Neurologic Protection in Arch Surgery

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Disclosures

- Thrasos Therapeutics, not relevant to this presentation
Neurologic protection quiz

Which of the following have been demonstrated to protect the brain from ischemic insult?

A) Magnesium  
B) Steroids  
C) Barbiturates  
D) Hypothermia
Neurologic protection quiz

Which of the following have been demonstrated to **protect** the brain from ischemic insult?

A) Magnesium  
B) Steroids  
C) Barbiturates  
D) Hypothermia
Risk of Neurologic Injury vs Ischemic Time

![Graph showing the relationship between brain temperature and risk of neurologic injury over time.](image)
Prosthetic replacement of the aortic arch

Four patients are reported in whom the aortic arch and variable portions of the ascending and descending aorta were replaced with a prosthesis. In three patients the preoperative diagnosis was dissecting aneurysm of the aortic arch and in one an arteriosclerotic aneurysm of the aortic arch was present. A combination of surface cooling and cardiopulmonary bypass was utilized to produce total body hypothermia. Arch replacement was carried out during a period of total circulatory arrest. Cardiopulmonary bypass was then utilized to warm the patient and resuscitate the heart. The average duration of cerebral ischemia was 43 minutes and the average duration of myocardial ischemia was 74 minutes. The average lowest esophageal temperature was 14° C., and the average lowest rectal temperature was 18° C. Three patients are alive and well 4 to 13 months following surgery. One patient died 4 days postoperatively of pulmonary insufficiency. This experience indicates that by utilizing total body hypothermia and circulatory arrest aortic arch replacement can be carried out with an acceptable mortality rate. Corrective surgery should be offered to patients with life-threatening enlarging aneurysms of the aortic arch.

Randall B. Griepp, M.D., Edward B. Stinson, M.D., Jefferson F. Hollingsworth, M.D., and Donald Buehler, M.D., Stanford, Calif.
Simplification with hypothermia

Prosthetic replacement of the aortic arch

Conclusion

Although resection and prosthetic replacement of the aortic arch has been considered a relatively formidable procedure the experience herein reported suggests that the use of hypothermia and total circulatory arrest simplifies the operation, resulting in acceptable postoperative mortality and morbidity rates. Accordingly, we feel that resective therapy should be offered to patients with expanding life-threatening aneurysms of the aortic arch.
Simplification with hypothermia

I should like to compliment Dr. Griepp and his co-authors for calling our attention to this innovative approach to a very challenging clinical entity.

The problems of aortic arch resection, as all know, are those of (1) myocardial protection, (2) cerebral protection, and (3) hemodynamic management.

I have no objection to their technique of myocardial protection; it seems to be quite satisfactory in their hands. I will comment mainly on that.

It seems to me that the real achievement of Dr. Griepp's paper is the use of profound hypothermia and circulatory arrest, directed primarily at the problem of cerebral protection. Their method eliminates cannulation of the brachiocephalic vessels, obviating the possibility of particulate emboli due to cannulation of atherosclerotic vessels, as well as generally simplifying the procedure. The problems of artificial perfusion of the brain, where pressure-flow relationships are uncertain, and where the problems of overperfusion may be as damaging as those of underperfusion, are thereby avoided.
Advantages of Deep Hypothermia

- Simple
- Operative field is uncluttered
- Protects the viscera and spinal cord as well as the brain
- Is easily supplemented with selective antegrade perfusion

In practice –
- How cold you need to go depends on what needs to be done!
- It is a tradeoff - you can “get away” with less hypothermia by decreasing ischemia time
Adjuncts for Neurological Protection: Retrograde Cerebral Perfusion

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Adjuncts for Neurological Protection: Retrograde Cerebral Perfusion

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Does Retrograde Cerebral Perfusion help?

Cardiopulmonary Support and Physiology

Retrograde cerebral perfusion provides negligible flow through brain capillaries in the pig

Marek P. Ehrlich, MD
Christian Hagl, MD
Jock N. McCullough, MD
Ning Zhang, MD
Howard Shiang, DVM
Carol Bodian, DrPH
Randall B. Griep, MD

J Thorac Cardiovasc Surg 2001;122:331-8
Figure 3. Saturation of blood returning to the aortic arch during retrograde perfusion: cerebral “venous” satura-
tions. The falling saturations did not differ significantly whether or not the inferior vena cava was occluded dur-
ing retrograde cerebral perfusion (abbreviations as in previous figures); low saturations indicate high extraction
and imply low flow.
Does Retrograde Cerebral Perfusion help?

Operative Mortality vs. HCA Time (min):

- All Patients
- HCA Only
- HCA & RCP

Operative Mortality:

- 0% ≤ 30
- 0% 30-45
- 20% 45-60
- > 60% > 60

HCA Time (min):

- ≤ 30
- 30-45
- 45-60
- > 60
Does Retrograde Cerebral Perfusion help?

Neurologic Complications

HCA Time (min)

- All Patients
- HCA Only
- HCA & RCP

HCA Time:
- ≤ 30
- 30-45
- 45-60
- > 60

Neurologic Complications:
- 0%
- 20%
- 40%
- 60%
- 80%
Selective Antegrade Perfusion

SURGERY FOR ACQUIRED CARDIOVASCULAR DISEASE

IMPROVED RESULTS OF ATHEROSCLEROTIC ARCH ANEURYSM OPERATIONS WITH A REFINED TECHNIQUE

Teruhisa Kazui, MD
Naoki Washiyama, MD
Bashar A. H. Muhammad, MBBS
Hitoshi Terada, MD
Katsushi Yamashita, MD
Makoto Takinami, MD

Objective: We analyzed the influence of a refined technique on early and late postoperative outcomes of aortic arch surgery for atherosclerotic arch disease (mean follow-up 10 years). Forty-five patients underwent total arch replacement, and the remaining 24 were treated for arch aneurysm.

For related editorial, see p. 425.
Type of Arterial Cannulation

- Central
- Femoral
- Axillary
The Third Variable: CVA and Mortality vs Time

Perfusion Strategy: PHCA

- Mortality (P<0.01)
- Stroke (P<0.01)

![Graph showing mortality and stroke rates over time with statistical significance](image)
CVA and Mortality vs Time

Perfusion Strategy: RCP

- **Mortality (P=0.59)**
- **Stroke (P=1.00)**

Time intervals:
- <30 min (n=23)
- 30-45 min (n=18)
- ≥ 45 min (n=12)
CVA and Mortality vs Time

Perfusion Strategy: PHCA + SACP

- Mortality (P=0.39)
- Stroke (P=0.06)

- <30 min (n=33)
- 30-45 min (n=13)
- ≥ 45 min (n=28)
Is Unilateral Perfusion Adequate?
Brachiocephalic/L Carotid Stump pressures with SACP

5 cc/kg/min
10 cc/kg/min
15 cc/kg/min

Brachiocephalic
Left carotid
Brachiocephalic
Left carotid
Brachiocephalic
Left carotid

p1  p2  p3  p4  p5  p6  p7
Hypothermia alone or with SAP?

A meta-analysis of deep hypothermic circulatory arrest alone versus with adjunctive selective antegrade cerebral perfusion

David H. Tian¹, Benjamin Wan¹, Paul G. Bannon¹,², Martin Misfeld³, Scott A. LeMaire⁴,⁵, Teruhisa Kazui⁶, Nicholas T. Kouchoukos⁷, John A. Elefteriades⁸, Joseph E. Bavaria⁹, Joseph S. Coselli⁴,⁵, Randall B. Griepp¹⁰, Friedrich W. Mohr³, Aung Oo¹¹, Lars G. Svensson¹², G. Chad Hughes¹³, Malcolm J. Underwood¹⁴, Edward P. Chen¹⁵, Thoralf M. Sundt¹⁶, Tristan D. Yan¹,²

*Ann Cardiothorac Surg* 2013;2(3):261-270
Hypothermia alone or with SAP?

Permanent Neurologic Event

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<th>Study or subgroup</th>
<th>Odds ratio M-H, random, 95% CI</th>
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Hypothermia alone or with SAP?

Temporary Neurologic Event

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Favours [DHCA] vs. Favours [DHCA + SACP]
Hypothermia alone or with SAP?

Operative Mortality

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Favours [DHCA]  Favours [DHCA + SACP]
Trifurcated Graft

Arterial perfusion via direct cannulation of right axillary a.

Trifurcated dacron brachiocephalic/aortic arch graft

(12-14mm)

(8-10mm)

(8-10mm)
Trifurcated Graft

Left subclavian anastomosis performed 1st (of 3 brachiocephalic branches)

Deep hypothermal circulatory arrest

Selective cerebral perfusion
Trifurcated Graft

Graft inverted into itself and sewn with felt strip to cut edge of aorta to create "elephant trunk"
Moderate Hypothermia and SAP

Systematic Review

A meta-analysis of deep hypothermic circulatory arrest versus moderate hypothermic circulatory arrest with selective antegrade cerebral perfusion

David H. Tian¹, Benjamin Wan¹, Paul G. Bannon¹,², Martin Misfeld³, Scott A. LeMaire⁴,⁵, Teruhisa Kazui⁶, Nicholas T. Kouchoukos⁷, John A. Elefteriades⁸, Joseph Bavaria⁹, Joseph S. Coselli⁴,⁵, Randall B. Griep¹⁰, Friedrich W. Mohr³, Aung Oo¹¹, Lars G. Svensson¹², G. Chad Hughes¹³, Tristan D. Yan¹,²

Table 1 Expert consensus on classifications of hypothermia in circulatory arrest during aortic arch surgery

<table>
<thead>
<tr>
<th>Category</th>
<th>Nasopharyngeal temperature</th>
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<tr>
<td>Profound hypothermia</td>
<td>≤14 °C</td>
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<tr>
<td>Deep hypothermia</td>
<td>14.1-20 °C</td>
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<tr>
<td>Moderate hypothermia</td>
<td>20.1-28 °C</td>
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<tr>
<td>Mild hypothermia</td>
<td>28.1-34 °C</td>
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Reproduced with permission from Yan et al. (10)

Moderate Hypothermia and SAP

Postoperative Stroke

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Moderate Hypothermia and SAP

Temporary Neurologic Deficit

- Di Eusanio
- Harrington
- Halkos
- Wiedemann
- Misfeld

Odds Ratio
M-H, Random, 95% CI

Study or Subgroup

Total (95% CI)
Total events

0.01 0.1 1 10 100
Favours [DHCA] Favours [MHCA+SACP]
Operative Mortality

Study or Subgroup
Kazui
Di Eusanio
Harrington
Müller
Sundt
Halkos
Misfeld
Wiedemann

Odds Ratio
M-H, Random, 95% CI

Favours [DHCA]  Favours [MHCA+SACP]

Total (95% CI)
Total events
Does MHCA+SACP Save Time?

Mean DHCA vs. MHCA+SACP CPB time:
189.9 vs. 188.2 mins;
Mean difference: 1.38 mins; 95% CI, -26.90-29.66; P=0.92; I²=89%†
Hybrid approach to complex thoracic aortic aneurysms in high-risk patients: Surgical challenges and clinical outcomes

Wei Zhou, MD,* Michael Reardon, MD,* Eric K. Peden, MD,* Peter H. Lin, MD,* and Alan B. Lumsden, MD,* Houston, Tex

Background: Endovascular therapy is a less invasive alternative treatment for high-risk patients with thoracic aortic aneurysms. However, this technology alone is often not applicable to complex aneurysmal morphology. The purpose of this study was to evaluate the utility of hybrid strategies in high-risk patients who are otherwise unsuitable for endovascular therapy alone.

Methods: During an 18-month period, 31 high-risk patients (mean age, 69 years; range, 52-89 years) underwent combined open and endovascular approaches for complex aneurysms, including 16 patients with ascending and arch aneurysms and 15 patients with aneurysms involving visceral vessels. Among them, 11 patients had histories of aneurysm repairs. To overcome the anatomic limitations of endovascular repairs, various adjunctive surgical maneuvers were used, including aortic arch reconstruction in 3 patients, supra-aortic trunk debranching in 13 patients (including 8 patients who required aortas as inflow sources), and visceral vessel bypasses in 15 patients (including 10 patients who required bypasses to all 3 visceral branches). Additionally, carotid artery access was obtained in 1 patient, and iliac artery conduits were created in 12 patients.

Results: Technical success was achieved in all patients. There was one perioperative death (3.2%) due to postoperative bleeding. Two patients (6.4%) had immediate type I endoleaks, which were resolved by the 1-month follow-up. Other procedure-related complications occurred in three patients (9.6%), including renal bypass thromboses in two patients and retroperitoneal hematoma, which was successfully managed conservatively, in one patient. During a mean follow-up of 16 months, two patients died of unrelated causes, whereas the remainder of patients were asymptomatic, without aneurysm enlargement.

Conclusions: Our study highlights how hybrid strategies incorporating surgical and endovascular approaches can be used successfully in treating patients with complex thoracic aortic aneurysms. This combined approach potentially expands the field of endovascular stent grafting and is an attractive solution for patients with poor cardiopulmonary reserves. (J Vasc Surg 2006;44:688-93.)
Figure 2. Valiant left-subclavian branch device (A); First-in-human case performed in the United States (B) (courtesy Dr Frank Arko).
Figure 4. Cook’s investigational multibranched endograft for arch repair.