In Situ Reconstruction with Extended Debridement in Patients with Mycotic Abdominal Aortic Aneurysms

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The surgical outcomes in patients with mycotic aortic aneurysm are still poor. In situ reconstruction and extra-anatomical bypass are the 2 main surgical options used in these patients, both of which have postoperative complications: recurrence of infection and aortic stump blowout, respectively. We performed in situ reconstruction in 25 consecutive patients with mycotic abdominal aortic aneurysms together with extended debridement using an irrigation device, omental flap coverage, rifampicin-soaked prosthetic graft, and sufficient antibiotics administration. There were 3 in-hospital mortalities; however, no infection- or procedure-related adverse events were observed in other cases during the mid-term follow-up period.

Keywords: mycotic abdominal aortic aneurysms, debridement, in situ reconstruction

Introduction

Mycotic aortic aneurysm (MAA) is rare compared to other thoracic/abdominal aortic aneurysms; however, it could progress insidiously, especially in high-risk patients (so-called compromised host). For these patients, surgical treatment is closely correlated with high operative mortality and morbidity1); therefore, surgeons must plan their surgical strategy, including procedural options and perioperative antibiotic administration, according to individual patient conditions. Patients with MAA have poor surgical outcomes, and this has not improved despite advances in antibiotics and endovascular devices.1,2)

Extra-anatomic and in situ reconstructions are surgical options for patients with MAA. Recently, endovascular aneurysm repair has been performed as a bridging treatment for laparotomy if infections are well controlled; however, the method is still controversial.3) Extra-anatomic reconstruction has fewer risks of infection-related complications than in situ reconstruction; however, there is risk of aortic stump blowout and graft occlusion. Previous reports have suggested that extra-anatomic reconstruction should be performed in patients with gross pus or remnant inflammation, whereas in situ reconstruction is recommended for patients who respond well to antibiotics.4)

We performed surgery in all patients with mycotic abdominal aortic aneurysms (MAAAAs) via in situ reconstruction together with extended debridement using the Pulsavac system (Zimmer Biomet Nederland B.V., Dordrecht, the Netherlands), which is usually used in orthopedic surgery for wound irrigation and vacuum cleaning. In this study, we discuss the outcomes of our surgical strategy and perioperative treatment, including antibiotic administration.

Methods

Data were collected by means of a retrospective review of the medical records of patients with a diagnosis of MAAA. We obtained comprehensive informed consent from patients before the operation or at hospital admission to use their data while carefully managing their personal information. The diagnosis of mycotic aneurysm was made based on the patients’ symptoms, laboratory findings, blood or tissue cultures, and images obtained from contrast-enhanced computed tomography, in accordance with the definition previously reported by Pasic5): (i) infectious erosive arteritis with false aneurysm caused by infection of the aortic wall and (ii) manifestation of infection in a preexisting aneurysm, which can be caused by microorganisms. MAA was diagnosed when clinical
and histologic signs of infection were observed, including symptoms such as fever, abdominal or back pain, nausea, appetite loss, and computed tomography findings, including asymmetrical or rapidly expanding aneurysm with increased periaortic fat density. Patients with infected grafts were excluded.

**Preoperative care**

We administered antibiotics for at least 7 days preoperatively as a basic strategy, unless the hemodynamic condition of the patient was unstable. If the aneurysm enlarged, or ruptured, we performed the operation urgently, without waiting for the end of the 7-day administration period. We started with empirical administration of broad-spectrum antibiotics on admission. Thereafter, we changed to the most sensitive antibiotic based on the results of tissue or blood sample cultures.

Contrast-enhanced computed tomography was performed every 2 or 3 days to monitor geometric changes of the aneurysm during the preoperative period. The mean

| Case | Age | Gender | Timing of surgery | Status of rupture | Abscess | Causative microorganism | Postoperative complication | Outcomes (follow-up period) | Cause of death |
|------|-----|--------|-------------------|-------------------|--------|------------------------|--------------------------|----------------------------|----------------|
| 1    | 72  | Male   | Emergent          | Contained         | −      | Streptococcus Pneumoniae | None                     | Death (20 mo.)             | Skin cancer |
| 2    | 72  | Male   | Emergent          | Contained         | −      | *E. Coli*               | None                     | Alive (50 mo.)             |                |
| 3    | 73  | Female | Emergent          | Free              | −      | Streptococcus Pneumoniae | None                     | Death (16 mo.)             | Cerebral infarction |
| 4    | 58  | Male   | Early             | Contained         | −      | Streptococcus Epidermidis | None                     | Alive (60 mo.)             |                |
| 5    | 51  | Male   | Early             | Contained         | +      | *Salmonella*            | None                     | Alive (211 mo.)            | Sepsis        |
| 6    | 77  | Female | Emergent          | Contained         | −      | Anaerobic gram-positive cocci | None                     | In-hospital death (1 mo.) |                |
| 7    | 65  | Male   | Elective          | Contained         | −      | Streptococcus Pneumoniae | None                     | Death (8 mo.)              |                |
| 8    | 68  | Male   | Emergent          | Free              | −      | Streptococcus Pneumoniae | None                     | Death (52 mo.)             |                |
| 9    | 75  | Male   | Elective          | Contained         | −      | *Tuberculosis*          | Ischemic colitis         | In-hospital death (3 mo.) | Ischemic colitis |
| 10   | 83  | Male   | Emergent          | Contained         | −      | *MRSA*                 | Ischemic colitis         | Death (15 mo.)             | Esophageal cancer |
| 11   | 63  | Male   | Emergent          | Free              | +      | *Salmonella*            | Hyperbilirubinemia       | Alive (88 mo.)             |                |
| 12   | 68  | Male   | Early             | Contained         | +      | Gram-positive *Streptococci* | None                     | Alive (73 mo.)             |                |
| 13   | 55  | Male   | Early             | Contained         | +      | Negative               | None                     | Alive (62 mo.)             |                |
| 14   | 69  | Female | Emergent          | Contained         | +      | *Haemophilus influenzae Type b, MRSA* | Enteritis Unstable angina | Alive (63 mo.)             |                |
| 15   | 63  | Male   | Early             | Contained         | −      | Negative               | None                     | Alive (43 mo.)             |                |
| 16   | 83  | Female | Emergent          | Contained         | −      | *MRSA*                 | None                     | Death (3 mo.)              | Myelodysplastic syndrome |
| 17   | 62  | Male   | Early             | Contained         | −      | Negative               | None                     | Alive (36 mo.)             | Cerebral infarction |
| 18   | 64  | Female | Elective          | Intact            | +      | *MRSA*                 | None                     | Alive (35 mo.)             |                |
| 19   | 46  | Male   | Elective          | Intact            | −      | Negative               | None                     | Alive (37 mo.)             |                |
| 20   | 63  | Male   | Emergent          | Intact            | −      | Negative               | None                     | In-hospital death (5 mo.) |                |
| 21   | 77  | Male   | Elective          | Intact            | −      | Negative               | None                     | Alive (10 mo.)             |                |
| 22   | 73  | Male   | Elective          | Contained         | −      | Coagulase-negative *Staphylococci* | None                     | Alive (9 mo.)              |                |
| 23   | 82  | Male   | Elective          | Contained         | −      | Negative               | None                     | Alive (3 mo.)              |                |
| 24   | 68  | Male   | Elective          | Contained         | −      | Negative               | None                     | Alive (1 mo.)              |                |
| 25   | 87  | Male   | Elective          | Contained         | −      | *Mycobacterium tuberculosis complex* | Pneumonia | Alive (6 mo.) |                |
duration of preoperative antibiotics was 12 days (range, 0–52 days).

**Surgery**

We performed total excision of the aneurysm and extended debridement of the infected tissue, irrigation of the abdominal cavity, and in situ reconstruction of blood flow. Synthetic grafts were used in all cases, except for case 4, for which we used an autovenein graft for the aortoiliac arterial patch (Table 1). The preparation method changed during this study. Initially, we used unsoaked Dacron grafts in cases 1–3. In cases 5–7, we soaked the grafts in amikacin. From case 8 to case 25, we used gelatin-impregnated Dacron grafts soaked in rifampicin. The grafts were covered with an omental flap in all cases. We used the Pulsavac system for irrigation.

**Postoperative care**

We administered antibiotics intravenously for at least 3 weeks postoperatively, and then switched to oral antibiotics if clinical (i.e., febrile) or imaging signs (i.e., increased periaortic fat density) of infection disappeared. Our strategy involves lifelong intake of antibiotics. Postoperative surveillance was performed with routine physical and laboratory examinations and ultrasonography and/or computed tomography, every 6–12 months. Detailed investigation or re-intervention was considered if any signs of infection recurrence were observed.

Values are reported as mean ± standard deviation. Kaplan–Meier survival analyses were used to evaluate the rate of overall survival and rate of freedom from aortic/infectious events.

**Results**

From 1995 to 2015, 25 consecutive patients with MAAA underwent surgery at our institution. They consisted of 21 men and 4 women with a mean age of 68.7 ± 10.1 years. Most patients (23 of 25, 92%) were symptomatic. Specifically, 12 (48%) patients had abdominal pain, 7 (28%) patients had back pain, and 14 (56%) patients had fever. Case 11 had shock and multiple organ dysfunction, case 3 had shock, and case 14 had disseminated intravascular coagulopathy. Fourteen patients had immunosuppressive conditions, including diabetes mellitus (n = 7), long-term corticosteroid therapy (n = 4), malignant disease (n = 5), chronic renal failure (n = 1), and alcoholism (n = 1).

There were 3 timings for surgery according to the interval between diagnosis and surgery: emergent surgery was performed within 24 hours (n = 10), urgent surgery between 24 hours and 7 days (n = 6), and elective surgery after 7 days (n = 9).

The rupture status was classified into 2 types based on imaging and intraoperative findings: free rupture (n = 3) was defined as a tear in the aneurysmal wall and bleeding into free space, whereas contained rupture (n = 18), also known as pseudoaneurysm, was defined as a tear in the aneurysmal wall with bleeding covered by surrounding tissue, including the retroperitoneum, intestinal wall, or mesenterium. Conversely, true aneurysms were defined as aneurysms that were circumferentially surrounded by the aortic wall and intact (n = 4) (Table 1). Total excision with extended debridement of grossly infected tissues was performed in all cases except cases 1, 4, and 7 (Table 1).

Eleven patients had a history of antecedent infection, including meningitis (n = 2), enteritis (n = 2), purulent aortitis (n = 2), venous catheter infection (n = 1), urinary tract infection (n = 1), pyogenic cholangitis (n = 1), and liver abscess (n = 1). Pyogenic osteomyelitis of the lumbar spine was directly invading the abdominal aorta in case 13.

Causative organisms were detected in 16 (64%) patients. Blood cultures were positive in 6 patients, and abdominal wall cultures taken intraoperatively were positive in 10 patients. The aortic clamp site was infrarenal in almost all patients, except in patients with a suprarenal aortic clamp. Periaortic abscesses were present in 6 cases (24%). None of the patients presented with aortoenteric fistula (Table 1).

Due to the thorough removal of infected tissues, there were some cases of injuries to adjacent organs (inferior vena cava, 2; iliac vein, 2; ureter, 2), all of which were successfully repaired during surgery.

The mean length of hospital stay was 58 days. No graft-related complications occurred. There were 3 (12%) in-hospital deaths caused by sepsis, ischemic colitis, or cerebral infarction; we believe that all of these deaths were surgery related. None of the late deaths (6 cases) were related to either the surgery or initial infection (Table 1). The 5-year survival rate was 54% (Fig. 1).
causes of death are also listed in Table 1. There were no aortic events and only 1 case of sepsis postoperatively. We produced the Kaplan–Meier graph of the rate of freedom from aortic/infectious events, which is presumed to be linked to the procedure outcome (Fig. 2).

Discussion

Although surgical procedures, devices, and antibiotics have improved in recent decades, the outcomes of surgeries in patients with MAAs are still poor, compared to those in patients without MAAs.\(^1\)\(^2\) The most important and problematic aspect of the surgical procedure was complete exclusion of the infected periaortic tissue, because the remnant infection might cause events related to recurrent infection, such as local abscess, aortoduodenal fistula, and systemic sepsis. We assumed that the extra-anatomical bypass was originally a last resort to isolate newly implanted grafts from infected lesions. Although it increased the risk of stump blowout and limb loss due to bypass occlusion, we had to select this procedure based on the patient condition or other procedural factors. The surgery outcomes for patients with mycotic thoracic and suprarenal aortic aneurysms may differ from those for patients with infrarenal aortic aneurysms owing to the incision length, lesion, procedural methods, and surgeon skills. Our study, which demonstrated only the operative cases of patients with MAAA, can exclude such bias because we performed surgeries on all 25 consecutive cases via in situ reconstruction with debridement and without selecting extra-anatomical bypass as an alternative method. There were no aortic events, and there was only 1 case of sepsis. We attribute the good patient outcomes to our strategy, which consisted of extended debridement using an irrigation device.

Previous studies have reported the methods that surgeons select for these patients. Specifically, in situ reconstruction was performed in cases of low-grade infection, and extra-anatomical bypass was conducted in patients with severe purulent infection.\(^1\)\(^2\) These strategies may be reasonable if the degrees of infection were distinguished appropriately.

We used rifampicin-soaked gelatin-impregnated grafts after the 1990s. Theoretically, these are supposed to achieve a locally high concentration of antibiotics and have shown clinical antibacterial effects for some specific organisms, except for methicillin-resistant \textit{Staphylococcus aureus} (MRSA).\(^7\) Although cryopreserved allografts or autovein grafts are considered ideal for infected lesions,\(^8\) we did not use them routinely because there are some limitations to using these grafts in Japan. Besides their low supply, harvesting of autovein grafts consumes surgery time. In addition to omental flap coverage being a classic procedure, we also assumed that it would contribute to infection control together with the graft soaking in rifampicin.

We could not find a relationship between bacterial organisms and the adverse events observed. Among 3 in-hospital deaths, there was 1 case of tuberculosis, which we found to be resistant to antibiotics.\(^4\) MRSA is resistant to the rifampicin-soaked graft and generally considered to be one of the prognostic factors in patients with MAA. However, all 3 patients with MRSA in our series did not have infection-related events. Uchida et al. reported an excellent overall survival rate (95% at 5 year) in their study despite having 5 of 23 patients with MRSA.\(^9\) The surgical outcome might be affected by multidisciplinary treatment, including bacterial control, rather than by the organism itself.

In conclusion, in situ arterial reconstruction in combination with extended debridement, omental flap coverage, and appropriate antibiotic therapy is effective in the treatment of patients with MAAA.

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Disclosure Statement

There are no conflicts of interest for all authors.

Author Contributions

Study conceptions: YN, YH
Data collection: YN, MN
Analysis: KH
Investigation: KH, YH, MN, KH
Writing: NY, HK
Critical review and revision: KH, WT
Final approval of the article: all authors
Accountability for all aspects of the work: all authors

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