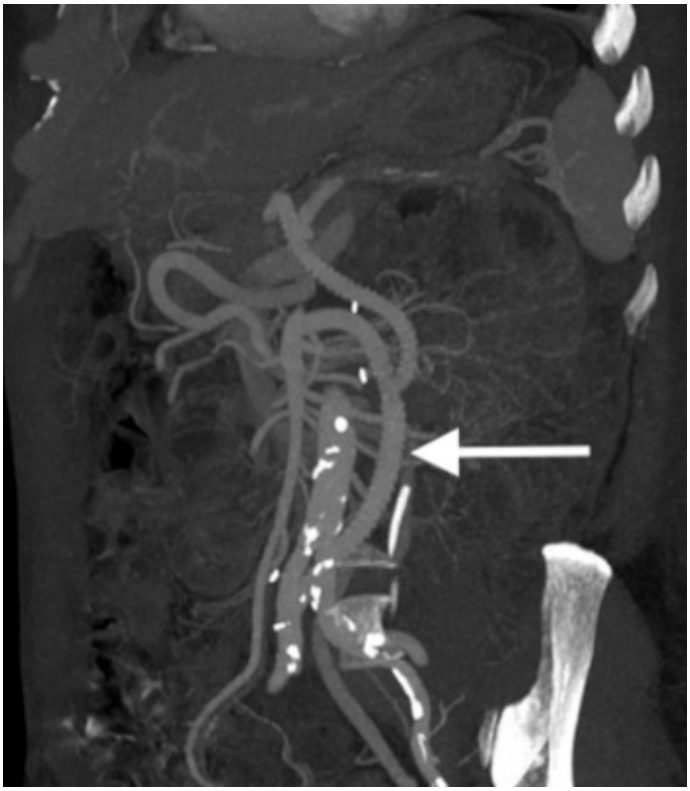

Figure 2. Visceral bypass performed from the iliac artery in the direction of retrograde flow; white arow

Stent graft selection was performed thoroughly by oversizing the affected aortic diameter by 10% to 20%. At the end of the procedure, a control angiography was performed to assess the final position of the stent graft and to identify any possible endoleaks. Open side of the femoral artery was closed surgically and distal pulses of the leg were controlled. Postoperative six-hour long compression was applied to the site of percutaneous entry. Most commonly used stent graft types were conformable TAG (c-TAG) device (Gore&Associates) and "Vailant Captiva system" (medtronic,Inc). Medical treatment: All patients received dual antiplatelet treatment (100 milligrams acetylsalicylic acid per day, plus 75 milligrams clopidogrel per day).

Statistical Analysis

The data obtained for this study was collected from digital hospital records and was analyzed with the IBM SPSS for Windows version 21.0 software program (IBM Corp., Armonk, NY, USA). In the descriptive statistics given, mean, standard deviation, minimum-maximum (min-max), median, ratio and frequency values were used. Distribution of the data was analyzed with the Kolmogorov-Smirnov test. Independent sample t-test and Mann-Whitney U tests were used in the analysis of quantitative data. Chi-square and Fischer tests were used in the analysis of

qualitative data, and results with a p value below 0.05 were considered as statistically significant.

RESULTS

Demographic characteristics of the patients are shown in Table 1, and it was found that female gender was prominent in both groups. While gender was not statistically significant when the mean ages of both groups were compared, it was found that the patients in Group I were younger and the difference in mean age (58.3±11.0 years (32-70)) was statistically significant. In addition, it was found that the variables of peripheral artery disease and active smoking differed statistically significantly between the two groups (Table 2).

Coeliac bypass was performed in 14 (87.5%) patients, SMA was performed in 15 (93.8%) patients, and left renal bypass was performed in 1 (6.3%) patient with visceral revascularization, due to mesenteric ischemia. Right renal artery and IMA (inferior mesenteric artery) bypass were not performed in this group. Extra-anatomical bypasses were performed in 16 (88.9%) Coeliac artery, 16 (88.9%) SMA, 7 (38.9%) left renal artery and 7 (38.9%) right renal artery patients who underwent hybrid approach for TAAA. IMA bypass was not applied in this group either. Of the patients who underwent TEVAR and visceral revascularization, 11 (61.1%) of the procedures were combined, and 7 (38.9%) of the patients underwent gradual surgery (Table 3). Cerebrospinal fluid (CSF) drainage catheter was applied to 17 (94.4%) of the patients who underwent TEVAR and visceral revascularization, and 3 (16.7%) patients had ruptures where surgical intervention was planned (Table 3). Aetiologically, 69% atherosclerosis (11 patients), 19% acute thrombosis (3 patients), 12% vasculitis (2 patients) rates were observed in patients who underwent visceral revascularization due to mesenteric ischemia (Table 3).

Table 1. Demographic characteristics

	Group 1			Group 2			P
	Avg + - sd/n-%	Med	(Min – Max)	Avg + - sd/n-%	Med	(Min – Max)	
Age	58.3+ -11.0	62	32-70	68.4 + - 10.3	72	39 – 81	0.004
Gender	12	75.0%		13	72.2%		0.855
Female	4	25.0%		5	27.8%		
Male							
Preoperative				6.8 + - 1.4.	7	5-10	

Table 2. Co-morbidities of patients

	GROUP I		GROUP II		P
	n	%	n	%	
Hypertension	(-)8	50%	8	44.4%	00746
	(+)8	50%	10	55.6%	
Diabetes Mellitus	(-)14	88%	18	100%	0.214
	(+)2	13%	0	0%	
Chronic Renal Insufficiency	(-)13	81%	17	94.4%	0.233
	(+)3	19%	1	5.6%	
Hyperlipidemia	(-)11	69%	14	77.8%	0.551
	(+)5	31%	4	22.2%	
Coronary Arterial Disease	(-)11	69%	14	77.8%	0.551
	(+)5	13%	4	22.2%	
Peripheral Arterial Disease	(-)12	75%	18	100%	0.039
	(+)4	25%	0	0%	
Carotid Artery Stenosis	(-)16	100%	18	100%	-
	(+)0	0%	0	0%	
Active Cigarette consumption	(-)4	25%	11	61.1%	0.034
	(+)12	75%	7	38.9%	
COPD	(-)11	69%	16	88.9%	0.147
	(+)5	31%	2	11.1%	
Previous Aortic Surgery	(-)16	100%	15	83.3%	0.087
	(+)0	0%	3	16.7%	
Chi-square Test (Fisher Test)					

COPD: Chronic Obstructive Pulmonary Disease

Table 3. Number of the bypassed vessels in group I and group II

	GROUP I		GROUP II		P
	n	%	n	%	
Coeliac artery	(-)2	13%	2	11.1%	1.000
	(+)14	88%	16	88.9%	
SMA	(-)1	6%	2	11.1%	1.000
	(+)15	94%	16	88.9%	
Left Renal artery	(-)1	94%	11	61.1%	0.025
	(+)15	6%	7	88.9%	
Right Renal artery	(-)16	100%	11	61.1%	0.005
	(+)0	0%	7	88.9%	
IMA	(-)16	100%	18	100%	-
	(+)0	0%	0	0%	
Staged	(-)0	0%	11	61.1%	0.000
	(+)16	100%	7	88.9%	

SMA: Superior mesenteric Artery, IMA: Inferior mesenteric artery

In-hospital mortality rate was 6.3% (1 of 16) in patients who underwent visceral revascularization due to mesenteric ischemia, and 1 patient died due to heart failure. In-hospital mortality rate of patients who underwent TEVAR and visceral revascularization was 16.7% (3 of 18). 2 patients died due to respiratory and heart failure, 1 patient died due to heart failure (Table 4). Postoperative event rate did not differ significantly ($p>0.05$) between the two groups that were compared. However, when the duration of hospitalization was compared, it was found that the duration of hospitalization in Group II was longer and statistically significant.

In the group of patients who underwent visceral revascularization due to mesenteric ischemia, hemorrhage was observed in 1 (6%) patient, respiratory failure in 2 (13%) patients, infection in 1 (6%) patient, heart failure in 1 (6%) patient, and renal failure in 1 (6%) patient. In the group of patients who underwent TEVAR and visceral revascularization, respiratory failure was observed in 4 (22%) patients, infection in 2 (11%) patients, heart failure in 2 (11%) patients, acute renal failure in 2 (11%) patients and chronic renal failure in 2 (11%) patients. As for the neurological complications of TAAA treatment dissimilar to Group I, paraparesis was observed in 1 (6%) patient, and a cerebrovascular event was observed in 1 (6%) patient.

Table 4. Postoperative events

	GROUP I		GROUP II		P
Postoperative complications	n	%	n	%	
Bleeding	(-)15	(-)15	18	100%	0.471
	(+)1	(+)1	0	0%	
Respiratory Complication	(-)14	(-)14	14	77.8%	0.458
	(+)2	(+)2	4	22.2%	
Infection Complication	(-)15	(-)15	16	88.9%	1.000
	(+)1	(+)1	2	11.1%	
Cardiac Complication	(-)15	(-)15	16	88.9%	1.000
	(+)1	(+)1	2	11.1%	
Permanent Dialysis	(-)16	(-)16	16	88.9%	1.000
	(+)0	(+)0	2	11.1%	
Temporary Dialysis	(-)16	(-)16	16	88.9%	0.487
	(+)0	(+)0	2	11.1%	
Mesenteric Ischemia	(-)16	(-)16	16	88.9%	0.487
	(+)0	(+)0	2	11.1%	
Paraoaresis	(-)16	(-)16	17	94.4%	1.000
	(+)0	(+)0	1	5.6%	
Paraplegia	(-)16	(-)16	18	100%	-
	(+)0	(+)0	0	0%	
Stroke	(-)16	(-)16	17	94.4%	1.000
	(+)0	(+)0	1	5.6%	

Chi-square Test (Fisher Test)

No significant difference was observed in the rates of hemorrhage, respiratory complications, infective complications, cardiac complications, renal complications, cerebrovascular events, and paraparesis between the two patient groups (p>0.05).

There was no significant difference between two patient groups in terms of graft patency rates (p>0.05). Coeliac artery graft patency was encountered as the highest in both groups. Coeliac graft patency rate was 81% in Group I, while it was 83% in Group II. SMA graft patency rate was 94% in Group I, compared to 78% in Group II. The visceral bypass vessel with the lowest patency rate was found as the left renal artery in both groups. While rate of the left renal patency was 6% in Group I, it was 33% in Group II. In patients who underwent TEVAR and visceral revascularization, a borderline value was detected statistically (p:0.051). The reason for this could possibly be the small group size.

In the initial control angiography that was performed after procedure, type 2 endoleaks were detected in 7 (39%) patients; all resolved spontaneously and was not detected in control CT angiography performed on the first month. In long-term follow-up, aortic-enteric fistula developed in 1 (6%) patient with Behçet's disease, and axillary pseudoaneurysm developed in 1 (6%) patient. Migration was not observed in any patients.

DISCUSSION

Arterial structures that provide blood supply to the abdominal organs are mostly revascularized for two reasons. One reason is, visceral revascularization is performed due to MI, and the other reason is, visceral revascularization is applied in hybrid surgeries that have become one of the recently developed TAAA treatment methods. Although the aetiology and clinical features of these two groups are completely different, extra anatomic bypass is applied to the visceral arteries in both groups. While many studies related to both clinical entities have been reported in the literature, no study has been found comparing the results of these two groups. In this study, postoperative results of both groups were compared with our single center study. Three key vessels in mesenteric blood supply are celiac artery (CA), superior mesenteric artery (SMA) and inferior mesenteric artery (IMA). Although significant stenosis of the mesenteric arteries is common, only a small percentage of patients would actually develop symptoms [9,10]. Postprandial pain, loss of bodyweight due to avoidance of eating and diarrhea that could not be explained by other causes, would constitute the typical presentation of chronic MI [11]. Two main methods were used in patients who were revascularized due to MI; angiographical stenting and open revascularization. Both methods have their own advantages and disadvantages.

Although percutaneous method is preferred as the first choice treatment with many advantages such as being less invasive, short hospital stay, fast recovery and successful early outcomes, there are many studies which reported high re-intervention and poor patency rates in late outcomes [12]. On the other hand, there are studies showing that the long-term results of the surgical group are better and the mortality rate is similar between two groups; therefore, they advocate the superiority of surgical treatment [13]. Mesenteric bypass is applied by a graft from aorta or iliac artery, to a location distal to the site of occlusion. To make a decision about the graft type for using visceral bypass is another debatable issue. To date, autologous reversed saphenous vein, PTFE grafts with rings and dacron grafts could be used. The autologous veins known as high kinking rate and low suitability are a reason of small diameter [9]. In our study, iliac arteries were chosen as a retrograde source and PTFE ring grafts or dacron grafts were used.

Although the gold standard treatment method for TAAA is conventional aortic repair, hybrid surgery is widely accepted due to high mortality and high postoperative complications of conventional aortic repair [14-16]. In hybrid technique; visceral debranching would be applied to the intra-abdominal organs, whose blood supply is provided by the arteries originating from the aneurysm sac, and then TEVAR is performed with the endovascular stent technique. Mesenteric debranching from the iliac arteries prior to endoluminal graft placement to the TAAA, was reported by Flye et al [15]. An intraperitoneal approach was employed, where end-to-side anastomosis was made from external iliac artery and end-to-end anastomosis was made from external iliac artery to the SMA for PTFE graft placement.

Minimally invasive procedure, TEVAR, was initially targeting patients who were not fit to go through open surgery, but currently it is widely preferred because of the reduced risks due to avoidance of sternotomy and thoracotomy, less ischemia-related complications and decreased perioperative blood loss, when compared to the open surgery option. Visceral debranching would be performed before endovascular repair and the blood influx would be characteristically supplied from iliac arteries or the unaffected aorta sections [16-18]. The aim of debranching would be to supply blood flow to the visceral aorta. Endograft repair could be applied simultaneously or at a later date, depending on condition of the patient.

There is no study that demonstrates the long-term results of patency times of endografts and extra anatomic bypasses that have been used in hybrid interventions [19]. In this study, mortality rate of the mesenteric artery surgery was determined as 5-12%, and 6% in visceral revascularization due to mesenteric ischemia. Mortality rate was found to be 17% in visceral revascularization performed in the hybrid method. Although there was no statistically significant difference between the mortality rates, the reason for the high rate in the hybrid method was observed as co-morbidities in graft patency times. The lack

of statistically significant difference showed that etiology and pathology were ineffective on graft patency times. Besides the disadvantages of open TAAA repair, the most important advantage is that it allows revascularization of the intercostal arteries and theoretically reduces the rate of spinal cord ischemia. In some previously conducted studies, it was shown that the application of a preoperative CSF drainage catheter in TEVAR cases reduced the risk of spinal cord ischemia [20-23]. In our study, procedural success of the hybrid surgical procedure was found to be 100%.

When neurological complications were examined, the rate of paraparesis and stroke was recorded as 6%, and these results were found to be lower than the previous studies in the literature [23]. Although difference in the patency rates of visceral debranching vessels were not statistically significant, it was determined that the left renal artery debranching procedure remained open at around 6% in Group I patients, and remained open at a rate of 33% in Group II patients, with the poorest revascularization patency. This result shows that interventional treatments applied to renal arteries percutaneously can also be considered as an alternative treatment and that open surgical revascularizations should be compared with the percutaneous revascularizations.

While the average hospitalization period was 9 days in Group I, this rate was found to be 23 days on average in Group II. The reason for this difference is the waiting time for the second stage in hybrid surgical methods performed in stages.

Although no studies that compare these two groups exist, the promising results of our study expresses that there is a need for multicenter studies with larger patient groups. The main weaknesses of the study are that it was conducted in a single center with limited number of patients. Additionally, some patients discontinued after the 1st year of the surgery.

CONCLUSION

Visceral revascularizations can be performed in mesenteric ischemia and TAAA with hybrid surgery. Although there are two different aetiologies, extra anatomic bypass technique and the graft materials used are similar. Although long-term follow-up was not available, visceral revascularization for the mesentery was successfully applied regardless of aetiology and pathology, and early-term results were satisfactory. This study demonstrates that both hybrid surgery and mesenteric revascularization are promising methods.

Ethics Committee Approval: Ethical approval was obtained from our university's ethical review board with the following number; 15-5.1/44.

Patient Consent for Publication: A written informed consent was obtained from all patients.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: All authors contributed equally to the article.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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