Experiences of Surgical Treatment for Juxtarenal Aortic Occlusion

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Purpose: To evaluate the outcomes of juxtarenal aortic occlusion (JRAO), a review of 15 patients who underwent aortic bypass replacement following aortorenal thrombectomy, especially focusing on the safety of suprarenal aortic clamping or transient aortic compression, was undertaken.
Materials and Methods: During the period of June 2001 to November 2012, 15 patients with JRAO (chronic 10, acute 5) were analyzed retrospectively. JRAO with combined stenosis of the renal artery was found in 2 patients, renal artery thrombus in 8 patients, and normal in 5 patients.
Results: All patients were males. Mean age was 61.7±11.2 years. There were 14 aortobifemoral bypass grafting and 1 aortobiiliac bypass grafting. Six Dacron and 9 PTFE artificial Y-grafts were implanted to the aorta with end-to-end anastomosis in the proximal aorta. Suprarenal aortic clamping was performed in 7 patients, supraceliac clamping in 2 patients, and transient aortic compression in 6 patients. There were 13 cases with aortic clamping time <10 minutes and 2 cases with >10 minutes. Thrombectomy of the aorta and renal artery was performed in 10 (66.7%) patients. There were no operative mortality cases. The perioperative morbidity rate was 26.7% (4/15). Preoperative renal function was impaired in four patients. The renal functions of these cases were recovered postoperatively.
Conclusion: Aortic bypass replacement following aortorenal thrombectomy with suprarenal aortic clamping or transient aortic compression for JRAO is the optimal treatment. It is important to focus on short renal ischemic time during suprarenal aortic clamping for prevention of renal damage. It provides unmatched perioperative and long-term results.

Key Words: Juxtarenal aortic occlusion, Suprarenal aortic clamping, Aortobifemoral bypass

INTRODUCTION

Occlusion of the infrarenal aorta (IAO) is a variant of TransAtlantic Inter-Society Consensus (TASC) Type D lesions. Two different patterns of IAO can be identified: distal and proximal, or juxtarenal. Juxtarenal or proximal type extends cephalad approaching the level of the renal arteries, which may also cause acute renal failure, intestinal infarction, and even paraplegia due to the proximal propagation of aortic thrombosis. Occlusive disease of the infrarenal aorta, which may extend down to the bifurcation and the common iliac arteries, can lead to claudication or critical limb ischemia [1].

The renal and visceral vessel segment of the aorta fre-

quently has significant atherosclerotic disease that may embolize when manipulated or clamped. In addition, placement of a clamp near the origins of these vessels may damage their diseased ostia, resulting in stenosis or thrombosis. Preoperative angiogram is extremely helpful in providing important information regarding atherosclerotic disease in this segment of the aorta. The higher risk associated with juxtarenal aortic occlusion (JRAO) repair is related to the necessity for suprarenal aortic clamping leading to possible ischemic injury to the kidneys, visceral organs, and the spinal cord. Deterioration in renal function is a common cause of morbidity in patients treated surgically for juxtarenal and suprarenal abdominal aortic aneurysm with either preoperative renal insufficiency or with anticipated prolonged renal ischemia (>30 minutes). Postoperative renal insufficiency has been a prominent complication in most series involving surgery of the upper abdominal aorta and is usually secondary to ischemia-induced acute tubular necrosis [2,3].

To evaluate the outcomes of JRAO, a review of 15 patients who underwent aortic bypass replacement following aortorenal thrombectomy, especially focusing on the safety of suprarenal aortic clamping or transient aortic compression, was undertaken.

MATERIALS AND METHODS

During the period of June 2001 to November 2012, fifteen cases of JRAO were treated and analyzed retrospectively. The institutional review board approval was obtained (Inje University Haeundae Paik Hospital, 129792-2014018). All patients were males. The distribution of age was between 48 and 72 years. Mean age was 61.7±11.2 years. Follow-up period was from 1 to 12 years. Ten out of 15 patients presented with claudication, while 5 cases had ischemic rest pain without tissue necrosis or nerve injury. From the 15 patients, 12 patients were heavy smokers. A history of hypertension was identified in 6 patients (6/15, 40%) and diabetes mellitus in 5 patients (5/15, 33.3%). Three patients (3/15, 20%) had coronary artery disease, with a previous history of coronary bypass in 2 patients and stent insertion in one patient. Four patients (4/15, 26.7%) had a history of stroke but were asymptomatic. Four patients (4/15, 26.7%) had preoperative evidence of renal insufficiency, defined as a serum creatinine level >1.6 mg/dL (Table 1). Ten patients had chronic symptoms and 5 patients had acute aortic occlusive symptoms. JRAO with combined stenosis of the renal artery was found in 2 patients, with renal artery thrombus in 8 patients, and with normal renal artery in 5 patients (Table 2).

1) Surgical technique and suprarenal aortic clamping

Suprarenal aortic clamping or transient aortic compression was performed and aortic clamping time was less than 30 minutes in all cases. Methods for renal protection such as hypothermic renal perfusion or heparinized saline injection were not used in our cases. During surgery, the aorta was carefully dissected due to the risk of proximal propagation of aortic thrombosis, and to prevent injury to collateral pathways between visceral arteries, in addition to those with systemic arteries. Aortic cross-clamping above the level of the renal arteries was almost invariably required, which also avoided the risk of atheroembolic complications.

Basically, we tried to completely remove the thrombus in the renal arteries. However, 2 patients had adherent thrombus of renal arteries which could not be removed easily. In these two cases, suprarenal cross-clamping was done and the aorta was cut transversely in the infrarenal aorta at the origin of the renal arteries. A longitudinal anterior aortotomy was extended proximally, and the adherent thrombus in the renal arteries was removed completely.

Our technique of suprarenal aortic clamping and thrombectomy was similar to Liddicoat's method [4]. The origins of the renal arteries were exposed along with a segment of the infrarenal abdominal aorta. At this point, soft atraumatic bulldog vascular clamps were placed on the renal arteries at their origin. A vertical aortotomy was

Table 1. Patient characteristics (n=15)

Characteristic	Data
Age (y)	48–72 (61.7±11.2)
Sex	
Male	15 (100)
Female	0 (0)
Symptoms	
Claudication	10 (66.7)
Resting pain	5 (33.3)
Paresthesia	3 (20.0)
Underlying disease	
Diabetes	5 (33.3)
Hypertension	6 (40.0)
Renal insufficiency	4 (26.7)
History of smoking	12 (80.0)
Previous stoke	4 (26.7)
Previous prostate cancer	1 (6.7)
Previous coronary disease	3 (20.0)

Values are presented as range (mean±standard deviation) or number (%).

Table 2. Status of atherosclerotic aorta and renal artery involvement and operation

Patient No.	Symptom	Renal artery involvement	Aortic clamp or compression	Renal ischemic time (min)	Operation for renal artery
1	Chronic	Normal	Compression	5	
2	Chronic	Normal	Compression	4	
3	Chronic	Normal	Compression	5	
4	Chronic	Stenosis	Suprarenal clamp	8	Thrombectomy
5	Chronic	Normal	Suprarenal clamp	5	
6	Chronic	Normal	Compression	5	
7	Chronic	Thrombus	Suprarenal clamp	10	Thrombectomy
8	Acute	Thrombus	Suprarenal clamp	8	Thrombectomy
9	Acute	Thrombus	Suprarenal clamp	8	Thrombectomy
10	Chronic	Thrombus	Suprarenal clamp	10	Thrombectomy
11	Acute	Stenosis	Suprarenal clamp	30	Vertical aortotomy and thrombectomy
12	Acute	Thrombus	Suprarenal clamp	28	Vertical aortotomy and thrombectomy
13	Chronic	Thrombus	Compression	6	Thrombectomy
14	Chronic	Thrombus	Compression	8	Thrombectomy
15	Acute	Thrombus	Suprarenal clamp	5	Thrombectomy

performed. While the left hand compressed the suprarenal abdominal aorta, thrombectomy of the infrarenal aorta was performed. With intermittent flushing, any residual debris was removed from the aorta. The bulldog clamps were then released from the renal arteries to allow for flush out of any material from their lumen. With the left hand still controlling the suprarenal aorta, a vascular clamp was then placed across the infrarenal aorta above the aortotomy. suprarenal aortic compression was then released, restoring renal blood flow.

2) Statistical analysis

All variables are represented with the mean±standard deviation or median range. Analyses were carried out using PASW Statistics 18.0 (IBM Co., Armonk, NY, USA).

RESULTS

1) Renal ischemia

The preoperative and postoperative creatinine levels are presented in Table 3. Suprarenal aortic occlusion time was less than 30 minutes in all patients. Four patients had preexisting renal insufficiency, but their serum creatinine levels improved postoperatively and were normalized at the time of discharge. In 3 of these patients, the serum creatinine levels decreased to normal range after operation, while in one patient, creatinine levels were normalized after undergoing fasciotomy for compartment syndrome, which

Table 3. Comparison of serum creatinine levels before and after bypass surgery

Patient No.	Serum creatinine (mg/dL)		
	Preoperative	Postoperative 3rd day	Follow up (1 year-12 years)
1	0.8	0.9	0.9
2	0.9	0.7	0.9
3	1.6	1.3	1.2
4	0.9	1.2	0.9
5	0.8	1.0	0.8
6	0.7	0.5	0.8
7	1.5	1.3	1.2
8	0.7	1.0	0.7
9	0.6	1.2	0.8
10	2.7	1.6	1.2
11	2.9	3.6	1.4
12	1.6	1.3	1.1
13	1.1	0.97	1.0
14	1.2	1.1	1.09
15	0.7	0.65	0.8

developed as a postoperative complication. None of the patients required dialysis postoperatively despite having undergone suprarenal aortic clamping or transient aortic compression. However, the differences in preoperative and postoperative creatinine levels were not statistically significant.
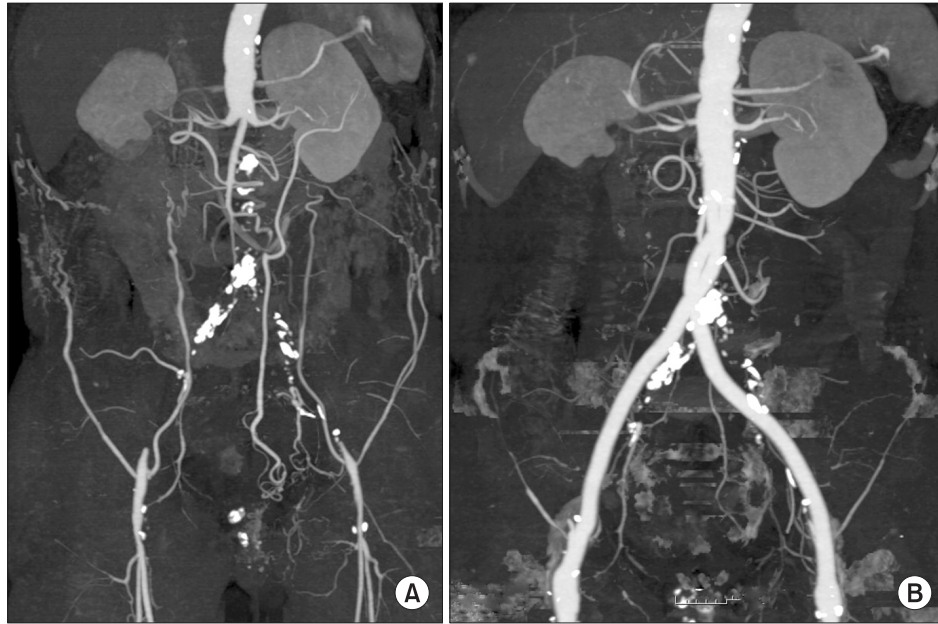
Fig. 1. Abdominal computed tomography angiogram revealed total juxtarenal aortic occlusion combined with renal artery stenosis preoperatively (A). Aorta was revascularized following aortobifemoral bypass graft with renal artery thrombectomy (B).

2) Aortic bypass replacement following renal artery thrombectomy with suprarenal aortic clamping or transient aortic compression

There were 14 aortobifemoral bypass grafting (Fig. 1) and 1 aortobiiliac bypass grafting. Six Dacron and 9 PTFE artificial Y-grafts were implanted into the aorta with end-to-end anastomosis in the proximal aorta and distal graft limbs were anastomosed to the common femoral arteries or iliac arteries. There was no operative mortality related to the aortobifemoral or aortoiliac bypass with suprarenal aortic clamping. Suprarenal aortic clamping was performed in 7 patients, supraceliac clamping in 2 patients, and transient aortic compression in 6 patients. There were 13 cases with aortic clamping time <10 minutes and 2 cases with >10 minutes due to vertical aortotomy. Thrombectomy of the aorta and the renal arteries was performed in 10 (66.7%) patients (Table 2).

3) Combined operations during admission

At the time of surgery, femoropopliteal bypass was performed in one patient due to distal arterial stenosis. Fasciotomy for postoperative compartment syndrome was performed in one patient.

4) Postoperative renal function

Although, we did not use any diuretics or renal hypothermia, there was no renal insufficiency postoperatively. We focused on keeping the renal ischemic time as short as

Table 4. Postoperative complications (within 1 month)

Complication	n (%)
Compartment syndrome	1 (6.6)
Hepatic failure	1 (6.6)
Sexual dysfunction	2 (13.3)

possible, which is known to be the most safe and effective method for renal protection.

5) Complications

Immediate postoperative complications were found in 4 patients: 1 compartment syndrome, 1 hepatic failure and 2 sexual dysfunctions. The perioperative morbidity rate was 26.7%. However, hepatic failure and sexual dysfunction were recovered at the time of discharge. Postoperative compartment syndrome was also resolved after fasciotomy (Table 4).

Graft obstructions developed during the period of follow-up, postoperatively in the 3rd, 5th and 6th years in 3 patients (1 Dacron graft, 2 PTFE grafts), which improved after thrombectomy and achieving normal range of ABI. One patient had a history of prostatic cancer, died within the postoperative 11th month of aortobifemoral bypass due to systemic metastasis of cancer, not related to this bypass operation. Another one patient died on the postoperative 4th year because of brain tumor.

DISCUSSION

Occlusive disease of the infrarenal aorta, which may affect in varying degrees and extent to involve the bifurcation and the common iliac arteries, entails claudication or critical limb ischemia, and is also typically associated with absent or diminished peripheral pulses, and with erectile dysfunction in men. It was named a century later after Leriche [5], who identified its underlying mechanism, and proposed a treatment, namely surgical excision of the occluded segment followed by graft interposition, which still remains the gold standard [5,6]. Total IAO may also propagate proximally, leading to visceral artery stenosis or occlusion and consequent acute renal failure and intestinal infarction, and even acute spinal cord ischemia and paraplegia as reported by Bergan and Trippel [7]. IAO represents from 3% to 8.5% of aortoiliac occlusive diseases [7,8].

The proposed pathogenesis of IAO is that of iliac and distal aortic atherosclerotic disease progression with subsequent infrarenal aortic thrombosis. The thrombus organizes over time and typically ascends to the level of the renal arteries. Outflow to the low-resistance renovascular bed maintains the patency of the suprarenal aorta. Propagation of thrombus extends cephalad approaching the level of the renal arteries and superior mesenteric arteries which may also cause acute renal failure, intestinal infarction, and even paraplegia. Such symptoms of occlusive disease of the infrarenal aorta depend on varying degrees and extent of thrombosis. If acute critical limb ischemia occurs in the patient without any preoperative symptoms during the perioperative period, it may lead to very dangerous morbidity and complications postoperatively. Therefore careful and exact preoperative work-up to evaluate combined arterial diseases is very important. In our cases, acute arterial obstructions were combined in 5 patients, who underwent emergency operations. Two patients had preoperative renal insufficiency. One patient had a postoperative compartment syndrome, which improved after immediate fasciotomy. There was no ischemic enteritis or paraplegia.

Hunt et al. [9] reported mortality rates for infrarenal occlusive diseases, comparing two groups treated by either operation or non-operation. From 7 to 14 years follow up period, mortality rate was 16% in the operation group and 40% in the non-operation group [9]. The cause of death of the non-operation group was progression of chronic arterial occlusive diseases or superior mesenteric artery (SMA) obstruction [10]. These reports imply that the end point of operation for IAO is to improve inflow to the lower limbs, renal arteries and SMA to prevent obstruction.

A critical issue in surgery for IAO is the crossing of the occluded lesion that often requires thrombolysis prior to angioplasty, and is responsible for the vast majority of technical failures, and also major embolic events. Direct aortobifemoral or aortoiliac bypass surgery rather than extraanatomical operation is recommended. Injuries to systemic collateral pathways should be carefully avoided and the thrombus of the aorta should be completely removed to prevent propagation of thrombus or debris to the renal arteries.

Surgery for IAO, namely thrombectomy and bypass grafting, can be considered the treatment of choice as it allows favorable long-term outcomes. The reported cumulative patency at 10 years is between 70% and 75%, and that at 20 years is 67.5%. On the other hand, early complication rate is not negligible, being reported between 5 and 10% [11,12].

In particular, the fundamental argument over the prevalence of proximal thrombus propagation leading to renal and visceral artery occlusion has been a point of ongoing debate. Controversy continues over the need for in-line aortic reconstruction with proximal thromboendarterectomy to remove infrarenal thrombus versus extraanatomic or remote bypass without addressing the proximal thrombus.

In cases of serious atherosclerotic change of the aortic wall or renal arteries involved in the thrombosis, Madiba and Robbs [8] recommended the following type of operation. A suprarenal clamp is applied, the renal arteries are controlled and the aorta is divided just below the renal arteries. A vertical aortotomy is then made between the renal vessels. The aorta as well as the orifices of the renal arteries are thrombectomized under direct vision. Thereafter a standard Dacron bifurcation graft is inserted with the proximal anastomosis placed obliquely between the renal arteries and made end-to-end to the juxtarenal aorta.

We have also performed this operation in two patients having severe atherosclerotic change of the aorta and old thrombus in the renal arteries. The method of clamping of the aorta superior to the renal artery is supraceliac or suprarenal. Supraceliac cross-clamping of the aorta is easy technically, but there is a risk for hepatic and intestinal ischemia, and is more stressful for the heart. On rare occasions, the SMA is so close to the origin of one or both renal arteries that supraceliac occlusion of the aorta may be preferred. The cross-clamping of the aorta between the SMA and renal artery has a risk for injury to the pancreas, duodenum, and vessels during dissection of the atherosclerotic aorta and propagation of adherent clots [13]. First, the clamping of the renal arteries before clamping the aorta is recommended to avoid atheroembolic complications [7]. As a means of renal protection, diuresis with mannitol

or renal hypothermia with cold fluid injection prior to aortic cross-clamping is used, but its effects are still controversial [14-16]. The perioperative mortality is 5% to 31%, the cause of death being related to renal failure, coronary artery disease and bleeding. Some report that the mortality rate decreases to 5% by early diagnosis, more younger patients, and less comorbidities [17,18]. Marrocco-Trischitta et al. [1] reported that the perioperative (i.e., 30-day) mortality was 1.9% (1/53) and perioperative morbidity was 20.7%. At a mean follow-up of 37±12 months, overall survival was 96%. Primary patency was 91.4%, and secondary patency was 97.1%.

We did not have any mortality cases after aortofemoral or aortoiliac bypass with thrombectomy for juxtarenal aortic occlusive disease patients. Of 15 patients, 13 patients still have patent grafts until now, even though some patients had a thrombotic occlusion.

In the current era, endovascular therapy for extensive aortoiliac occlusive disease remains controversial. Although surgery is still the procedure of choice for total aortic occlusion, endovascular stent treatment is increasingly being performed. Revascularization can be done either by surgery or by endovascular treatment. However, revascularization should be considered as an initial therapy in patients with limb-threatening ischemia.

Otahbachi et al. [19] reported the endovascular stent treatment of an infrarenal aortic occlusion case through a brachial arterial approach in addition to the traditional femoral access, with excellent patency rates over a mean follow-up period of 15 months. Among TASC type D lesions, technical success rates range from 73% to 93%.

Recanalization of the occluded aorta was found to be associated with major adverse events, including spinal cord ischemia, acute renal ischemia, side branch jailing, distal embolization and access site complications [20,21].

A critical issue in IAO is the crossing of the occluded lesion that often requires thrombolysis prior to angioplasty, and is responsible for the vast majority of technical failures, and also of major embolic events, which might be treated percutaneously or by means of non-invasive techniques. This is particularly the case in JRAO.

Surgery still provides a better long-term primary patency rate than endovascular treatment, even though endovascular reinterventions can achieve secondary patency rates of 80% to 98% [22].

CONCLUSION

Aortic bypass replacement following aortorenal thrombectomy for JRAO is the optimal treatment procedure that requires almost invariably aortic cross-clamping above the level of the renal arteries, and may be associated with significant morbidity and mortality. Removal of the adherent thrombus in the orifices of the renal arteries will be necessary to preserve renal function. The most safe and effective method for renal protection is to prevent exposure to ischemia. We focused on keeping this renal ischemic time as short as possible. Suprarenal or supraceliac clamping for prevention of renal damage in pararenal thrombectomy is safe and useful for better outcome in juxtarenal aortic occlusive disease. It provides unmatched perioperative and long-term results, and may be regarded as the treatment of choice.

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