Improved outcome after repair of descending and thoracoabdominal aortic aneurysms using modern adjuncts

Department of Cardiothoracic Surgery, Mount Sinai Medical Center, Mount Sinai School of Medicine, New York, NY, USA
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Abstract

Objective: To evaluate current strategies to decrease spinal cord and organ dysfunction in patients undergoing repair of descending and thoracoabdominal aneurysms. Methods: We reviewed 94 consecutive cases of descending and thoracoabdominal aortic aneurysm repairs to determine the impact of modern adjuncts on postoperative neurologic deficit and mortality. The adjuncts used in these patients included perioperative cerebrospinal fluid drainage, distal aortic perfusion, reattachment of critical intercostal vessels, permissive hypothermia and hypothermic circulatory arrest with antegrade cerebral perfusion. Between December 1999 and March 2005, 24/94 (26%) patients were operated on for thoracoabdominal aortic aneurysm type I, seven (7%) for type II, 25/94 (27%) for type III or type IV, and 38/94 (40%) for descending thoracic aneurysms. Perioperative parameters were collected for all patients, and analyzed retrospectively. Results: Twenty (21%) of the patients required hypothermic circulatory arrest for conduction of the operation. The postoperative rate of paraplegia was 3% (3/94). One patient developed temporary paraparesis. Overall operative mortality was 10% (9/94). This included 12/94 (13%) patients who underwent surgery emergently for ruptured or contained rupture of aortic aneurysm. Conclusion: Use of perioperative cerebrospinal fluid drainage, distal aortic perfusion and permissive hypothermia result in a low incidence of spinal cord injury and a low operative mortality.

Keywords: Abdominal aortic aneurysm; Neurologic deficit; Postoperative complications; Spinal cord protection; Thoracic aortic aneurysm

1. Introduction

Since its inception in the early 1950s, repair of descending (DTA) and thoracoabdominal aortic aneurysms (TAAA) has been associated with significant risk of postoperative spinal cord injury and mortality [1–4].

Several adjuncts, aiming to increase the ischemic tolerance time of the spinal cord during the period of cross-clamping, have been proposed [2–4]. CSF drainage and distal aortic perfusion (DAP) have been shown to lower the incidence of neurologic complications following repair of DTA and type I and II TAAA [4]. DAP increases distal aortic pressure, and CSF drainage decreases CSF pressure. These techniques lead to an augmentation of the spinal perfusion pressure during the period of the aortic cross-clamping. Other important adjuncts are reattachment of critical intercostal vessels and permissive hypothermia. The aim of this study is to evaluate the effects of these adjuncts on spinal cord injury and mortality after repair of DTA and TAAA.

2. Materials and methods

Between December 1999 and March 2005, 94 patients underwent repair of descending and TAA aneurysms. The patients’ charts were reviewed and more than 350 pre-, intra- and postoperative parameters on each patient were entered into an Excel® data sheet. The statistical analysis was performed using SPSS statistical software.

There were 50 men and 44 women. The median age was 65.5 years (range 24–85). Significant preoperative risk factors included hypertension in 85 patients (90%), cerebrovascular disease in 18 (19%), smoking in 53 (56%), diabetes in 22 (23%), coronary artery disease in 32 (34%), and chronic obstructive pulmonary disease in 25 (27%). Chronic aortic dissection was the etiology of the aneurysmal dilatation in 24 patients (25%), trauma in 1 patient (1%), and medial degeneration in 58 (59%). There were 38/94 (40%) patients with DTA, 24/94 (26%) with TAAA type I, seven (7%) patients with type II, 15/94 (16%) with type III and 10/94 (11%) with type IV according to Crawford classification [5].

After induction of general anesthesia, a CSF catheter was introduced into the L4 and L5 space, and a silastic catheter was advanced within the intrathecal space over a guide-wire. The CSF pressure was monitored and CSF was drained as needed to maintain the CSF pressure below 12 mmHg.
for the first 72 h. Left atrial femoral bypass was established using a centrifugal pump. Distal flows were maintained between 1.5 and 2.5 l/min during the procedures. The aorta was clamped sequentially above the diaphragm or below the visceral arteries as needed. Patent T8-L1 intercostal arteries were reattached using Carrel technique in 41 patients (44%). The core temperature was allowed to drift passively between 32° and 34 °C in the majority of cases. Hypothermic circulatory arrest was used in 20 (21%) patients. Median hypothermic circulatory arrest time was 27 min (range 21–56). These patients were cannulated in the femoral vessels, and cooled down to 18 degrees, before the circulation was stopped. After the proximal anastomosis was performed, antegrade cerebral perfusion at 0.5–1 l/min was initiated via a side branch attached to the graft. Patients were rewarmed after distal anastomosis was completed.

3. Results

Median CSF drainage was 37.5 ml (range 5–250) during the operation. Mean bypass time was 40 min (range 21–60). Median aortic cross-clamp time was 45 min (range 18–96). The in-hospital mortality was 9.6% (9 of 94 patients). Six out of 56 (10.7%) were patients with TAAA. Patients with types III and IV TAA, according to Crawford classification, had a higher in-hospital mortality (2/15 and 2/10, respectively), when compared to patients with types I and II (2/24 and 0/7, respectively). The in-hospital mortality for patients with DTA was 3/38 (8%).

Four of the 94 patients (4.3%) developed paraplegia or paraparesis. One of the patients with paraparesis recovered completely. The overall rate of postoperative paraplegia and paraparesis for patients with DTA was 1/38 (3%). In patients with TAAA, two developed immediate spinal cord injury, while one patient with type III TAAA developed delayed paraplegia. The incidence of spinal cord injury in types II and III TAAA was 1/4 (1/17) vs. 13% (2/15). Patients with types I and type IV TAAA had no evidence of postoperative spinal cord injury.

Nine patients (10%) had postoperative respiratory failure requiring tracheostomy. Seven of the patients (7.4%) developed new renal failure requiring dialysis and 3/94 (3%) had a postoperative myocardial infarction. Seven patients (7.4%) required re-exploration for bleeding.

Univariate statistical analysis of pre-, intra- and postoperative parameter revealed the following risk factors that are associated with adverse outcome. In patients with TAAA, risk factors associated with development of postoperative spinal cord injury were previous ascending aortic aneurysm, renal occlusive disease, and intraoperative perfusion of celiac, superior mesenteric, or renal artery (P<0.05). Preoperative coronary artery disease was associated with postoperative stroke in patients with TAAA (P<0.05), while a history of percutaneous coronary intervention was a risk factor for postoperative myocardial infarction (P<0.05). Risk factors for in-hospital mortality in patients undergoing repair of TAAA were a history of coronary artery bypass grafting, preoperative ejection fraction below 40%, preoperative creatinine 2.5, and reattachment of intercostal arteries (P<0.05).

In patients undergoing repair of DTA, a history of coronary artery bypass grafting was a risk factor for developing postoperative myocardial infarction (P<0.05). Univariate statistical analysis failed to demonstrate any significant risk factors associated with postoperative neurologic injury in patients with DTA. In-hospital mortality in these patients correlated with a history of aortic/cardiac operation and preoperative PaO₂<70 mmHg (P<0.05).

The incidence of adverse events was too low to perform a meaningful multivariate analysis. This would have been helpful in identifying independent risk factors associated with spinal cord injury, myocardial infarction, stroke or death.

4. Discussion

This study shows that CSF drainage and distal aortic perfusion played a key role in preventing paraplegia/paraparesis during the repair of TAAA and extensive descending thoracic aneurysms. Safi et al. showed that the use of distal aortic perfusion and atriofemoral bypass may decrease the incidence of neurologic complications, particularly in the very high-risk group of patients with type I and type II aneurysms [4]. The combination of both techniques leads to an increase in spinal cord perfusion, and consequently allows enough time to perform the surgical repair of complex thoracic and TAA aneurysms. Also, distal perfusion reduces left ventricular stroke work and the proximal systemic pressure without the need for significant pharmacologic manipulation. Hence, the clamping and unclamping of the aorta can be performed without significant hemodynamic fluctuations, facilitating the fluid and anesthetic management of the patient. The use of the BioMedicus pump is clearly superior to shunts, because it allows very precise control of the flow rates, as well as the proximal and distal aortic pressures. Adequate distal aortic pressure is ensured by sufficient urine output (0.5 cc/kg/min).

The benefit of these techniques can be realized when they are used in conjunction with sequential clamping of the aorta. Indeed, when the aorta is cross-clamped, either above or below the subclavian artery and at the mid-descending thoracic aorta, all the patent intercostal arteries below the distal clamp are perfused, thus preventing ischemia of the spinal cord during construction of the proximal anastomosis. At the same time, maintaining perfusion of the visceral arteries may have a beneficial effect in preventing renal insufficiency, as well as liver and intestinal injury, which potentially can lead to severe coagulopathy and multisystem organ failure [6,7].

It has been shown that the artery of Adamkiewicz originates from the aorta between T8 and L1 in 85% of the cases. We routinely reimplant all intercostal arteries originating from that segment of the aorta using the aortic button technique [8]. However, we recognize that postoperative arteriograms have shown that only 50% of these reimplanted arteries are patent, which makes it difficult to accurately evaluate the significance of reimplantation of intercostal arteries in preventing paraplegia [9].

Passive hypothermia has been used in all cases. We have intentionally allowed the body temperature to drop to
32–34 °C during the procedure. Hypothermia, by decreasing the metabolic demands of the spinal cord, may be beneficial in preventing postoperative paraplegia. At the completion of the operation, the patients were rewarmed to 37 °C.

Critical to the success of the CSF drainage technique is the unmitigated flow of CSF, as first advocated by Hollier and Moore [9]. The amount of CSF drained is dependent on the CSF pressure, which has to be kept below 10–12 mmHg. Indeed, in a previous report in which the amount of CSF withdrawn was limited to a maximum of 50 cc, no benefit—in terms of preventing paraplegia/paraparesis—was shown [10].

This study showed that the use of CSF drainage and left atrial femoral bypass had a positive effect on decreasing postoperative spinal cord ischemic complications in descending and TA aortic aneurysm repairs. The results in this study compare favorably to the results of other contemporary series using CSF drainage and distal bypass [6,11] or various other techniques for spinal cord protection [8–13]. However, CSF drainage and atriofemoral bypass have been used exclusively for all aneurysms in this series, including descending thoracic aneurysms, which have a relatively low risk for spinal cord ischemic complications. Nonetheless, even in those cases, there is still an appreciable risk of neurologic complications, which may be decreased by the use of the above techniques. Indeed, these techniques carry a low risk of complications, which makes them very attractive.

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References