How to do it
Pressure-adjusted antegrade brain perfusion for surgery of the aortic aneurysm

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Abstract

Determining cerebral blood flow during circulatory arrest in patients undergoing surgery for aortic aneurysms has been traditionally based on body weight. We report the use of per-aortic antegrade cerebral perfusion regulated by perfusion pressure using a triple lumen cardioplegia catheter thus optimising cerebral flow.

Keywords: Aortic aneurysm; Cerebral protection; Pressure-adjusted antegrade; Cerebral perfusion

1. Introduction

In order to extend the safe limits of cerebral protection without subjecting the patient to the unwanted systemic effects of deep hypothermia in aortic aneurysm surgery, various methods of selective antegrade cerebral perfusion have been advocated [1]. Regardless of their precise modalities, these techniques share in common the reliance of cerebral perfusion on a given flow rate calculated for body weight. The technique described herein has been designed to specifically address this issue by adjusting blood flow to cerebral arterial pressure.

2. Patients and methods

From February 1997 to February 1999, 20 consecutive patients were operated on for aortic aneurysm under circulatory arrest. The diagnosis was based on transesophageal echocardiography (TEE) in 15 patients and/or on CT scan and TEE in seven.

Cardio-pulmonary bypass (CPB) was established between the femoral artery and the right atrium. Myocardial protection was assured by continuous retrograde blood cardioplegia at the systemic temperature through the coronary sinus.

Once the temperature of CPB circuit was reduced to 25°C, CPB flow was lowered to approximately 500–700 ml/min, and the aortotomy extended to the innominate artery. Two manual inflatable ribbed-balloon triple-lumen retrograde cardioplegia cannulae (Sarns, 3M, Ann Arbor, MI) were inserted in the innominate artery (17 F) and left carotid artery (13 F) and secured in place by gentle balloon inflation with saline (Fig. 1). These allowed continuous intra-arterial pressure measurements.

Cerebral perfusion was then initiated through a separate line originating from the arterial part of the oxygenator and distally connected to these cannulae. The flow rate was set so as to achieve a distal perfusion pressure of 50 mmHg. In more lengthy procedures, the subclavian artery was occluded by a Foley catheter to avoid a steal syndrome. The whole segment of diseased aorta was resected en bloc and an appropriately sized dacron prosthesis was anastomosed. The prosthesis was subsequently cross clamped and cannulated for antegrade CPB and the patient was rewarmed while the proximal aortic anastomosis was completed.

3. Results

Intraoperative data are reported in Table 1 and the cerebral flow patterns are shown in Fig. 2. There were two deaths. One was due to low output syndrome in a patient with preoperative shock. The second death occurred after a reoperation for bleeding which was subsequently complicated with multi-organ failure. There was no postoperative neurological deficit (defined as focal or general neurological deficit) except for one patient who had a preoperative stroke.
and was ultimately discharged with an upper limb motor
deficit. Two patients had an acute renal failure and recov-
ered rapidly without dialysis. As a whole, six patients did
not receive blood nor blood products in the post-operative
period.

4. Discussion

Most techniques of selective antegrade perfusion involve
transfixing cannulation and carry the risk of inducing vessel
injury. This risk could be minimised by using retrograde
cardioplegia catheters whose distal tip balloons can be
gently inflated until the vessel lumen is adequately sealed
as we have previously reported [2].

A major interest of this technique, aside from limiting
intimal damage, is to allow adjustment of cerebral blood
flow on pressure rather than on body weight, as it is usually
done. There is convincing evidence that cerebral vascular
resistance continuously changes throughout the period of
hypothermia. At 25°C, the cerebral flow falls to 50% of
theoretical value, cerebral vascular resistance is doubled
and the oxygen extraction ratio which in normothermic
CBP was found to be 45% fell to 18% [3]. Furthermore,
hemodilution is known to reduce cerebral vascular resis-
tance and increase cerebral flow [3] whereas the use of
barbiturates frequently associated as neuro-protectants
increases cerebral vascular resistance by capillary vasocon-
striction. Therefore, maintenance of a fixed body weight-
adjusted flow may lead to dramatic fluctuations in perfusion
pressure and may cause brain damage consequent to hypo
[4] or hyperperfusion [5]. This is particularly of value in
patients who present with pre-operative stroke as frequently
seen in dissecting aneurysms. Knowing that the microvas-
cular bed of the ischemic zone loses its autoregulation after
stroke, a high pressure flow can lead to membrane damage
and consequent cerebral edema with aggravation of the
neurological status [6]. Conversely, reliance on perfusion
pressure allows to match cerebral flow to changes in cere-
bral vascular resistance in an on-line fashion, thereby help-
ing to preserve metabolic homeostasis in the
hypothermically-perfused brain. Fig. 2 shows how different

<table>
<thead>
<tr>
<th>Patients</th>
<th>Age/sex</th>
<th>Body weight (kg)</th>
<th>Bypass time (min)</th>
<th>Circulatory arrest time (min)</th>
<th>Selective cerebral flow time (min)</th>
<th>Selective cerebral flow (ml)</th>
<th>Selective cerebral pressure (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>56.15</td>
<td>77.75</td>
<td>141</td>
<td>34.8</td>
<td>30.65</td>
<td>444</td>
<td>47.750</td>
</tr>
<tr>
<td>Standard error</td>
<td>2.879</td>
<td>3.209</td>
<td>13.101</td>
<td>5.146</td>
<td>4.693</td>
<td>31.106</td>
<td>0.547</td>
</tr>
</tbody>
</table>
perfusion patterns can be depending on whether flow is fixed or pressure-regulated. In our protocol, a target perfusion pressure of 50 mmHg was selected on the basis of experimental [7] and clinical studies [8] showing that this value is both safe and effective.

Despite our encouraging results, we are aware of the limitations of this study; a limited number of patients, absence of control group and lack of cerebral metabolic endpoints. However, our data support the claim that pressure controlled endoaortic cerebral perfusion under moderate hypothermia is more physiological and can be an effective means to protect the brain during surgery of dissecting aneurysm.

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References


Fig. 2. Cerebral cannula flow obtained in our series of patients adjusted to perfusion pressure of 50 mmHg (lower curve) compared to theoretic values as if flow had been adjusted to body weight calculated by the formula 10 ml/kg (upper curve).