Cerebral Protection
In Aortic dissection

Davide Pacini

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UNIVERSITY OF BOLOGNA - ITALY
FINANCIAL DISCLOSURE: NONE
Cerebral protection in type A AoD
Antegrade Selective Cerebral Perfusion

Antegrade Cerebral Perfusion With Cold Blood: A 13-Year Experience

Joan Raich, MD, David Covertz, MD, Bertrand Couleau, MD, Gilles D., Diesner, MD, R.L. Deodirudley, MD, Ann E. Dresdale, MD, and C.L. Deperdieu, MD

Service de Chirurgie Cardiovasculaire, Hôpital de la Pitie-Salpêtrière, Paris, France

Background: In 1996 we introduced the technique of antegrade selective perfusion of the brain with cold blood during surgery of the aortic arch. This technique has been used in our institution since March 1996. We report our experience over a 13-year period, including 64 patients who were alive and well at 5 years or more. The patients were divided into two groups: group I (1996-2000) and group II (2001-2013). Group I patients had a mean age of 56 years (range 20-87) and a mean New York Heart Association (NYHA) functional class of II (range I-II). Group II patients had a mean age of 68 years (range 22-85) and a mean NYHA functional class of III (range I-II). The neurological complications were significantly lower in group II compared to group I.

Conclusions: Our study confirms the safety and efficacy of antegrade selective cerebral perfusion with cold blood during surgery of the aortic arch. The technique is simple, easy to perform, and avoids the risks associated with retrograde cerebral perfusion.

Key Words: Antegrade cerebral perfusion; Cold blood perfusion; Selective perfusion of the brain.

Antegrade Selective Cerebral Perfusion During Operations on the Thoracic Aorta: Our Experience

Roberto Di Bartolomeo, MD, Davide Pacini, MD, Marco Angelone-Ferrandini, MD

Department of Cardiovascular Surgery, University of Bologna, Italy

Background: Various methods of cerebral protection have been used during aortic arch operations. Deep hypothermic circulatory arrest is the most commonly used technique but has a limited safety period for circulation arrest. Selective cerebral perfusion has been introduced to extend the safe period of circulation arrest. We reviewed our experience with antegrade selective cerebral perfusion during operations on the thoracic aorta.

Methods: Between November 1996 and December 1998, a total of 50 consecutive patients were operated on for aortic arch aneurysms using selective cerebral perfusion. For our first 20 patients, we used an in-house designed perfusion system. For the remaining 30 patients, we used the Thoracic Aorta Cerebral Perfusion Device (TACPD). The mean age of the patients was 62 years (range 35-80).

Conclusions: Our results indicate that antegrade selective cerebral perfusion is a safe and effective method for cerebral protection during operations on the thoracic aorta.

Key Words: Cerebral protection; Aortic arch operations; Antegrade selective cerebral perfusion; Thoracic aorta.

Antegrade Selective Cerebral Perfusion Attenuates Brain Metabolic Deficit in Aortic Arch Operations: A Prospective Randomized Trial

D.K. Hung et al.

Background: Brain injury associated with aortic arch surgery is a significant concern. Several studies have shown that antegrade selective cerebral perfusion can attenuate brain metabolic deficit in aortic arch operations. The aim of this study was to evaluate the safety and efficacy of antegrade selective cerebral perfusion in attenuating brain metabolic deficit in patients undergoing aortic arch operations.

Methods: This was a prospective, randomized, controlled trial. Patients were randomized to either the control group or the intervention group. The control group received standard perioperative care, while the intervention group received antegrade selective cerebral perfusion. The primary endpoint was the change in cerebral blood flow (CBF) and cerebral metabolic rate for oxygen (CMRO2) in the perioperative period.

Results: A total of 100 patients were enrolled in the study. The intervention group had a lower change in CBF and CMRO2 compared to the control group. The difference was statistically significant. The side effects of antegrade selective cerebral perfusion were minimal and transient.

Conclusions: Antegrade selective cerebral perfusion is a safe and effective method for attenuating brain metabolic deficit in aortic arch operations. This technique should be considered as a standard of care for patients undergoing aortic arch surgery.

Key Words: Aortic arch operations; Antegrade selective cerebral perfusion; Brain metabolic deficit; Central nervous system.

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Key Words: Aortic arch operations; Antegrade selective cerebral perfusion; Brain metabolic deficit; Central nervous system.
## Cerebral protection: the problem

Isselbacher et al., Circulation. 2016

<table>
<thead>
<tr>
<th>Management</th>
<th>Type A Aortic Dissection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
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<tr>
<td>Medical</td>
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<td>Surgical</td>
<td>2090 (86.7)</td>
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<td>Endovascular</td>
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### Pre or post neurological injuryes

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<th>Condition</th>
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<td>582 (25.5)</td>
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<td>701 (30.7)</td>
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<td>Preoperative or postoperative limb ischemia</td>
<td>289 (12.8)</td>
<td>4 (4.5)</td>
</tr>
<tr>
<td>Preoperative or postoperative cardiac tamponade</td>
<td>444 (19.5)</td>
<td>7 (8.0)</td>
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<tr>
<td>Preoperative or postoperative mesenteric ischemia</td>
<td>141 (6.2)</td>
<td>2 (2.2)</td>
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<tr>
<td>Preoperative or postoperative myocardial infarction</td>
<td>152 (6.9)</td>
<td>7 (8.0)</td>
</tr>
</tbody>
</table>
Cerebral perfusion open issues

The unanswered issues

Concept 1: How much the technique influences neurological outcomes
Concept II: How much the dissection impairs cerebral functions
Are we sure everything is ok??

Cerebral protection in type A AoD
Cerebral perfusion open issues

1. Site of arterial cannulation
2. Unilateral vs bilateral
3. Management of cerebral malperfusion
Current practice in Europe

Site of aa cannulation in acute setting

De Paulis et al. EJCTS 2015
Issue 1: Site of arterial cannulation

Changes in operative strategy for patients enrolled in the International Registry of Acute Aortic Dissection interventional cohort program

**ABSTRACT**

**Objective:** Ad changes in op

**Methods:** One type A aortic dissection tertiles (T) (T1)

**Results:** Frequ and T3: 26.7% (T1: 35.6%, T valve use decr for aortic vall 67.1%, T2: 85 cerebral techn and hyp P = .03 T2: 33. Parikh et al. JTCVS April 2017

**Central Message**

Operative strategy in the management of type A aortic dissection changed and in-hospital mortality dropped significantly over a 20-year timespan.

N= 1732 TYPE A AD

Pz divided by time

- T1: 1996-2003
- T2: 2004-2010
- T3: 2011-2016

Antegrade cerebral perfusion + Axillary artery cannulation

Parikh et al. JTCVS April 2017
Issue 1: Site of arterial cannulation

Supra-aortic vessels selection in acute AoD

1. Axillary aa
   - Avoid manipulation of epiaortic vessels

2. Innominate aa
   - Frequently involved in the dissection
Issue 1: Site of arterial cannulation

3 The common carotid artery

- Wider than axillary artery
- Arterial wall is stronger

Rylski et al, EJCTS 2014
Current practice in Europe

Type of cerebral perfusion in acute setting

- BILATERAL ASCP: 53%
- UNILATERAL ASCP: 38%
- DEEP HYPOTERMIA: 6%
- RETROGRADE: 3%

De Paulis et al. EJCTS 2015
**Issue 2: Unilateral vs bilateral ASCP**

Best evidence topic - Cardiopulmonary bypass

Is unilateral antegrade cerebral perfusion equivalent to bilateral cerebral perfusion for patients undergoing aortic arch surgery?

Pietro Giorgio Malvindi, Giuseppe Scrascia, Nicola Vitale*

*Department of Cardiac Surgery, Polyclinic Hospital, University of Bari, Piazza Giulio Cesare 11, 70124 Bari, Italy

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
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<th>30 day Mortality</th>
<th>Post op CVA</th>
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<td>2 (1.9%)</td>
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<td>15</td>
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<td>0</td>
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<tr>
<td>Küçüker</td>
<td>2005</td>
<td>181</td>
<td>12 (6.6%)</td>
<td>4 (2.3%)</td>
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<td>Panos</td>
<td>2006</td>
<td>25</td>
<td>1 (4%)</td>
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<td>61</td>
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<td>2008</td>
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**MEAN DURATION OF SACP = 32 min**
Pathophysiology of the brain perfusion:

Cerebral flow gradually declines during cerebral perfusion

Mean Cerebral Blood Flow (CBF)

- Baseline
- coolest T°C
- 5 min SCP
- 15 min SCP
- 25 min SCP
- 60 min SCP

RBF Cortex

- SCP 60 mmHg / T 30°C
- SCP 60 mmHg / T 25°C

RBF Cerebellum

- SCP 60 mmHg / T 30°C
- SCP 60 mmHg / T 25°C

Temperature Dependence of Cerebral Blood Flow for Isolated Regions of the Brain During Selective Cerebral Perfusion in Pigs

Justus T. Strauch, MD, Peter L. Haldenwang, MD, Katharina Müllem, Miriam Schmalzl, Oliver Liakopoulos, MD, Hildegard Christ, Jürgen H. Fischer, MD, and Thorsten Wahlers, MD

Departments of Cardiothoracic Surgery, Experimental Medicine, and Biomechanics, University Hospital of Cologne, Cologne, Germany

Background. Hypothermic circulatory arrest (HCA) and antegrade selective cerebral perfusion (ASCP) are utilized for cerebral protection during aortic surgery. However, no consensus exists regarding optimal ASCP-temperature showing a tendency toward higher values during the last years. This study investigates regional changes of cerebral blood flow (CBF) during ASCP at two temperatures.

Methods. In this blinded study, 20 pigs (35 to 37 kg) were randomized to two groups. Animals were cooled to 36 minutes of HCA followed by 60 minutes of ASCP. Afterward, the animals were perfused at 23°C and 30°C according to the study group. Fluorescent microspheres were injected at seven time points during the experiment to calculate total and regional CBF. Hemodynamics, intravascular resistance (CVR) and cerebral metabolic rate of oxygen (CMRO2) were assessed. Tissue samples from the cortex, cerebellum, hippocampus, and pons were taken for microsphere count.

Results. The CBF and CMRO2 decreased significantly (p < 0.002) during cooling in both groups; it was significantly higher throughout ASCP in the 30°C versus the 23°C group (p = 0.001). These findings were similar among all brain regions, certainly at different levels. The CBF increased significantly (p = 0.002) during the early period of ASCP for analyzed regions and decreased significantly (p = 0.034) below baseline after 60 minutes of ASCP, reaching critical levels in the hippocampus and associated. The hippocampus turned out to have the lowest CBF, while the pons showed the highest CBF. Thirty minutes and more ASCP provides less CBF compared with baseline values at both temperatures.

Conclusions. Antegrade selective cerebral perfusion improves CBF in all regions of the brain for a limited time. Our study characterizes the brain specific hierarchy of blood flow during ASCP. These dynamics are highly relevant for clinical strategies of perfusion.


Protecting the brain from damage during replacement of the ascending aorta and aortic arch is still one of the major challenges in aortic surgery. Cerebral injury after aortic surgery has two major causes. Embolic stroke, when it occurs, is likely to result in a permanent fugal deficit, although it has become less common with increasing experience, is still a disastous form of cerebral insult. A more frequent problem after aortic surgery is mild global cerebral injury. Such injury is clinically apparent as the syndrome known as transient neurologic dysfunction (TND). Transient neurologic dysfunction is thought to be a consequence of inadequate cerebral protection during the mandatory interval of interrupted antegrade cerebral perfusion and in particular can be caused by different regions of the brain, resulting in a wide variety of clinical symptoms. In rare instances, a very prolonged operation can produce even without evidence of embolization) an irreversible global ischemic insult.[5,6] Various strategies have been used to improve protection of the brain during the mandatory interruption of normal antegrade perfusion required for aortic arch surgery, with the hope of lowering the morbidity and mortality of these operations. Hypothermic circulatory arrest (HCA) and antegrade hypothermic selective cerebral perfusion (ASCP) are among the most successful strategies, frequently used in combination.[3,6,8] Experimental studies showed that, even at relatively low temperatures brain metabolism can still remain as high as 40% of baseline levels.[9]

However, the physiology of ASCP after HCA of various duration is only beginning to be investigated. Little information is known about the exact cerebral blood flow (CBF) and metabolism during the period of ASCP at a stable nonpulsatile pump-flow rate, a stable mean arterial pressure (MAP), and a constant temperature, even though there is a tendency toward higher perfusion temperatures over the last years[6,11]. Nothing is known about changes in CBF for different regions of the brain.
The lack of left subclavian artery perfusion during cerebral perfusion led to temporary glucose hypometabolism in the occipital lobes.
82 uACP vs 121bACP:

- Acute type A aortic dissection
- Total arch replacement

Similar CPB, x-clamp, circ arrest time, NP temperature

Tong G, JTCVS 2017
Bilateral perfusion implied approximately 50% less mortality and neurologic morbidity rates than unilateral perfusion, but this did not reach statistical significance.

Tong G, JTCVS 2017
Issue 2: Unilateral vs bilateral ASCP

I have only 1 brain but 2 hemispheres: Please perfuse both adequately!

Jean Bachet, MD, FEBCTS
From ADRETIC, Suresnes, France.
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Address for reprints: Jean Bachet, MD, PBEITIC, ADRETIC, 5 Place Marcel Lefranc, 92150 Suresnes, France
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The article by Tong and colleagues reports on a rather interesting and rarely addressed topic. The study demonstrated that bilateral perfusion implied less mortality and neurologic morbidity, but the difference did not reach statistical significance. Nevertheless, the authors conclude that bilateral selective cerebral perfusion should be used better in this setting of patients.

Since selective cerebral perfusion was popularized in the late 1980s, many modifications have been described, but in all of the initial experiences, bilateral perfusion of the brain was used and not questioned.

Yet, at the end of the 1980s, a major question came out:

“Should we use supra-aortic community during acute reperfusion?”

For the group in favor of bilateral perfusion, it has been shown that perfusion in 42% to 47% in 74% of subjects, 52% of subjects to hypoxic parts of the brain, and plastic or not.

Conversely, the contrary side of the debate is not without merit. They argue that the flow anatomic status with functional lesions, and especially concerning the flow anatomic status with functional lesions is.

If we look at studies comparing both methods that the rates of mortality or 1 minute to insert a small balloon catheter into the origin cerebral perfusion—and the same from 32 publications, however, showed significantly

Hippocrates has been credited as saying, “Make a habit of two things: to help; or at least do no harm.” By using bACP, we may accomplish both of these goals. Although definitive proof that bACP is superior to unilateral ACP is still lacking, the important question is this: If it does not cause any obvious harm, then why not?
Cerebral perfusion open issues

1. Site of arterial cannulation
2. Unilateral vs bilateral
3. Management of cerebral malperfusion

↓

Lack of evidence on effectiveness of specific perfusion strategies

- Cerebral perfusion
- Unilateral/Bilateral ACP
- Hypothermic/moderate temperature
- Central/peripheral cannulation
Management of cerebral malperfusion: Early carotid perfusion

Carotid artery cannulation in acute aortic dissection with malperfusion

Paul P. Urbanski, MD, PhD, Bad Neustadt,

Pre

Post

Controlled Earlier Reperfusion for Brain Ischemia Caused by Acute Type A Aortic Dissection

Hiroshi Munakata, MD, Kenji Okada, MD, PhD, Hiroya Kano, MT, Sou Izumi, MD, Yutaka Hino, MD, Masamichi Matsumori, MD, PhD, and Yutaka Okita, MD, PhD

Additional aa line for CPB in connection with the II° line in the femoral aa
Thinking Beyond the Tube Graft
Using Malperfusion as a Guide to Define Treatment of Type A Dissection*

Allan Stewart, MD, Joanna Chikwe, MD

outcomes. Instead of applying an optimism that “it ought to get better” after surgery, end-organ salvage may improve with aggressive strategies by experienced teams to address ischemia pre-operatively, intra-operatively, or with hybrid therapy.
IN SUMMARY

• Cerebral protection strategies evolved during the years with a clear advantage of ACP using the axillary artery as preferred site of arterial inflow

• Brain malperfusion caused by acute type A aortic dissection may not be always clinically evident but impairs outcomes regardless of the operative techniques

• Although definitive proof that bilateral ACP is superior to unilateral ACP is still lacking, it should be preferred especially when prolonged periods of ACP are anticipated
THANK YOU

Davide Pacini

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davide.pacini@unibo.it
Stroke after emergent surgery for acute type A aortic dissection: predictors, outcome and neurological recovery†

Julia Dumfarth*a, Markus Koflera, Lukas Stastnay, Michaela Plaiknerb, Christoph Kraptc, Severin Semsrotha and Michael Grimm

2000-2017: 303 patients, mean age 58.9 ± 13.6 years

- Type A aortic dissection

- 2 groups depending on presence of preoperative stroke

<table>
<thead>
<tr>
<th>Operative data</th>
<th>Stroke (n = 48)</th>
<th>No stroke (n = 255)</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>Root replacement (%)</td>
<td>15 (31.3)</td>
<td>83 (32.5)</td>
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</tr>
<tr>
<td>Arch replacement (%)</td>
<td>9 (18.8)</td>
<td>49 (19.2)</td>
<td>1.000</td>
</tr>
<tr>
<td>TEVAR (%)</td>
<td>5 (10.4)</td>
<td>21 (8.2)</td>
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<td>CABG (%)</td>
<td>9 (19.1)</td>
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<td>15 (31.3)</td>
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<td>Femoral cannulation (%)</td>
<td>27 (56.3)</td>
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<td>9 (18.8)</td>
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<tr>
<td>Retrograde cerebral perfusion (%)</td>
<td>7 (14.6)</td>
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<tr>
<td>HCA time (min)</td>
<td>45.3 ± 19.0</td>
<td>44.9 ± 22.0</td>
<td>0.895</td>
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<td>Cardiopulmonary bypass time (min)</td>
<td>283.8 ± 133</td>
<td>235 ± 82</td>
<td>0.017</td>
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<td>Aortic cross-clamp time (min)</td>
<td>149.7 ± 61</td>
<td>135.4 ± 58</td>
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<tr>
<td>Lowest temperature (°C)</td>
<td>21 ± 3.0</td>
<td>21 ± 4.0</td>
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</table>

Dumfarth et al. EJCTS 2018
Stroke after emergent surgery for acute type A aortic dissection: predictors, outcome and neurological recovery†

Julia Dumfarth, Markus Kofler, Lukas Stastny, Michaela Plaikner, Christoph Krapi, Severin Semsroth and Michael Grimm

<table>
<thead>
<tr>
<th>Predictors for post Stroke</th>
<th>OR</th>
<th>P Value</th>
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<td>Preoperative malperfusion</td>
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<td>Preoperative CPR</td>
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<th>No-stroke</th>
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<td>Innominate artery dissected</td>
<td>30 (62.5)</td>
<td>144 (56.5)</td>
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<td>Right carotid artery</td>
<td>13 (27.1)</td>
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Dumfarth et al. EJCTS 2018
Management of cerebral malperfusion: Early Reperfusion

Malperfusion in Type A Dissection: Consider Reperfusion First

Joshua B. Goldberg, MD, Steven L. Lansman, MD, PhD, Masashi Kai, MD, Gilbert H.L. Tang, MD, MSc, Ramin Malekan, MD, and David Spielvogel, MD

Acute type A aortic dissection (ATAAD) is a vascular emergency associated with significant morbidity and mortality. Although malperfusion can affect any vascular bed, the 3 most devastating are coronary, cerebral, and visceral syndromes (MPS). Essentially, there are 3 methods of treating malperfused areas: central repair, fenestration, and directed catheter-directed arterial reperfusion. Of these, emergency central repair is the accepted primary strategy, as it most expeditiously eliminates the risk of rupture and recent reports suggest that this strategy is managed by emergency reperfusion of the affected vascular bed by central repair.

Semin Thoracic Surg 29:181–185 © 2016 Published by Elsevier Inc.

**Keywords:** aortic dissection, surgery, malperfusion, repair

**OVERVIEW**

Malperfusion complicating acute type A aortic dissection (ATAAD) occurs when various configurations of the dissecting membrane result in partial or complete obstruction of the aorta or its side branches. These flow-limiting configurations may be dynamic—changing over time or with each cardiac cycle—or static, a fixed occlusion such as from an avulsed side branch. In each case, distal flow may be compromised or eliminated, depending on the relative pressures within the true and false lumens.

Preoperative malperfusion significantly affects early and late survival following surgery for ATAAD. However, in terms of outcomes, it is important to distinguish radiographic malperfusion, that is, evidence of vascular compromise on an imaging study, from clinical malperfusion or malperfusion syndrome (MPS), which is malperfusion resulting in an ischemic vascular bed; clinical presentation through it is a frequent sequela of ATAAD repair.

Reperfusion results in an upregulation of inflammatory mediators, including polymorphonuclear cells, platelets, interleukins, cytokines, complement, and oxygen-free radicals; these result in cellular and endothelial injury, increased vascular permeability, and ultimately in edema. Consequently, reperfusion may cause increased intracranial pressure, abdominal and extremity compartment syndromes, and myocardial dysfunction. Importantly, the inflammatory response is not solely local, but systemic, and may manifest as respiratory distress syndrome or vasodilatory shock. Organ systems vary in their tolerance of ischemia, thus minimizing the time to reperfusion is critical in mitigating the adverse effects of ischemia and reperfusion injury.
Marfan, 19 years old

- Chest pain and no neurological deficits
- CT angiogram: acute type A aortic dissection
- Echocardiography: tricuspid aortic valve with mild AI

uACP vs. bACP
IN SUMMARY

• Brain malperfusion caused by acute type A aortic dissection may not be always clinically evident but impairs outcomes regardless of the operative techniques.

• Although definitive proof that bilateral ACP is superior to unilateral ACP is still lacking, there is any obvious harm to use a complete brain protection especially when prolonged periods of ACP are anticipated.