Review

Clinical Trends in Optimal Treatment Strategy for Type A Acute Aortic Dissection

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The mortality rate in emergency surgical intervention for type A acute aortic dissection (AAD) has been variously reported as 15%–30%. These findings are often derived from series spanning 10–20 years. Many factors, such as surgical techniques, use of sealed prosthesis, access to cardiopulmonary bypass, cerebral protection techniques, and postoperative surveillance, have markedly changed during this long time interval, influencing the recently improved surgical outcomes. Earlier referral to the operating theater improves surgical results before dissection-related complications become irreversible. Preoperative malperfusion of the vital organ, pulse less shock, and required cardiopulmonary resuscitation are independent predictors of operative mortality. Deep hypothermia itself and very long cerebral perfusion are associated with a higher incidence of neurological injury. Moderate hypothermic circulatory arrest (28°C) followed by aggressive rapid rewarming is safe and makes the surgery much quicker while providing a less-invasive procedure. Especially for octogenarians, recently developed less-invasive techniques are quite attractive. When the entire aortic arch replacement is required, additional open-stent implantation is effective to avoid further dilatation of descending false lumen. According to a review of previous reports, recent advances in surgical techniques are quite likely to have lowered the mortality of emergency operations for AAD to less than 10%. (Ann Thorac Cardiovasc Surg 2010; 16: 228–235)

Key words: aortic dissection, brain protection, less invasive surgery, elderly

Introduction

Acute type A aortic dissection (AAD) is a lethal disease with extremely poor prognosis. DeBakey, a pioneer in the development of cardiovascular surgery, initially classified the different types of acute aortic dissection.[1] It is surprising, and even ironic, that DeBakey himself was stricken with type I aortic dissection at the age of 97. He survived after emergency surgery, however, and was the oldest patient in the world to successfully undergo AAD surgery. He died at 99 in July 2008. As evidenced by Dr. DeBakey, in our recent aging society the number of octogenarians undergoing emergency surgery for AAD has been steadily increasing, and this may negate the impact of the beneficial advances, even though many factors, such as surgical techniques, use of sealed prosthesis, access of cardiopulmonary bypass, cerebral protection techniques, and postoperative surveillance, have markedly changed during this long time interval to influence the recently improved surgical outcomes. We then review clinical trends of the optimal treatment strategy for type AAD.

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Primary Care

When we consider the aging patient populations in Western and Asian societies with prolonged survival despite hypertension, and the excellent diagnostic modalities being

made available to more and more patients, we are made aware that cardiovascular centers face increasing incidences of AAD. The prognosis of AAD depends on prompt diagnosis and the subsequent start of treatment because early mortality rate increases by 1% to 2% every hour after the onset of AAD.[2] More than 60% of patients die before reaching a hospital, and mortality rate is approximately 7.3% within one hour after the onset, 12.4% within 6 hours, 11.7% within 12 hours, and more than 90% within 24 hours.[3] Therefore all patients with suspected AAD should be admitted to an intensive care unit and be treated immediately upon arrival, regardless of the type of dissection. Intravenous beta blockers, calcium antagonists, and/or nitroglycerin should be started as soon as possible, and the use of morphine is also important for pain relief. During primary care, it is essential to take the patient to the operating theater as soon as the diagnosis has been made. On the other hand, asymptomatic AAD also exists and is indicated in 9%–20% of AAD sudden-death cases or cases that happen to be diagnosed in public health examinations.[2]

In the primary care of AAD, delayed diagnosis and referral may result in an advanced state of deterioration because of prolonged hemopericardium/tamponade or malperfusion, thus causing multiple organ failure. It is generally accepted that patients with AAD require emergency surgery to prevent hospital death after the onset of dissection. However, the mortality rate in emergency surgical intervention for AAD still remains unsatisfactory in many institutions; it has been variously reported as 15%–30%.[4–8] Recent advances in surgical techniques, anesthesia, and perioperative medical management are quite likely to have lowered the mortality rate of emergency operations over the past few years. On the other hand, the complexity of patients undergoing this procedure in regard to age, comorbidities, and concomitant procedures is ever increasing and may negate the impact of the beneficial advances.

Outcome for Surgical Intervention

Currently available surgical techniques yield good immediate and long-term results with minimal risk in operations for AAD. After 15 years of experience, Ehrlich et al. reported hospital mortality and long-term survival rates were 15.3% and 54% at 10 years, respectively.[4] From 22 years of experience, Bachet et al. reported that actuarial survival rates, including hospital deaths, were 71.5%, 66%, 56.4%, and 46.3% at 1, 5, 10, and 15 years, respectively.[5] Bernard et al. reported from 13 years of experience that actuarial survival rates were 52%, 46%, and 37% at 1, 5, and 10 years, respectively.[8] As in the above, these findings are often derived from experience spanning 10–20 years or more. Many factors, such as surgical techniques, use of sealed prostheses, cerebral protection techniques, and postoperative surveillance have in fact markedly changed during this long time interval, influencing the recently improved surgical outcomes.[7-11] For example, open distal anastomosis to avoid aortic cross clamping and antegrade systemic recirculation after distal anastomosis have dramatically improved the early and late outcomes of surgery for AAD.[7,12] Biologic glue has enabled us to preserve the native aortic valve whenever possible and to avoid prosthesis-related and anticoagulation-related complications,[13,14] Even though cerebral metabolism was diminished by deep hypothermic circulatory arrest (DHA), the risk of death would increase when the DHA time exceeded 60 minutes.[15] Selective cerebral perfusion (SCP) has led us to use the most appropriate cerebral protection to prevent the "safe" period of circulatory arrest from being exceeded.[16] Furthermore, a postoperative examination with magnetic resonance imaging (MRI) can be done to determine the patency and dilatation in the false lumen in a later phase.[17] During the past two decades, we have used recently available techniques of these kinds that were relatively similar among patients.

Recent data from the International Registry of examining AAD (IRAD) showed preoperative hypotension, shock, and cardiac tamponade to be independent predictors of operative mortality.[2,18] However, many investigators agree that cardiac tamponade and hemodynamic shock could be defined as a permanent deterioration in systolic blood pressure to below 90 mmHg.[19,20] Our opinion is that preoperative hypotension with systolic blood pressure of less than 90 mmHg is quite common for AAD patients and that tamponade is present in most AAD cases.[21] Although it does not always mean aortic rupture, it does always threaten the patient's life and may be fatal if not relieved. In general, patients with cardiac tamponade had systolic blood pressure of less than 60 mmHg, and they are almost always brought to the operating theater within 24 hours after onset. We believe that these patients can be rescued by immediate surgical intervention, even though their preoperative systolic blood pressure is less than 60 mmHg. However, if cardiopulmonary resuscitation (CPR) is required for shock with arterial pulse less and respiratory distress evident, malpurfusion in the vital organs might have already developed during

the resuscitation. Bayegan et al. reported that preoperative severe cardiac tamponade without palpable pulses were associated with preoperative death.[20] This might mean that most patients requiring CPR in previous worldwide AAD studies could not reach even the operating theater.[22,23] In Japan, the Japanese Association for Thoracic Surgery database shows that emergency surgical mortality was 10.4% in 2007, which is much better than in Western and Asian countries.[24]

Surgical Procedures

The first priority of our emergency surgical intervention for AAD is primary tear excision and avoidance of serious complications. In the great majority of patients, an ascending or proximal arch replacement is sufficient because the intimal tear is generally located in the concavity of the transverse arch.[21] However, when the it is in the aortic arch, total arch replacement should be carried out for tear excision. Several investigators advocate systematic extended or total aortic arch resection for the initial surgical management of AAD, irrespective of the intimal tear location.[25,26] Although those provide satisfactory results, we must always keep in mind that AAD is an inherently lethal condition. Our first job is to produce a live patient. If the patient survives the acute episode, this constitutes a success, regardless of later onset of further aortic problems. Such extended approach will necessarily increase an already-high operative risk. Ehrlich et al. report that the site of the intimal tear does not influence the outcome, but the mortality rate is higher with more extensive resection.[6] In fact, Kazui et al. reported that the early mortality rate of emergency total arch replacement was 16%, and the freedom from reoperation was 77% at 5 years.[25] Even though the emergency intervention for primary tear excision was performed, our results showed that freedom from reoperation was 85.6% at 8 years.[27] Bachet et al. also showed that closure of the entry site during the initial emergency operation resulted in a reduced rate of reoperation.[28] We believe that extended surgery largely outweighs the relatively low incidence of reoperation and the associated operative risk. Westaby et al. have advocated the same policy of primary tear excision, namely: "conservative pathology-oriented approach".[29] We previously reported that the overall hospital mortality rate was 6.3%.[27,30] This seems to be much better than those in the previous reports demonstrating a worldwide hospital mortality of 15% to 20%.[31–34] Similarly, Westaby et al. presented excellent surgical results, showing an overall hospital mortality for AAD of just 6.3%.[29]

Mild to moderate aortic regurgitation (AR) is well tolerated. Many patients are left with mild to moderate AR after AAD repair and do well for many years. This represents a successful outcome, even if further surgical attention is required many years later.[27, 35] The severity of AR usually improves even from simple tube graft replacement of the aorta, which brings the aortic valve leaflets closer to coaptation. Furthermore, biological glue has enabled us to preserve the native aortic valve whenever possible and to avoid prosthesis-related and anticoagulation-related complications.[36] The quality of the aortic wall adhesion by gelatin resorcin formalin (GRF) glue may explain the absence of late AR in most patients because the deformation of the aortic annulus could be repaired, and the commissure support system could also be restored by adhesion of the dissected layers. Several reports from Japan and Europe have recently questioned the toxicity and the adverse role of GRF glue in the occurrence of late redissection of the aortic root. Indeed, the formalin-glutaraldehyde mixture is highly toxic.[37,38] However, chemical injury by GRF glue is avoidable by an appropriate minimum usage of glue to mix approximately 1 part formalin to 10 parts gelatin.[27] But we should not hesitate to replace the aortic root for AAD if necessary, though some authors have considered this riskier.[35] That's because preoperative moderate-to-severe AR is a significant risk factor for the development of postoperative AR and may result in early reoperation on the aortic root.[39]

Cerebral Protection

In AAD surgery, cerebral protection is the most important factor, and the lack of it is the best predictor of hospital mortality.[40] Several ancillary measures, such as SCP (Fig. 1) and retrograde cerebral perfusion (RCP), in addition to DHA, have been advocated.[41,42] Ueda et al. reported the effectiveness of RCP.[43] They outline that its advantages include uniform brain cooling, de-airing of the arch vessels, capability of flushing of the cerebral emboli, flushing of toxic metabolites that accumulated during DHA, and provision of oxygen and substrates.[42] Coselli et al. reported that the mortality rate (7.9%) and stroke rate (2.4%) of patients undergoing aortic surgery with DHA and RCP were significantly lower than those with only DHA.[44] Safi et al. also demonstrated that RCP showed a protective effect against stroke.[45] However, the physiological advantage of RCP has not been clarified. Svensson et al.

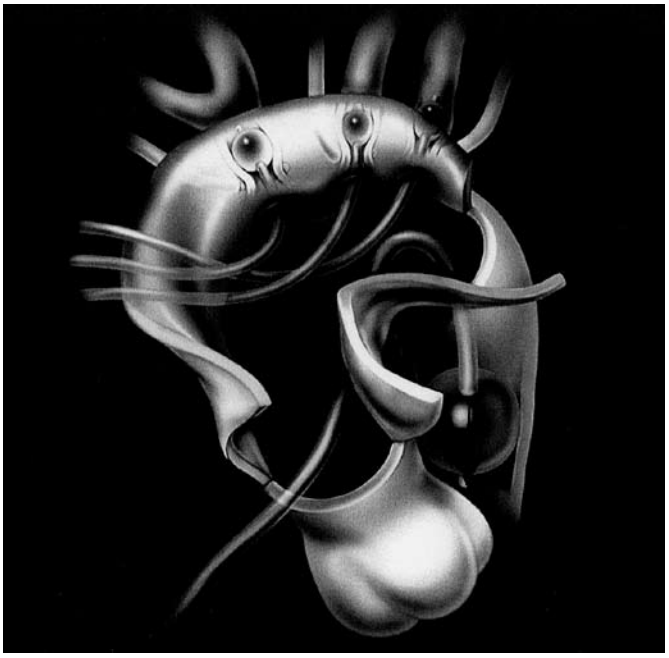

Fig. 1. Antegrade selective cerebral perfusion.

reported that the brain was incompletely perfused by the RCP method.[46] Although RCP can extend the safety duration of DHA, it is considered to be limited to 80 minutes.[47] Furthermore, most of the efforts to document significant improvement in cerebral metabolic function as a result of nutritive flow during RCP have failed.[48] On the other hand, Hagl et al. reported that the method of cerebral protection did not influence the occurrence of stroke, but that SCP resulted in a significant reduction in incidence on temporary neurological dysfunction.[49] However, SCP also has the more serious potential disadvantage of requiring manipulation of cerebral vessels, with the risk of dislodging atherosclerotic debris.[41] Several reports indicated that most permanent neurological injuries were due to strokes from embolic phenomena and were not directly related to the method of cerebral protection used.[46,50] Cook et al. reported that systemic temperatures below 22°C may not be necessary and may be associated with a higher incidence of neurological injury when SCP is used during DHA.[51] Greeley et al. reported that patients cooled to 28°C had a predicted brain ischemic tolerance of 11 to 19 minutes.[52] In the ascending to proximal hemiarch replacement, the open distal anastomosis could be completed within 20 minutes at the moderate hypothermic circulatory arrest (26°C to 28°C) without any additional cerebral perfusion.[53,54] Fortunately, in most patients with AAD, proximal arch replacement is sufficient because the intimal tear is located in the concavity of the transverse arch.

Strategy for Thrombosed AAD

With the development of CT and MRI, which confirmed that clots and hematomas fill false lumens, steps in the progression of hematomas have become clear. This type of dissection is well known as thrombosed dissection. Controversy remains about treatment strategy for the acute type A thrombosed aortic dissection.[55,56] Even if the initial CT scan reveals a thrombosed occlusion, emergency surgical treatment should be recommended because cardiac tamponade could develop during surgery. In fact, we often encountered patients who had a thrombosed occlusion-type condition without hemopericardium in the initial CT finding, and they actually presented about 400 ml of blood and hematoma at the time of surgery.[33] Several investigators also reported high mortality and morbidity associated with medical treatment for patients with thrombosed AAD.[57,58]

For Elderly Patients (Octogenarian)

Becausue of the ever-increasing human lifespan, cardiovascular surgeons are faced with treating an increasing number of elderly patients. The efficacy of emergency

surgical intervention for AAD is well accepted, but its role in the treatment of octogenarians with AAD remains unclear. Surgical mortality and morbidity rates are especially high in the elderly compared to younger patients.[5,6,10,31] Therefore controversy still exists as to whether surgical intervention should be avoided in elderly patients who have little chance of survival. Elderly patients are a high-risk group for neurological complications, and sometimes dementia also develops in the very elderly, even though the surgery is successful. This is another issue for emergency surgery on octogenarians. If the patients are completely bedridden, the family must continuously look after them. Therefore in this era of diminishing economic resources for health care, the controversy remains whether such expensive surgery should be offered to such elderly patients.[32] In the elderly with AAD, even though the patient died on the operating table, the patient's family was satisfied that they had not elected to go ahead with the surgery and expressed their appreciation. However, if the patient had suffered complications such as cerebral damage, depression, pneumonia, or renal failure and ultimately became bedridden, the family would suffer significant mental, physical, and economic stress. In fact, in our patients in which the patient survived the surgery but subsequently became bedridden, the families complained bitterly and refused payment.[33] The in-hospital survival rate for octogenarians with AAD was definitely better when emergency surgical treatment was provided than for those who had none. However, significant improvement in long-term mortality is considered difficult because the older age of the patient includes physiological and pathological factors related to the normal degenerative process of senescence. Furthermore, impaired autonomy or bedridden status following emergency surgery is another concern; therefore fully informed consent that describes the prognosis after emergency surgery is mandatory in regard to aggressive surgical treatment for octogenarians with AAD.[5,7,33,34]

A Less Invasive New Procedure for The Elderly

Octogenarians often have a concomitant disease, such as renal insufficiency, chronic obstructive pulmonary disease, peripheral vascular disease, or degenerative cerebral disease.[59] Therefore they may be unable to tolerate the aggressive surgical stress of deep hypothermia, a long duration of cerebral exclusion, or cardiopulmonary bypass (CPB). Furthermore, a prolonged operation can increase mortality through coagulopathy, cerebral ischemia, infection, or multiple organ failure.[29] So especially for octogenarians, the performance of surgery with minimum invasive stress is considered to be a key factor in saving lives and maintaining quality of life.

Recently, the durations of brain protection, CPB, and total operation for AAD have been reported to be approximately 60, 200, and 400 minutes, respectively.[60–62] They all require DHA and additional SCP. But these durations are unnecessarily long. It has been generally accepted that rewarming from DHA should be conducted as slowly as possible.[63] In the proximal arch replacement in AAD, however, moderate hypothermic arrest at 28˚C with no adjunctive cerebral perfusion within 20 minutes for open distal anastomosis is safe.[53,54] Fortunately, in the surgical intervention for AAD, a partial or hemiarch replacement is sufficient in most patients. The patients that cooled to 28˚C demonstrated a return to baseline in cerebral blood flow during rewarming and after weaning from CPB.[52] Therefore it may be no problem to induce rapid rewarming after circulatory arrest with moderate hypothermia (28˚C). Moreover, this can shorten the durations of CPB and overall operation. We performed a newly modified technique, less-invasive quick replacement (LIQR) with moderate hypothermic circulatory arrest followed by aggressive rapid rewarming in emergency surgery for AAD in octogenarians, and it presented no incidence of brain injury, reexploration for bleeding, renal failure, respiratory failure, or hospital death.[64] Our shortest CPB and operation times were 53 and 101 minutes, respectively. In general, quicker is not always better. However, we believe that quicker surgery definitely results in a better outcome because it can minimize the surgical stress resulting from hypothermia or CPB minimum for such a lethal disease.[65]

Additional Open-stent Technique

In most patients, an ascending or proximal arch replacement is sufficient because the intimal tear is generally located in the concavity of the transverse arch.[21] However, some patients had patent residual false lumen, which had progression of their aneurisms after replacement of the ascending to the entire aortic arch.[66,67] This problem was resolved by a recent and more aggressive approach to surgical treatment of AAD; using entire aortic arch replacement combined with implantation of a stented elephant trunk demonstrated a low incidence of reoperation.[68] However, many problems remain to be resolved in this open-stent approach. Although open-stent

implantation is easier to perform than conventional entire arch replacement and is more effective and reliable for closing the residual false lumen, this procedure cannot prevent neurological complications such as bleeding, stroke, or paraplegia as a result of longer CPB and lower body arrest time.[69] Further modification of this technique by shortening CPB and spinal cord ischemic time and reconstruction of the left subclavian artery may reduce neurological complications.

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