How-to-do-it

Combined distal aortic perfusion and balloon occlusion to facilitate the repair of complex thoracic and thoracoabdominal aortic aneurysms

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Abstract

We investigated a unique method utilizing a Heartport bifurcated arterial cannula and an aortic occlusion balloon to provide both distal perfusion and bloodless, distal arterial exposure during repair of thoracic and thoracoabdominal aortic pathology. Between February 2002 and September 2008, 21 patients underwent thoracic or thoracoabdominal aortic repair with this method. Because of an inability or potential difficulty in achieving distal aortic control secondary to anatomic or technical challenges, a compliant balloon was passed through the accessory arterial channel using fluoroscopic guidance. Adjunctive cerebrospinal drainage was used in all cases. Balloon deployment and satisfactory occlusion was attained in all cases. The overall 30-day mortality rate was 4.75% (1 of 21 patients). Renal failure occurred in one patient (4.75%) and heart failure occurred in two patients (9.5%). Six patients (29%) had pulmonary complications. Transient encephalopathy occurred in two patients (9.5%). Spinal cord neurologic deficit and stroke were avoided in all patients. We recommend the application of this simple method to obtain a bloodless anastomotic field and maintain ongoing distal aortic perfusion in instances where distal control with a clamp is challenging, not feasible or presents the potential for catastrophic intra-operative bleeding.

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1. Introduction

Obtaining distal arterial control is imperative for the repair of descending thoracic and thoracoabdominal aortic aneurysms. This is generally accomplished by open dissection and securing of the normal artery. Several circumstances make the procurement of such control with atraumatic clamps difficult or impossible. These include vessel fragility, scarring or infection in the area where distal control is to be obtained, the presence of stents, heavy circumferential calcification or plaque formation, or difficult angulation of the target vessel, which prevent all clamps from successfully occluding the vessel lumen.

This article describes a unique method utilizing a Heartport bifurcated arterial cannula and a large, compliant aortic occlusion balloon (Coda®, Cook, Inc., Bloomington, IN, USA) to provide both distal perfusion and bloodless, distal arterial occlusion in these and other difficult circumstances.

1.1. Surgical technique

The operating room table is positioned with the pedestal towards the patient’s feet, to allow passage of a fluoroscopic C-arm along the torso for appropriate catheter positioning. After executing the appropriate exposure (fifth interspace thoracotomy for thoracic pathology, or a thoraco-phrenolaparotomy in the sixth intercostal space, with proximal section or resection of the sixth rib when necessary for more extensive disease), the proximal aorta is then isolated.

After a left groin incision and exposure of the femoral artery and vein, heparin is administered (250 UI kg⁻¹) and a bifurcated catheter (Heartport®, Redwood City, CA, United States) for distal aortic perfusion is placed in the left common femoral artery. Fluoroscopically guided wire placement is then utilized to successfully navigate a long 28 French catheter into the right atrium for the venous portion of cardio-femoral bypass, and the occlusion balloon is deployed in the appropriate portion of the aorta (Fig. 1)

2. Results

The 30-day survival rate over the 6-year period of study was 95% (20/21). One patient had transient spinal cord dysfunction (lower-extremity paraparesis) which was
resolved prior to discharge, and there was no incidence of paraplegia (postoperative characteristics are presented in Table 1).

A bloodless, distal anastomotic field was accomplished with the occlusion balloon in all cases. There was one complication related to the operative technique. Dacron patch arterioplasty of the femoral artery was required in one case after the removal of the inflow cannula. However, there were no complications related to wire passage or balloon manipulation, and there were no incidences where distal clamping was required to obviate malfunction or rupture of the occlusion balloon.

3. Discussion

Despite the vast cardiovascular technical evolution over the past 30 years, aneurismal pathology of the thoracic and thoracoabdominal aorta continues to represent a challenge for surgeons [1], owing to the difficulty in anatomic localisation, complexity of their surgical repair, and arduous perioperative management. The inherent risk of massive blood loss, radical hemodynamic fluctuations, and limited tolerance of the target organs to ischaemia [2] also contribute to the formidable morbidity and mortality associated with repair. Numerous strategies exist to minimise these factors, varying from pharmacologic initiatives [3,4] (mannitol, steroids and vasodilators) to surgical strategies [5,6] (hypothermia, sequential cross-clamping, and intercostal re-implantation) and mechanical devices [7] (cerebrospinal fluid (CSF) drainage, retrograde perfusion and extracorporeal perfusion).

Native vessel abnormalities, such as fragility, scarring, infection, heavy circumferential calcification or stents, present further challenges to the operator during such difficult cases. Conventional approaches to these problems involve open, direct deployment of a balloon catheter to obtain a bloodless field. However, this technique is plagued by excessive blood loss during placement, frequent dislodgement secondary to perfusion back-pressure and creation of a cumbersome, unstable field for graft anastomosis.

The technique described in this report overcomes these difficulties. By applying a multidisciplinary approach to the operative care of these patients, difficulty in obtaining distal control can be eliminated as a contributor to the multifactorial nature of the procedural problems. Further, by using a bifurcated arterial cannula from a remote site for access, this advantage can be seamlessly combined with the benefit of distal organ protection.

We recommend the application of this simple method to maintain ongoing distal aortic perfusion in instances where distal control with a clamp is challenging or presents the potential for catastrophic intra-operative bleeding.

Table 1
Postoperative complications (number/percent).

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postop, maximum creatinine (mg dl⁻¹)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5—1.1</td>
<td>2</td>
<td>9.5%</td>
</tr>
<tr>
<td>1.2—1.5</td>
<td>2</td>
<td>9.5%</td>
</tr>
<tr>
<td>1.6—2.4</td>
<td>9</td>
<td>43%</td>
</tr>
<tr>
<td>2.5—14</td>
<td>8</td>
<td>38%</td>
</tr>
<tr>
<td>Reoperation for bleeding</td>
<td>2</td>
<td>9.5%</td>
</tr>
<tr>
<td>Cardiac (heart failure)</td>
<td>2</td>
<td>9.5%</td>
</tr>
<tr>
<td>Stroke</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>Renal</td>
<td>2</td>
<td>9.5%</td>
</tr>
<tr>
<td>Spinal cord complication</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>6</td>
<td>29%</td>
</tr>
<tr>
<td>Wound complication</td>
<td>2</td>
<td>9.5%</td>
</tr>
<tr>
<td>Gastrointestinal complication</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>Sepsis</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>Mortality</td>
<td>1</td>
<td>5%</td>
</tr>
</tbody>
</table>

References


Appendix A. Conference discussion

Dr V. Falk (Zurich, Switzerland): Dr Watson and colleagues present a simple yet effective method for distal aortic occlusion in complete thoracoabdominal repair. The clinical outcome is outstanding and the absence of neurological complications deserves attention. I have two questions.

Do you see any future application of adding a second balloon for a double-balloon occlusion balloon technique, and thus be able to isolate one segment of the thoracic aorta avoiding any clamps in certain scenarios?

Dr Watson: Addressing the first question, we have used this technique in one circumstance to obtain proximal control. It did require a pre-dissection of the right axillary artery and passage of the balloon to get proximal control. That is not included in this case in terms of trying to acquire uniformity.

Our one hesitation, that is, in the U.S. the technology, the Heartport cannula itself costs about $1000, which is maybe, what, 200 Euro, and to us that’s a lot of money. And the balloon is also expensive. So we do try and limit that. And if we can place a clamp simply, we do that. And as I say in my first slide showing the children, typically one end in our experience is simple, the other end we’ll use the more expensive technology.

And the other question, in our dissection cases we’re very careful to monitor the pressure with a manometer and we have not used it in a dissected aorta to date. We always deploy it in a normal aorta. And I think there would be the potential for injury in a dissected aorta without a doubt.