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Original Article

Long-Term Outcomes of Surgical Treatment by In Situ Graft Reconstruction for Infected Abdominal Aortic Aneurysm

Munetaka Hashimoto, MD, PhD,[1,2] Hitoshi Goto, MD, PhD,[2] Daijirou Akamatsu, MD, PhD,[2] Takuya Shimizu, MD, PhD,[3] Ken Tsuchida, MD, PhD,[2] Keiichiro Kawamura, MD, PhD,[4] Yuta Tajima, MD, PhD,[5] Michihisa Umetsu, MD, PhD,[2] Shunya Suzuki, MD,[2] and Takashi Kamei, MD, PhD[2]

Objectives: The optimal surgical management for primary infected abdominal aortic aneurysm (IAAA) is controversial. Here, we report the early and long-term results of surgical treatments with the resection of the IAAA and in situ graft reconstruction with pedicled omental coverage that was performed at out hospital.

Methods: Between 2010 and 2017, 27 consecutive patients (26 males, 1 female, median age 69 years) with IAAA were surgically treated with the resection of the IAAA, in situ graft reconstruction and covered with a pedicled omental flap. Perioperative and long-term outcomes were reviewed retrospectively by medical records.

Results: Clinical manifestations, including pyrexia, fever and abdominal pain, were observed during the treatment of the patients. Aneurysm excision and in situ graft reconstruction with omental coverage were performed for all cases. In 13 cases (48.1%), tissue culture was positive. The antibiotic was administered intravenously for 9 to 47 days (median 18 days) postoperatively, and after confirming the reduction of the inflammatory response, it was administered as oral agents for 24 to 443 days (median 169 days).There was no perioperative death or re-infection. Perioperative complications were found in 8 cases (29.6%) of minor spinal cord infarction, ileus, chylous ascites, and cholangitis due to choledochlithiasis. During the observation period of median 1,147 days, there was no recurrence of infection, graft infection, or disease-related death. There were six deaths due to other diseases. And the overall survival rate was 76.2%.

Conclusion: According to our study, the long-term outcomes of surgical treatment with in situ graft reconstruction for IAAA were considered satisfactory. (This is a translation of Jpn J Vasc Surg 2019; 28: 35–40.)

Keywords: infected abdominal aortic aneurysm, mycotic aneurysm, in situ reconstruction

[1] *Department of Surgery, Iwate Prefectural Isawa Hospital, Oshu, Iwate, Japan*
[2] *Department of Surgery, Division of Vascular Surgery, Tohoku University Hospital, Sendai, Miyagi, Japan*
[3] *Department of Cardiovascular Surgery, Tohoku Medical and Pharmaceutical University Hospital, Sendai, Miyagi, Japan*
[4] *Department of Surgery, Japan Community Health Care Organization Sendai Hospital, Sendai, Miyagi, Japan*
[5] *Department of Surgery, Osaki Citizen Hospital, Osaki, Miyagi, Japan*

Received: August 18, 2019; Accepted: September 19, 2019
Corresponding author: Munetaka Hashimoto, MD, PhD. Department of Surgery, Iwate Prefectural Isawa Hospital, 61 Mizusawa-ryugababa, Oshu, Iwate 023-0864, Japan
Tel: +81-197-24-4121, Fax: +81-197-24-8194
E-mail: m_hashimoto@surg.med.tohoku.ac.jp
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Introduction

Infected abdominal aortic aneurysm (IAAA) is associated with a high risk of death from rapid aneurysm expansion, aneurysmal rupture, or septicemia and requires emergency treatment.[1,2] Antibiotics, the surgical resection of the infection focus, and anatomical revascularization are considered as standard treatments.[3–5] However, such invasive and extensive surgeries have high postoperative complication and mortality rates.[6,7] Therefore, recently, studies have reported on the application of stent grafting.[8,9] However, stent grafting in this patient population is controversial owing to the risk of fatal recurrent infection,[10,11] and thus its applicability for treating IAAA remains controversial.

Our department treats all IAAA by performing laparotomy for the resection of the infected aneurysmal wall and the debridement of the surrounding infected tissue along with in-situ graft reconstruction and omentoplasty. This treatment strategy has provided satisfactory results in terms of both early and long-term postoperative out-

comes. Herein, we report our experience and these outcomes.

Subjects and Methods

The study was reviewed and approved by the institutional review boards. The present study investigated 27 consecutive patients with IAAA who underwent surgical treatment at our department between February 2010 and September 2017. Data on symptoms, treatment strategies, and prognosis were retrospectively obtained from the medical records. We included patients with primary IAAA and excluded those with aorto-enteric fistula or graft infection. In addition, patients with thoracic aortic aneurysm, thoracoabdominal aortic aneurysm, and solitary iliac aneurysm were also excluded. Postoperative survival rate was determined using the Kaplan–Meier method.

Results

Patient characteristics

Table 1 presents the characteristics of 27 patients. Twenty-six patients were males, and one patient was female. Median age at time of surgery was 69 (range, 48–90) years. Symptoms included abdominal pain and low back pain in 17 patients (63.0%) and fever of ≥37.5°C in 15 patients (55.6%). At initial examination, median white blood cell (WBC) count was 9,300 (range, 5,000–19,200)/μL and median C-reactive protein (CRP) level was 9.1 (range, 0.4–25.3) mg/dL. Inflammatory findings on blood test results (WBC count ≥9,000/μL and/or CRP ≥2.0 mg/dL) were observed in 24 patients (88.9%).

Table 1 Clinical and laboratory characteristics of the 27 patients

Age (years)	69	(48–90)
Gender (male)	26	
Comorbidity		
Diabetes mellitus	6	(22.2%)
Hypertension	23	(85.1%)
Dyslipidemia	6	(22.2%)
Coronary artery disease	6	(22.2%)
Cerebrovascular disease	2	(7.4%)
Renal dysfunction (CRN>2.0 mg/dL)	1	(3.7%)
Dialysis	1	(3.7%)
Malignant disease	2	(7.4%)
Smoking history	24	(88.9%)
Clinical symptoms		
Abdominal/Back pain	17	(63.0%)
Fever (>37.5°C)	15	(55.6%)
Laboratory findings		
WBC count (/μL)	9300	(5000–19200)
CRP level (mg/dL)	9.1	(0.4–25.3)
Serum albumin (g/dL)	3.1	(1.8–4.3)
Positive blood culture	3	(11.1%)

Data are presented as number (%) or median (range).
CRN: creatinine; WBC: white blood cells; CRP: C-reactive protein

Blood culturing was preoperatively performed for 26 patients. Three patients (11.5%) showed positive results: Staphylococcus aureus was detected in two and Streptococcus agalactiae in one. The remaining 23 patients tested negative for blood culture tests. All patients underwent contrast enhanced computed tomography (CT) imaging, which revealed irregular saccular protrusions of the aortic wall, saccular aneurysm, and rapid expansion or morphological change in the aneurysm. **Figure 1** presents typical CT images.

The diagnosis of IAAA was based on the presence of typical clinical symptoms (abdominal pain, lumbar pain, and fever) along with positive blood culture results, inflammatory findings on blood testing, and findings characteristic to IAAA on contrast enhanced CT imaging.

All cases were referred from another hospital. Twenty-

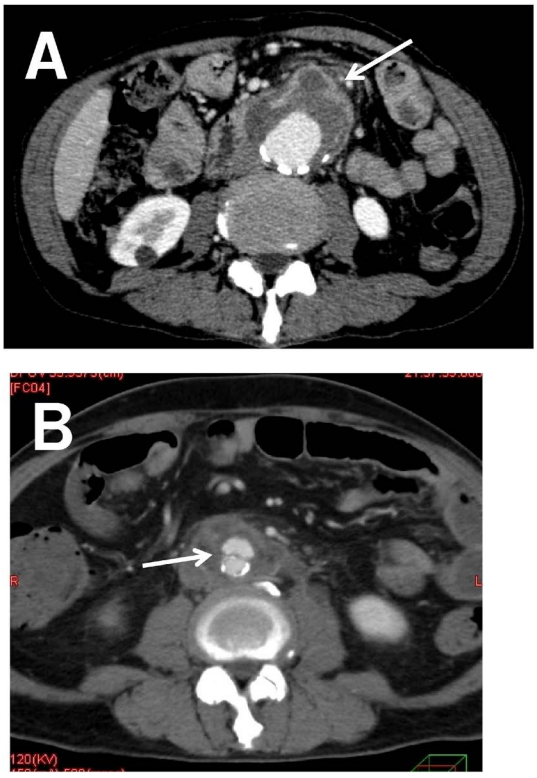

Fig. 1 Contrast enhanced computed tomography findings of the infected abdominal aortic aneurysm.
A: Showing an asymmetrical periaortic soft tissue mass and non calcified eccentric saccular and irregular aneurysm (arrow). **B**: Showing an irregularity of the aortic wall close to the periaortic soft tissue mass, and a vascular paraaortic structure without calcified walls adjacent to a non dilated calcified aorta, so-called double aorta (arrow).

four patients had already received antibiotics at the referring hospital. The remaining three had received antibiotic treatment immediately after transfer to our hospital. The median duration of preoperative antibiotic therapy was 14 (range, 1–52) days.

Treatment and outcomes

Laparotomy was performed as soon as the diagnosis was made.

Intraoperative findings revealed arterial wall rupture (sealed rupture) that may have been due to infection in 11 patients. Abscess formation around the aneurysm was observed in 13 patients and intra-aneurysmal suppurative thrombosis in six patients.

Surgery involved infected aneurysmal wall resection, surrounding tissue debridement, in-situ graft reconstruction, and omentoplasty (**Fig. 2**). For the graft, a rifampicin-soaked Dacron graft or autogenous superficial femoral vein (SFV) was used. A rifampicin-soaked woven Dacron graft was used in 24 patients: a branched graft was used in 16 and a straight graft in 8. Three patients received an SFV graft: 15–20 cm of autogenous superficial femoral vein was harvested from one side in advance before laparotomy, using which a branched graft was constructed. All grafts were wrapped with the greater omentum to cover the entire circumference and length of the graft.

The diagnosis of IAAA was confirmed by intraoperative macroscopic findings that suggested infection, such as abscess formation within the aneurysmal wall and edematous changes as well as supportive histopathological findings determined using surgical specimens, including neutrophil accumulation, inflammatory cell infiltration, and arterial wall rupture.

The mean operative duration was 311.8 ± 66.2 (range, 198–462) min. Mean estimated blood loss was 2,098.6 ± 1,597.7 (range, 562–7,158) g. No cell salvage device was used in any patient.

Early postoperative complications included temporary, partial paralysis (suspected spinal cord infarction) in one patient, chylous ascites in one, pneumonitis in one, paralytic ileus in two (both were mild and conservatively treated), strangulation ileus (removed by surgery) in one, Mallory–Weiss syndrome (endoscopically achieved hemostasis) in one, and choledocholithiasis and cholangitis (treated using endoscopic lithotomy) in one. There were no cases of recurrent aortic infection or graft infection. There were no surgery related deaths, deaths within 30 days of surgery, or in-hospital deaths (**Table 2**). The median postoperative hospital stay was 24 (range, 18–95) days.

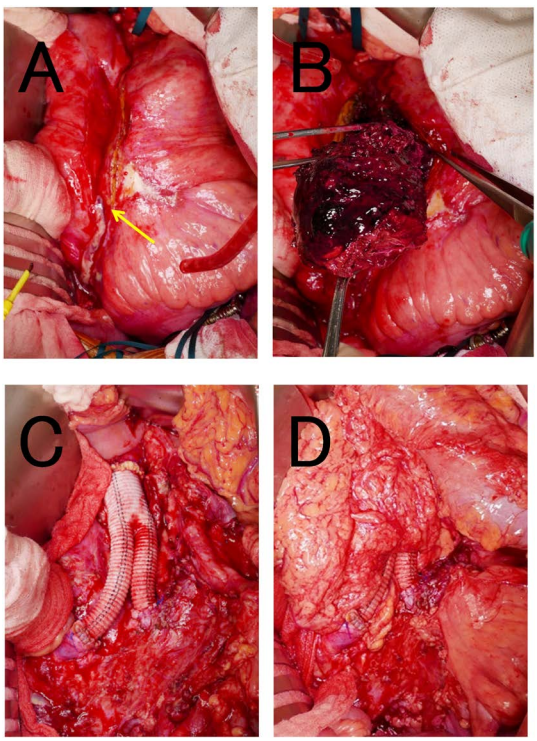

Fig. 2 Intraoperative findings of the infected abdominal aortic aneurysm.
A: The pus flowed out from infected aneurysm (arrow). **B**: Infected clot in aneurysms. **C**: After in situ replacement by rifampicin soaked Dacron graft. **D**: Graft is wrapped in omental pedicle flap.

Table 2 Early and late results

Perioperative complication	8
Vascular related complication	0
Graft infection	0
Graft occlusion	0
Non-vascular related complication	8
Spinal infarction	1
Chylous ascites	1
Pneumonia	1
Choledocholithiasis	1
Mallory–Weiss syndrome	1
Paralytic ileus	2
Strangulation ileus	1
Colostomy necrosis	1
Perioperative mortality	0
In-hospital mortality	0
Postoperative 30-day mortality	0
Postoperative mortality	6
Vascular related mortality	0
Graft infection	0
Graft occlusion	0
Non-vascular related mortality	6
Heart failure	1
Lung cancer	1
Pneumonia	2
Mediastinitis	1
Senility	1

Table 3 Bacteriology of infected aortic aneurysm

	Number (%)
Culture positive	13 (48.1%)
Staphylococcus aureus (MSSA)	2
Staphylococcus aureus (MRSA)	1
Staphylococcus capitis	1
Streptococcus agalactiae	1
Clostridium clostridioforme	1
Escherichia coli	1
Corynebacterium striatum	1
Aeromonas sobria	1
Listeria monocytogenes	1
Spirillum	1
Filamentous fungi	1
Bacteroides fragilis	1
Culture negative	13 (48.1%)
Uninspected	1 (3.7%)

MSSA: methicillin-sensitive Staphylococcus aureus; MRSA: methicillin-resistant Staphylococcus aureus

Table 4 Antibiotics used for treatment

Intravenous		Number
Carbapenems	(IPM/CS, MEPM, DRPM)	16
Penicillins	(ABPC/SBT, PIPC/TAZ)	7
Cephems	(CTRX, FMOX, CFPM)	5
Antifungal agent	(MCFG, AMB, ITCZ)	3
Others	(MINO, VCM, LZD, DAP, TEIC)	7
Oral		**Number**
Penicillins	(AMPC)	13
Cephems	(CCL, CFPN)	4
New quinolone	(LVFX)	7
Others	(VRCZ, EM, MINO)	11

Perioperative antibiotics are administered by intravenous, subsequently orally in outpatient. Multiple drug combination cases are included.
IPM/CS: imipenem/cilastatin; MEPM: meropenem; DRPM: doripenem; ABPC/SBT: ampicillin/sulbactam; PIPC/TAZ: piperacillin/tazobactam; CTRX: ceftriaxone; FMOX: flomoxef; CFPM: cefepime; MCFG: micafungin; AMB: amphotericin B; ITCZ: itraconazole; MINO: minocycline; VCM: vancomycin; LZD: linezolid; DAP: daptomycin; TEIC: teicoplanin; AMPC: ampicillin; CCL: cefaclor; CFPN: cefcapene pivoxil; LVFX: levofloxacin; VRCZ: voriconazole; EM: erythromycin

Bacteria were detected in the cultures of intraoperatively collected aneurysmal wall samples of 13 patients (48.1%) (**Table 3**). In these patients, antibiotic treatment was postoperatively revised to an appropriate antibiotic to which the detected bacteria were susceptible. For patients in whom no bacteria were identified by culture examination, the preoperative antibiotics were continued. Following surgery, antibiotics were intravenously administered for a median of 18 (range, 9–47) days until WBC count and CRP level normalized and inflammatory findings disappeared on CT imaging. Thereafter, oral antibiotics were used on an outpatient basis (**Table 4**). Median duration of oral antibiotic therapy was 169 (range, 24–443) days.

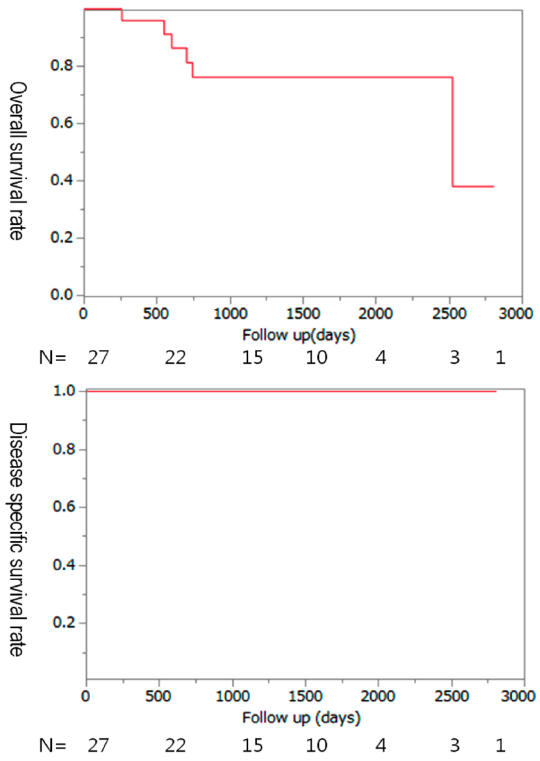

Fig. 3 Kaplan–Meier survival analysis.

During a median postoperative follow-up period of 1,147 (range, 167–2,804) days, none of the patients developed recurrent aortic infection or graft infection. Six late deaths were noted due to heart failure (n = 1), lung cancer (n = 1), pneumonia (n = 2), old age (n = 1), and mediastinitis (n = 1). There were no deaths related to IAAA or surgery (**Table 2**). One patient who died from mediastinitis had an underlying history of artificial heart infection; following surgery for IAAA, a repeat infection developed in the artificial heart of this patient after 2 years, which led to mediastinitis and sepsis. CT performed at the time of recurrent mediastinitis showed no findings of abdominal vascular graft infection.

The overall 5-year survival rate was 75.8%. In 27 patients, including six who died, no postoperative recurrent infections of the abdominal aorta or vascular graft occurred. The disease-related survival rate was 100% (**Fig. 3**). Five-year graft patency and lower limb amputation avoidance rates were both 100%.

Discussion

IAAA is a relatively rare condition that occurs in approximately 0.1%–3.4% of abdominal aortic aneurysms.

It is often difficult to diagnose and treat and has a high mortality rate (11%–36%), usually from rapid aneurysm expansion, sepsis, and aneurysmal rupture.[1–3] Surgical treatment involving the removal of the infection focus by in-situ graft reconstruction and omentoplasty has been considered to be effective[2,4,5]; however, this radical approach is invasive and is associated with high mortality and complication rates.[7,12,13] Thus, stent grafting has recently emerged as an alternative.[8,9] Stent grafting is minimally invasive, and some studies have shown no difference in outcomes of this technique when compared with those of in-situ graft reconstruction[14]; however, it may be associated with a high risk of postoperative recurrent infection,[10,11] and thus remains controversial. In our institution, the infected tissue debridement and in-situ graft reconstruction are performed soon after diagnosing IAAA in all patients.

In general, IAAAs present with abdominal pain, lower back pain, and fever.[1–3] As these were nonspecific symptoms, local physicians failed to accurately establish a diagnosis and continued symptomatic treatment with antipyretic analgesics and antibiotics before the patients were transferred to our hospital several days after the onset of symptoms, in some cases with symptom progression.

The definitive diagnosis of IAAAs requires the following: (1) the detection of bacteria cultured from the aneurysm wall and surrounding tissue and (2) clinicopathologic findings consistent with infection and inflammation.[1,3,6] Blood culture results may provide good evidence but may be insufficient. The reported positive rates range from 25% to 58%,[3,6] thus a definitive diagnosis is not necessarily achieved preoperatively. Therefore, in clinical practice, IAAA must be suspected based on clinical symptoms and signs such as abdominal pain and fever, inflammatory findings on blood testing, and CT imaging findings. CT imaging findings are particularly helpful as IAAAs have characteristic findings such as the hypertrophy of the soft tissue surrounding the aorta, contrast enhancement, and the presence of air bubbles.[13–15] Some patients show rapid expansion and/or morphological change of the aneurysm over several days on serial imaging studies, even when there are no obvious findings of infection on the initial CT. Ultrasound and/or CT examination should be performed several times if an IAAA is suspected. If the previously mentioned changes occur, then treatment should be promptly administered without delay to prevent rupture.

Reportedly, surgery should be performed after inflammation reduces following antibiotic treatment[16,17]; however, in our department, surgery is performed early, as soon as the diagnosis is made. We believe there is a benefit in the early removal of the infection focus to mitigate the risk of aneurysm expansion and rupture and to identify the causative bacteria as quickly as possible with tissue culture to choose an appropriate antibiotic treatment.

Previously, extra-anatomical bypass was a common treatment.[18] The advantage of this method is that an artificial graft is not used at the site of infection; however, previous reports have noted early postoperative mortality rates of 23%–44% and life-threatening complications such as graft obstruction, graft reinfection, lower limb amputation, and aortic stump rupture.[3,19] Therefore, in-situ graft reconstruction has become the standard treatment modality.[1,3,20]

With regard to the use of an artificial graft, initially performing in-situ graft reconstruction using SFV was selected for patients with serious infections or large abscesses. However, problems include a difference in the aortic diameter and difficulty of harvesting sufficient graft length for replacement. The utility of rifampicin-soaked Dacron grafts has been reported for the treatment of IAAA[4]; based on this, revascularization using a rifampicin-soaked Dacron graft was introduced in our department. Both grafting methods carry the risk of repeat infection, and therefore, it is considered important to surgically remove the infected aneurysmal wall and surrounding soft tissue as much as possible and to completely cover the graft with the greater omentum after debridement.

The culture results of infected tissue obtained during surgery were negative in 48.1% of the patients in this study. Other studies have reported positive tissue culture results in 64%–78% of cases.[3,4,21] We believe that negative culture results were noted because of the preoperative administration of antibiotics. When the culture result is negative, IAAA should be diagnosed based on macroscopic intraoperative findings, such as abscess formation and edematous change around the aneurysm, and histopathological findings, such as neutrophil accumulation, inflammatory cell infiltration, and destructed arterial wall structure.

In this study, for patients with positive blood culture or tissue culture results, appropriate intravenous antibiotics were selected based on susceptibility testing. For patients with negative culture results, preoperative antibiotics were presumed to be effective and were therefore postoperatively continued. After improvements in inflammatory parameters observed on blood testing and CT, we decided to continue long-term oral antibiotic therapy. Using this approach, no graft obstruction, lower limb amputation, or repeat graft infection was noted.

The early- and long-term outcomes in patients with IAAA who underwent radical treatment by in-situ graft reconstruction at our department were excellent. Our experience indicates that open in-situ graft reconstruction is useful for the surgical treatment of IAAA.

Conclusion

Based on our experience, laparotomy for the resection of infected aneurysm and tissue followed by in-situ graft reconstruction and omentoplasty in patients with IAAA can be safely performed and is associated with a good long-term outcome. As this was a retrospective single-center study with a small sample size of only 27 patients, further studies involving larger number of patients are required.

Disclosure Statement

All co-authors have no conflict of interest.

Additional Note

The original article was published in Japanese Journal of Vascular Surgery Vol. 28 (2019) No. 1; however, errors in a table and reference numbers were detected after the publication. The erratum was published in Vol. 28 (2019) No. 6 of the same journal. This translation reflects the corrections.

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