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Review Article

Multidisciplinary Treatment Approach for Prosthetic Vascular Graft Infection in the Thoracic Aortic Area

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Prosthetic vascular graft infection in the thoracic aortic area is a rare but serious complication. Adequate management of the complication is essential to increase the chance of success of open surgery. While surgical site infection is suggested as the root cause of the complication, it is also related to decreased host tolerance, especially as found in elderly patients. The handling of prosthetic vascular graft infection has been widely discussed to date. This paper mainly provides a summary of literature reports published within the past 5 years to discuss issues related to multidisciplinary treatment approaches, including surgical site infection, timing of onset, diagnostic methods, causative pathogens, auxiliary diagnostic methods, antibiotic treatment, anti-infective structures of vascular prostheses, surgical treatment, treatment strategy against infectious aortic aneurysms, future surgical treatment, postoperative systemic therapy, and antimicrobial stewardship. A thorough understanding of these issues will enable us to prevent prosthetic vascular graft infection in the thoracic aortic area as far as possible. In the event of its occurrence, the early introduction of appropriate treatment is expected to cure the disease without worsening of the underlying pathological condition.

Keywords: thoracic aorta, prosthetic vascular graft infection, multidisciplinary treatment

Introduction

The treatment strategies for thoracic aortic diseases have been changing significantly worldwide since the introduction of endovascular stent grafting. There is an increasing tendency to prefer less invasive stent grafting to conventional prosthetic vascular replacement that involves lengthy surgery, thoracotomy, and the risks of pulmonary complications due to the use of assisted circulation, surgical site infection (SSI) due to reduced immune function, and disuse muscle atrophy due to prolonged immobility. However, too much confidence in the endovascular procedure may lead to inadequate treatment, and complicate subsequent additional treatment of aorta-related diseases. Prosthetic vascular replacement is selected in cases of aortic aneurysm and aortic dissection that are anatomically or morphologically ineligible for endovascular stent grafting. In these cases, tight control of complications arising from massive invasion is critical. In particular, prosthetic vascular graft infection, which is known as a serious complication, requires multidisciplinary treatment approaches because it is a refractory pathological condition.

Prosthetic vascular graft infection during open surgery has an incidence of approximately 3%[1] and a high mortality of 25% to 75%,[2–4] and treatment is difficult in most cases. Infection associated with stent grafting is reportedly as serious as with open surgery, with an incidence of 1% or less and a mortality of 25%; and there is no difference in mortality between surgical and antibiotic treatments.[5] In

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any case, it is an accepted fact that prosthetic vascular graft infection is a serious complication. During case of open surgery, which depends more on the patient's condition and related medical environment than stent grafting, health-care staff involved in perioperative treatment take various approaches to prevent prosthetic vascular graft infection. Due to these efforts, we cardiovascular surgeons can control this serious infection with rapid, effective treatment. This paper provides a review of prosthetic vascular graft infection during open surgery in the thoracic aortic area and multidisciplinary treatment for it, based primarily on literature reports published within the past 5 years. We hope our paper will be useful during surgical aortic treatment, which is in the process of change.

Surgical Site Infection (SSI)

Almost all cases of prosthetic vascular graft infections, including both early and late prosthetic graft infections, are seemingly caused by so-called SSI. While thoracic aortic surgery is clean surgery, resident flora of the skin and falling bacteria during surgery can cause SSI. In the event of bacterial infection at the surgical site during surgery, neutrophils are recruited and suppress bacterial growth through phagocytosis. Antimicrobial therapy strongly supports neutrophilic phagocytosis. When bacterial growth is suppressed at this stage, some bacterial infections at the surgical site do not lead to SSI. If the suppression of bacterial growth fails at this stage, inflammatory findings may appear several days later, and SSI may develop and progress to prosthetic vascular graft infection. Therefore, whether SSI develops or not depends on the treatment during surgery and within the first several postoperative hours. To prevent prosthetic vascular graft infection with highly invasive surgical prosthetic replacement, closer attention than that paid during other kinds of surgery is required. The Centers for Disease Control and Prevention (CDC) published guidelines for prevention of SSI in 1999.[6] The guidelines provide preventive measures against SSI, including: (1) smoking cessation, (2) appropriate depilation, (3) blood glucose control, (4) preoperative skin antisepsis, (5) prophylactic antimicrobial therapy, (6) use of antimicrobial-coated absorbable sutures, (7) intraoperative replacement of gloves, (8) use of a closed sump drain, (9) preoperative nasal culture of methicillin-resistant *Staphylococcus aureus* (MRSA) and bacterial eradication, (10) intraoperative prevention of hypothermia, and (11) SSI surveillance. It is widely recognized that nasal carriers of *Staphylococcus aureus* constitute an important risk factor for nosocomial infection and SSI, whereas the usefulness of bacterial eradication with mupirocin or other antibiotics is controversial. Perl et al.[7] reported that mupirocin therapy produced a 48% reduction ($p = 0.02$) in the incidence of nosocomial infection due to *Staphylococcus aureus* among nasal carriers of this bacterium and a 35% reduction in the incidence of SSI; the reduction in SSI was not statistically significant. On the other hand, an updated version of *Annals of Surgery*[8] was issued in 2011. Recommendations provided in this version, most of which follow the CDC guidelines, include combination antimicrobial therapy with cefazolin and vancomycin for cardiac surgery and vascular surgery using prosthetic grafts.

Timing of Onset

Prosthetic vascular graft infections, most of which are thought to be caused by SSI, can be divided into two types: early prosthetic graft infections that occur within 4 months postoperatively, and late prosthetic graft infections that occur after 4 months postoperatively.[9] Most cases of early prosthetic graft infection begin with symptoms associated with sternal wound infection such as fever, cold sweat, chills, precordial pain, and purulent wound discharge within 30 days postoperatively. These symptoms are related to so-called SSI. However, some cases of early prosthetic graft infections exhibit none or very few of these symptoms and show only slight increases in while blood cell count and CRP.[1,4,10–12] Late prosthetic graft infections can occur 20 years or more postoperatively. Such remote-onset cases are unlikely to be caused by SSI.[10] Shiono et al.[13] examined the relationship between periodontal disease and infectious endocarditis. They reported a high incidence of oral lesions among patients with infectious endocarditis, and the same bacteria found in the mouth were also identified in the valvular tissue, vegetation, and blood samples. This indicates that opportunities for bacteria to enter the blood, not limited to periodontal disease, can constitute a risk factor for infection. In a report of basic research to investigate the pathology of prosthetic vascular graft infection, bacterial invasion was examined by measuring the bacterial load in saline in prosthetic vascular grafts that were immersed in the culture solution of *Pseudomonas aeruginosa*. In this study, two types of prosthetic graft, i.e., an elastomer- sealed vascular graft and a gelatin-coated Dacron vascular graft, were compared, and the bacterial invasion rate was lower for the elastomer-sealed vascular graft, which has a slightly thick, 3-layered vascular

wall structure. This report suggests that bacillemia may induce infection around the vascular graft because bacteria can penetrate the graft, and that the use of an elastomer-sealed vascular graft is less likely to result in serious conditions such as sepsis when prosthetic vascular graft infection occurs during the acute phase.[14]

Diagnosis

For a diagnosis of prosthetic vascular graft infection, contrast-computed tomography (CT) is useful and provides the following findings: (1) presence of perigraft fluid with a density of <20 Hounsfield Units, (2) presence of ectopic gas, (3) loss of normal tissue planes in the mediastinal and perigraft structures with an increased amount of soft tissue (>5 mm) between the graft and the surrounding sac, and (4) pseudoaneurysm formation.[15] Usually, hematomas around the aorta and gas around the vascular graft are absorbed within 7 weeks[16] and 1 week after surgery, respectively. Perigraft fluid or soft-tissue attenuation observed more than 3 months postoperatively suggests aortic graft infection.[17] Pseudoaneurysm, which occurs in 25% of prosthetic vascular graft infection cases, is not accompanied by such graft infection in most cases. Needless to say, pseudoaneurysm associated with infection occurs at an early postoperative stage and hematoma is enlarged relatively quickly.[18] While CT is useful for a diagnosis, the major disadvantages of CT imaging when diagnosing prosthetic vascular graft infection include decreased sensitivity in case of low-grade infection, difficulty to differentiate between normal postoperative changes and prosthetic vascular infection during the first 6 weeks after surgery.[19,20] Although diagnosis utilizing the features of the images is effective, CT-guided aspiration of cavity perigraft fluid collection enables the physician to accurately differentiate abscess formation from uninfected seroma or hematoma.

Magnetic resonance imaging (MRI) has the benefit of better soft tissue resolution that may help to differentiate subacute and chronic hematoma from inflammatory fluid in the perigraft area that may not be distinguishable on CT imaging.

Today, CT and fused fluorodeoxyglucose-positron emission tomography (FDG-PET)/CT have the highest diagnostic value to detect vascular graft infection. Fluorodeoxyglucose (FDG), which reflects glucose metabolism in tissues, is used for a diagnosis of malignancy, cerebral diseases, and inflammatory diseases accompanied by increased tissue metabolism. Some reports indicate the usefulness of FDG-PET-CT to identify the site of prosthetic vascular graft infection.[21,22] Other reports claim that PET-CT is very effective and reliable for a diagnosis of prosthetic vascular graft infection, as represented by 93% sensitivity, 91% specificity, 91% positive predictive value, and 96% negative predictive value.[23,24] Tokuda et al.[25] reported that a maximal standardized uptake value of >8 by FDG-PET-CT indicate a strong suspicion of prosthetic vascular graft infection. However, FDG-PET-CT is reported to reveal uptake in 92% of uninfected vascular grafts, indicating the need to know the specific patterns found with the presence and persistence of infection.[26]

Erba et al.[27] reported that (99m)Tc-HMPAO-leukocyte single photon emission computed tomography ((99m) Tc-HMPAO-WBC SPECT)/CT would be more useful than conventional radiological imaging to detect late, low-grade vascular graft infection. However, radioactive isotope (RI) imaging with a 50% to 90% accuracy rate has two limitations. Firstly, radionuclide uptake is non-specific in the early postoperative course (3 to 6 months after prosthetic graft implantation) due to the healing process and the anticipated perigraft inflammatory reaction, and secondly, this specific imaging technique is only infrequently available.[4,12,28]

Bacterial Strains

Identification of causative pathogens is important in patients with prosthetic vascular graft infection. However, tissue or blood cultures obtained from such patients for bacterial screening were negative in a third of them.[4] Therefore, it is standard to carefully obtain relevant intraoperative specimens from the perigraft fluid/pus collection, the prosthetic graft surface and tissue biopsies from the infected surrounding area.[29] Gram-positive bacteria, especially *Staphylococcus aureus*, are the prevalent pathogens involved in approximately 75% of all cases.[30] *Staphylococcus aureus* and coagulase-negative staphylococci possess virulence factors that facilitate their adherence to the prosthetic materials.[31,32] These include surface adhesion molecules and the ability to produce biofilm on the prosthetic surfaces. Biofilm on prosthetic surfaces constitutes a layer of extracellular matrix containing infective microbes. It coats the surface of prosthetic devices and protects the microorganism against the host immune response and interferers with antimicrobial penetration and killing of the organisms. Oxacillin-resistant *Staphylococcus aureus* and *Pseudomonas aeruginosa* infections are usually associated with more severe infections resulting in higher rates of

morbidity and mortality compared with low virulence organisms such as coagulase-negative *Staphylococcus*, *Corynebacterium*, and *Propionibacterium* species.[33,34] In acute-phase prosthetic vascular graft infection, systemic manifestations of infection such as fever, hypotension, and tachycardia are more frequent with more virulent organisms such as *S. aureus* and *P. aeruginosa*. Late-onset prosthetic vascular graft infection is usually associated with less virulent organisms such as coagulase-negative *Staphylococcus, Corynebacterium*, and *Propionibacterium* species.[35]

Auxiliary Diagnosis

In prosthetic vascular graft infection in the thoracic aortic area, imaging diagnostics play a critical role, besides examination of clinical symptoms. Assessment of blood markers is also important to understand the pathological severity. Through these approaches, appropriate treatment can be started rapidly. The diagnosis of sepsis secondary to mediastinitis or prosthetic vascular graft infection plays a major role in selecting a treatment approach as early as possible. Useful biomarkers include C-reactive protein (CRP), fibrinogen, white blood cells (WBC), major histocompatibility complex II (MHC II) density, lymphocyte CD4/CD8 ratio, and tumor necrosis factor-alpha (TNF-α). Among these, CRP is reported to be the most sensitive marker in an *in vitro* test of prosthetic vascular graft infection due to *Staphylococcus aureus*.[36] Biomarkers that increase along with open chest procedures and extracorporeal circulation, including CRP, are not useful for the differentiation of perioperative infections. Procalcitonin was reported as a protein marker for sepsis in 1993. Increased procalcitonin concentrations are specific to systemic inflammatory response syndrome caused by bacterial infection.[37] Since the marker reflects the severity of biological responses to trauma without infectious signs or at an early stage of surgery, an increase in procalcitonin concentrations is not necessarily infection-specific in these cases. Presepsin, a new biomarker, has been shown to be low in patients with systemic inflammatory response syndrome that is not complicated by infection and is not elevated in invasive trauma patients without concurrent infection. These features suggest that presepsin is more useful as a diagnostic marker for sepsis associated with prosthetic vascular graft infection after invasive surgery.[38,39]

Antibiotic Therapy

Appropriate treatment for patients developing prosthetic vascular graft infection is a combination of medical and surgical intervention. Treatment with medication alone is less effective and not recommended,[40] whereas appropriate antibiotic therapy has a great impact on surgical treatment and the vital prognosis. Intraoperative tissue specimens should be submitted to the microbiology laboratory for bacterial (gram stain) fungal (Gomori methenamine silver stain [GMS]), and mycobacterial (acid-fast bacteria [AFB]) stains and cultures. However, while awaiting the culture results, empiric broad-spectrum antibiotic therapy that includes coverage of resistant gram negative and gram positive organisms including methicillin-resistant staphylococci should be initiated. Empirical antifungal or anti-mycobacterial coverage is generally not needed. Total duration of antimicrobial therapy should be individualized and is usually based on clinical response and type of surgical intervention. However, in general, a minimum of 4 to 6 weeks of systemic antibiotic therapy is recommended. Duration of the antibiotic therapy should be counted from the day of the surgical debridement of the infected graft and the surrounding tissues. If infection is controlled after the end of 4-week intravenous antibiotic therapy following surgical intervention, the therapy is generally switched to oral medication. Appropriate duration of oral therapy is controversial. It is discontinued by necessity in the event of organ damage due to adverse drug reactions. Roy et al.[41] reported no cases of recurrent infection or organ damage after a median follow-up of 32 months, while another author reported recurrent infection in 7.3% and adverse drug reactions in 6.52% of assessed patients.[42] Optimal antibiotics are selected by drug sensitivity testing after identification of causative pathogens. Rifampin as perioperative antibiotic therapy after surgery is said to be effective for prosthetic vascular graft infection due to staphylococci.[43] Vancomycin is recommended for MRSA infections. If vancomycin lacks efficacy, linezolid is reported to be effective, with no difference in efficacy between oral and intravenous regimens, because of the better delivery to the bone, muscle, and skin tissues compared with other anti-MRSA drugs.

Anti-Infection Structures of Vascular Prostheses

Vascular prostheses for infection prevention have been actively studied. Among the coated grafts, silver-coated vascular prosthesis is suggested to be resistant to infection. As a coating agent, silver acetate is superior to vaporized metallic silver to reduce neovascularization and perigraft inflammation.[44] Rifampicin-bonded gelatin-sealed grafts, which are bonded to rifampicin with potent antibacterial

effects against gram-positive cocci, are reported to be useful.[45] The anti-infectious effect of rifampicin-bonded gelatin-sealed grafts is shown to be sustained for at least 3 days in animal tests but does not last very long. This indicates that, although there are no long-term preventive measures against prosthetic vascular graft infection, approaches with an anti-infectious effect for only several days can be effective for vascular reconstruction procedures.[46] To prolong the effect of rifampicin, Iida et al. developed a rifampicin-bonded gelatin-sealed graft using surfactant (Tween 80), and it has provided satisfactory clinical results.[47] Commonly reported drug concentrations are 0.5 to 1.0 mg/mL. A higher concentration of 10 mg/mL is reported to be more effective.[48] Gao et al.[49] infected the porcine abdominal aorta with *Staphylococcus aureus* and replaced it *in situ* with rifampicin-soaked silver-coated polyester (RSSCP) and expanded polytetrafluoroethylene (ePTFE) grafts to assess the onset of prosthetic vascular graft infection; the authors reported significant control of infection with RSSCP.

Surgical Treatment

The recommended treatments for prosthetic vascular graft infection in the thoracic aortic area include the removal of infected and necrotic tissues, debridement, and removal of infected prosthetic graft followed by aortic graft reconstruction. Treatments with homografts or xenografts are not generally accepted methods, despite some successful cases.[50,51] Aortic homografting is reported to be associated with low mortality and to enable avoidance of remote complications and re-operation,[52] but is not available or practical in routine clinical practice.

In 1999, Coselli et al.[1] reported a composite of aortic graft reconstruction and omental filling procedures after re-thoracotomy and debridement. Dacron grafts and homografts were used for prosthetic reconstruction. This series of surgical procedures resulted in high hospital and 1-year mortality rates of 27% and 36%, respectively. The mortality rates reported for aortic root replacement after sufficient debridement of infected tissues was even higher at 46%.[1,53–55] In 1984, Hargrove et al.[56] reported successful infection control by omental filling without removal of infected prosthetic grafts. This approach has subsequently produced favorable outcomes. The results of this approach were reported by Coselli et al.[1,4,54] The approach consisted of the following one-step procedures: (1) mediastinal, perigraft, and chest wall debridement, (2) intraoperative mediastinal antibiotic irrigation, (3) aortic coverage and closure of dead space with a vascular tissue flap, preferably an omental flap, and (4) sternal fixation and wound closure. Favorable results were obtained with 88% early survival rate and no recurrence.

During filling with omental or muscle pedicle flaps, infected prosthetic grafts are covered by blood-rich tissues and an adequate amount of antibiotics is delivered to the infected focus through systemic antibiotic therapy. This surgical technique is less invasive because it does not use a pump-oxygenator. The omentum is derived from the mesogastrium as a double layer of peritoneum, and it has a large absorptive surface and rich vascular and lymphatic supply and is a rich source of macrophages; it is extremely excellent as a filler tissue.[57] As musculocutaneous flaps, the latissimus dorsi muscle,[58] rectus abdominis muscle,[55] and greater pectoral muscle are useful. Removal and replacement of infected prosthetic grafts are needed for anastomosis with normal tissues when infection reaches the aorto-graft suture line with fragile anastomotic tissues, which may lead to anastomotic false aneurysm or rupture.[59]

Nakajima et al.[11] took the same approach in two steps and reported favorable results. The first step began with re-thoracotomy, removal of infected and necrotic tissues, and cleaning with 1% povidone iodine solution, followed by packing of the mediastinum with 10% povidone iodine solution and sponges. These cleaning and packing procedures were repeated every 8 hours under artificial ventilation. The second step, which was taken 48 hours later, consisted of an omental filling procedure and chest closure. The authors reported a 100% survival rate and a 100% recurrence prevention rate. Yamashiro et al.[60] reported that the operative mortality rates of patients with and without omental wrapping were 12.5% and 50%, respectively ($P = 0.06$, NS), and the 5-year event-free survival rates were 84.6% and 33.3% ($P = 0.025$). They used angiography to investigate blood circulation in omental flaps and reported well-preserved long-term blood circulation in the flaps.

These methods are presently used for the treatment of prosthetic vascular graft infection. Since the report of Obdeijin et al. in 1999,[61] vacuum-assisted closure (VAC) therapy has been spreading rapidly.[62] It is applied to refractory mediastinitis as a less invasive treatment. The VAC therapy involves stronger negative pressure than usual aspiration drainage, but is highly safe. The therapy facilitates granulation and neovascularization without damaging the tissues or anastomosed site and efficiently removes slime produced by bacteria and degradation products, and based on these functions, the therapy is expected to increase

the cure rate of mediastinitis and shorten the duration of treatment. Domkowski et al.[63] reported favorable outcomes with VAC therapy and successful primary direct suture in 53 of 96 patients receiving VAC therapy. Despite few reports on VAC therapy after thoracic aortic prosthetic replacement, its effectiveness after prosthetic vascular replacement has been reported.[3,64]

While some authors reported one-step procedures involving the removal of infected and necrotic tissues, debridement, and filling, followed by wound closure,[65,66] VAC therapy provides a more reliable approach, which reduces bacterial load and results in multiple negative bacterial culture, followed by filling with omental or pediculate muscle flaps. The timing of wound closure is comprehensively decided based on the following criteria: (1) improved histological findings and decreased drainage fluid, (2) negative results for tissue bacteria at two consecutive assessment procedures, and (3) blood sample monitoring of changes in inflammatory reactions and achievement of CRP ≤7 mg/dL.[67] In summary, the present surgical treatment for prosthetic vascular graft infection should be decided based on the causative pathogen, the severity of tissue breakdown due to infection, and the patient's general condition. After mediastinal sterilization, two-step filling procedures are performed. Tissue flaps for filling should be selected based on the size of the mediastinal space and the anatomical advantages.

Treatment Strategy for Infectious Aortic Aneurysm

Regarding prosthetic grafting in the infected site, namely, the treatment of infectious thoracic aortic aneurysm, the standard strategy consists of the removal of infected tissues to the extent possible, *in situ* revascularization, and long-term antibiotic therapy that is started perioperatively. Vascular prostheses to be used include rifampicin impregnated grafts, homografts, and xenografts. Recently, Czemy et al.[68] performed ascending aortic replacement using a self-made pericardial tube graft and reported favorable outcomes. Rahman et al.[69] reported a similar method using bovine pericardial sheets. During the surgical treatment of infectious aortic aneurysm, decreased immune function due to excessive surgical procedures and the use of a pump oxygenator may reduce the therapeutic effects, leading to difficulty to control infection. If possible, prosthetic vascular grafting after improvement of the general condition by means of preoperative antibiotic therapy, etc. may be effective. Rapid treatment is required in cases of impending rupture and broken aneurysms. Tamura et al.[70] reported a case of impending rupture of an infected thoracic aortic aneurysm; the authors performed thoracic endovascular aneurysm repair to avoid rupture, and after 2-week antibiotic therapy, they successfully performed *in situ* replacement using a rifampicin-bonded prosthetic graft as the second step. This will be an effective treatment approach in patients with infectious pseudoaneurysm after prosthetic replacement who are in an unstable condition due to sepsis, etc. For intraoperative debridement of the infection focus and graft cleaning, the use of saline containing antibacterial agents[71] or povidone iodine solutions[11] has been reported. Gentian violet has potent bactericidal activity against *Staphylococcus aureus* strains including MRSA and *Pseudomonas aeruginosa*, and also has antifungal activity, but is said to be ineffective against many gram-negative strains and tubercle bacillus.[72]

Future Treatment

Prosthetic grafts utilizing drug delivery system (DDS) technology have been developed to treat or prevent prosthetic vascular graft infection. In experimental *in vivo* studies, these grafts provide slow elution of antibiotics that prevent infection from *S. aureus* and *Staphylococcus epidermidis* for up to 2 weeks.[73] Other agents that are used to coat prosthetic grafts include polycationic peptides, quinupristin-dalfopristin, liposomal-encapsulated amikacin, vancomycin, teicoplanin, and 40% fusidic acid.[74–76] There are some reports of clinical application of polymethylmethacrylate beads loaded with antibiotics, including daptomycin, vancomycin, and gentamicin.[77–79] Aaron et al. [80] reported a case of infection of a prosthetic graft after replacement of the ascending aorta; the authors placed calcium sulfate beads impregnated with vancomycin and tobramycin around the infected graft and used a latissimus dorsi muscle flap for filling, resulting in cure. In experimental models, basic fibroblast growth factor incorporated into a prosthetic graft, with or without systemic granulocyte colony–stimulating factor, has been shown to induce angiogenesis around the graft and prevent prosthetic vascular graft infection.[81]

Systemic Therapy

In case of a weakened general condition associated with prosthetic vascular graft infection, not only local surgical treatment but also antimicrobial therapy with antibiotics is necessary, and nutritional management should also

be introduced to improve immune functions and increase the therapeutic effects. Intestinal management taking bacterial translocation due to the weakened general condition into consideration is also important. In diabetic patients who are susceptible to prosthetic vascular graft infection, blood glucose elevation related to the infection may exacerbate the infection. To prevent this situation, strict blood glucose control should be applied. Rehabilitation is also important as a preventive measure against new complications, such as pneumonia.

Antimicrobial Stewardship (AMS)

Increasing drug-resistant bacteria pose a worldwide problem. The major cause is suggested to be heavy use or abuse of antimicrobial agents.[82,83] On the other hand, the development of new antimicrobials has slowed recently. It is necessary to suppress the appearance of drug-resistant bacteria by promoting the use of existing antimicrobials. Prosthetic vascular graft infection may be induced in this context. In multidisciplinary treatment, antimicrobial stewardship (AMS) plays an important role to prevent the appearance of drug-resistant bacteria and increase the therapeutic effects through the promotion of proper use of antimicrobials.[84,85] In the United States, a report on antimicrobial doses indicates that overdose was found in 50% of antimicrobial use before the introduction of AMS, and dose adjustment based on AMS contributed to a decrease in adverse reactions to antimicrobials.[86]

Conclusions

Thoracic aortic treatment basically involves *in situ* replacement, and the use of artificial devices, such as synthetic vascular prostheses and stent grafts, cannot be avoided. This leads to a low rate of infectious complications. Since these complications may become more serious than those found in other areas, multidisciplinary treatment is important. A thorough understanding of these issues will enable us to prevent prosthetic vascular graft infection in the thoracic aortic area as far as possible. In the event of its occurrence, the early introduction of appropriate treatment is expected to cure the disease without worsening of the underlying pathological condition.

Disclosure Statement

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