



University of Bologna
S.Orsola-Malpighi, Bologna, Italy
Vascular Surgery

CEREBRAL PROTECTION IN AORTIC ARCH SURGERY

ISNVD

9th annual meeting

Ferrara, May 30-31, 2019, Italy



Paolo Spath MD

Aortic Arch Pathologies

- ✓ **Arch Aneurysm**
- ✓ Acute/Chronic Dissection
- ✓ Penetrating Aortic Ulcer
- ✓ Intramural Hematoma/Acute Aortic Syndrome



Aortic Arch Pathology
Surgical Options for the Aortic
Arch Replacement

Giorgio Zanotti, MD, Thomas Brett Reece, MD,
Muhammad Aftab, MD*

Background



Aortic Arch Pathologies

- ✓ Arch Aneurysm
- ✓ **Acute/Chronic Dissection**
- ✓ Penetrating Aortic Ulcer
- ✓ Intramural Hematoma/Acute Aortic Syndrome



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- ✓ Arch Aneurysm
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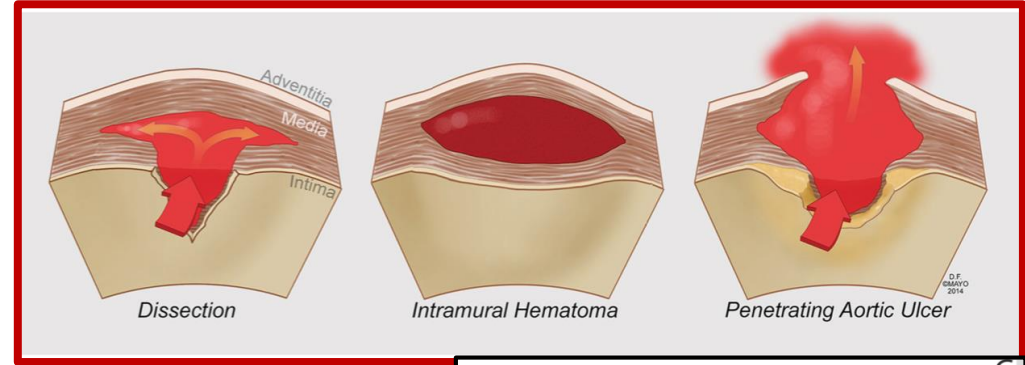


Aortic Arch Pathology
Surgical Options for the Aortic Arch Replacement

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Aortic Arch Pathologies

- ✓ Arch Aneurysm
- ✓ Acute/Chronic Dissection
- ✓ Penetrating Aortic Ulcer
- ✓ Intramural Hematoma/Acute Aortic Syndromes



Cardiovasc Intervent Radiol
<https://doi.org/10.1007/s00270-018-2114-x>

REVIEW

Penetrating Aortic Ulcer and Intramural Hematoma

Gustavo S. Oderich^{1,3} · Jussi M. Kärkkäinen¹ · Nanette R. Reed² ·
Emanuel R. Tenorio¹ · Giuliano A. Sandri¹

Aortic Arch Pathology Surgical Options for the Aortic Arch Replacement

Giorgio Zanotti, MD, Thomas Brett Reece, MD,
Muhammad Aftab, MD*

Preventive:

- ✓ **Type A Acute Dissection**
- ✓ **Aneurysmal Rupture**
- ✓ **Death**

Treatment



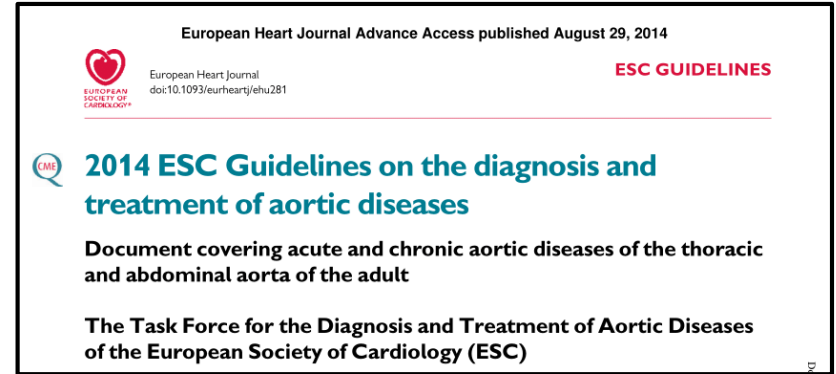
Indication for treatment:

LOW risk patients

✓ ≥ 55 mm

✓ Symptomatic Patients / Signs of Compression

✓ Rapid Growth (≥ 0.5 cm per year)



SURGICAL TREATMENT



PARTIAL REPLACEMENT

COMPLETE REPLACEMENT

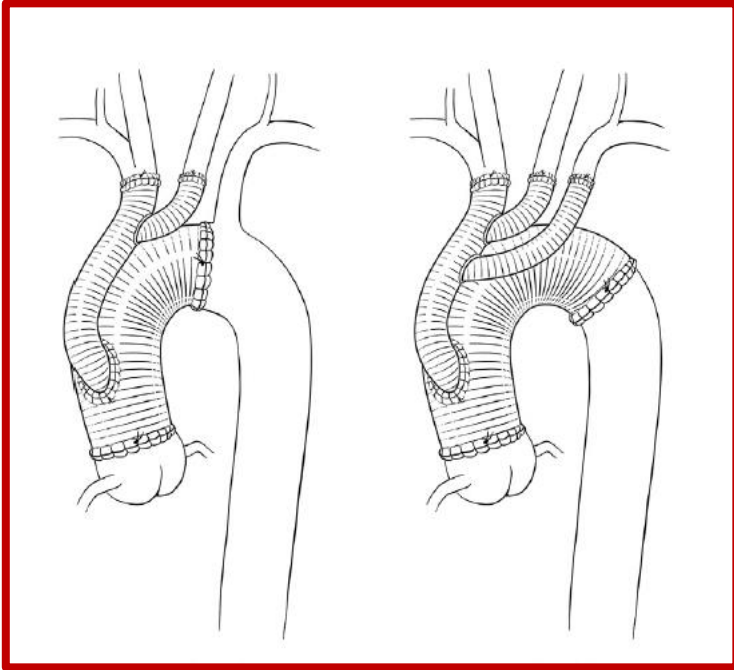


Fig. 4. Different configurations of the Y-graft technique for replacing the aortic arch. These include the arch with a single Y-graft, the arch with a double Y-graft, the elephant trunk with a single Y-graft, and the elephant trunk with a double Y-graft. (Courtesy of Baylor College of Medicine, Houston, TX; with permission.)

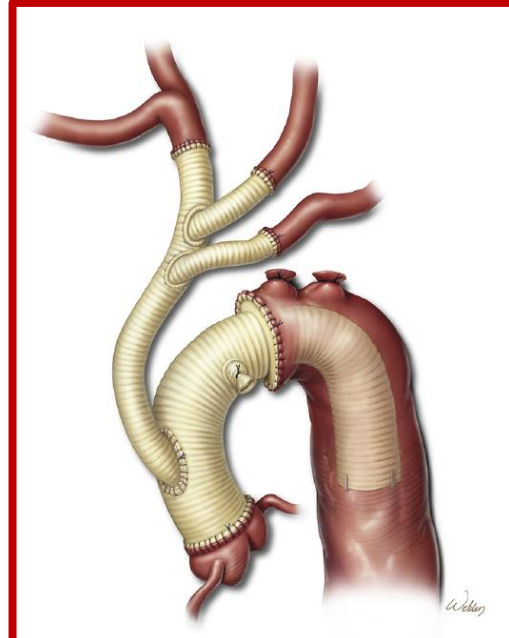
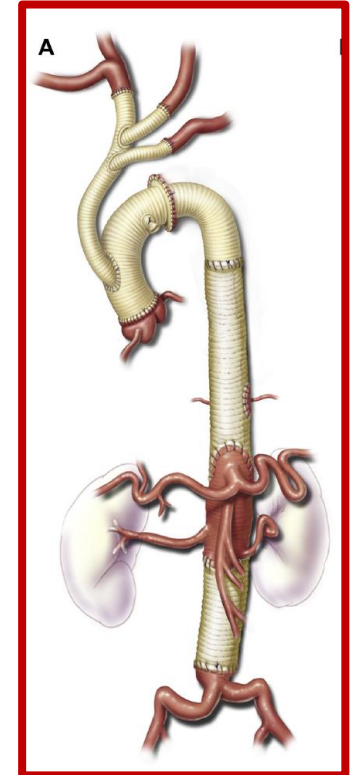


Fig. 3. The Y-graft technique of aortic arch replacement with an elephant trunk. (Courtesy of Baylor College of Medicine, Houston, TX; with permission.)



4.7 – 6.0% RISK OF INTRA-OPERATIVE STROKE

- ✓ Inadequate Cerebral Protection
- ✓ Embolism
- ✓ Pre-operative malperfusion (TAAD)

Acquired Cardiovascular Disease

Thomas et al

Patel et al

Acquired Cardiovascular Disease

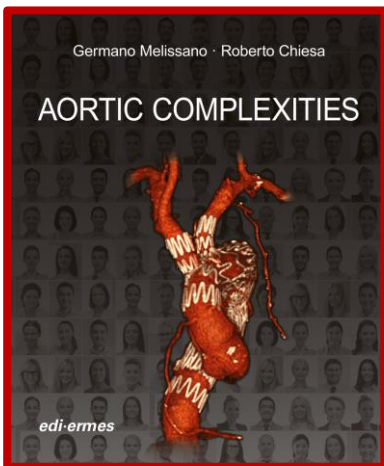
Contemporary results of open aortic arch surgery

Mathew Thomas, MBBS,^a Zhuo Li, MS,^a David J. Cook, MD,^b Kevin L. Greason, MD,^a and Thoralf M. Sundt, MD^c

Open arch reconstruction in the endovascular era: Analysis of 721 patients over 17 years

Himanshu J. Patel, MD, Christopher Nguyen, BS, Amy C. Diener, RN, BSN, Mary C. Passow, RN, BSN, Diane Salata, RN, BSN, and G. Michael Deeb, MD

METHODS OF CEREBRAL PROTECTION:

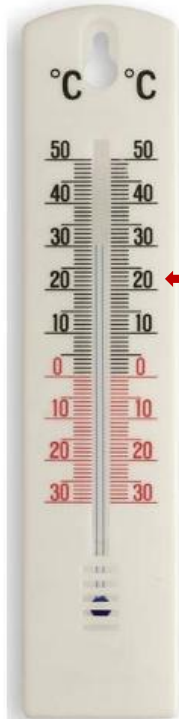


- ✓ Deep Hypothermic Circulatory Arrest (**DHCA**)
- ✓ Retrograde Cerebral Perfusion (**RCP**)
- ✓ Antegrade Selective Cerebral Perfusion (**ASCP**)

CEREBRAL PROTECTION



✓ Deep Hypothermic Circulatory Arrest (DHCA)



18°C

Reducing brain activity and energy consumption:

SAFE PERIOD OF TOTAL CIRCULATORY ARREST

*9th Current Trends
in Aortic & Cardio-
vascular Surgery &
Interventions*

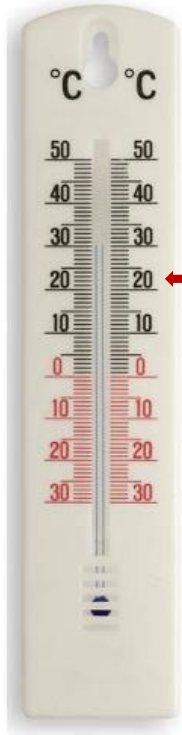
Julia Dumfarth, MD
Bulat A. Ziganshin, MD
Maryann Tranquilli, RN
John A. Elefteriades, MD

Cerebral Protection in Aortic Arch Surgery

Hypothermia Alone Suffices

Cerebral protection has been the cornerstone of successful aortic arch surgery for almost 40 years. Aneurysms of the aortic arch are among the most challenging cases for surgical treatment and require procedural expertise for their safe conduct. Up to now, 3 main strategies for cerebral protection of patients undergo-

✓ Deep Hypothermic Circulatory Arrest (DHCA)



18°C

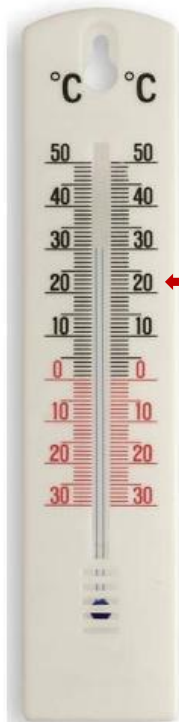
Reducing brain activity and energy consumption:

SAFE PERIOD OF TOTAL CIRCULATORY ARREST

SAFE PERIODS

- **5 MINUTES at NORMOTHERMIA**
- **25 MINUTES at 18°C**

✓ Deep Hypothermic Circulatory Arrest (DHCA)



18°C

UN- SAFE PERIODS at 18°C

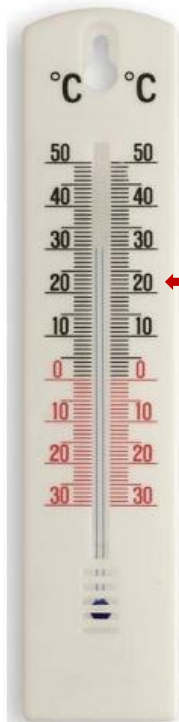
- 40 MINUTES: Permanent Neurological Injuries

- 60 MINUTES: Mortality

- ✓ NO BRACHIOCEFALIC AND SAV MANIPULATION
- ✓ TOTAL CIRCULATORY ARREST
- ✓ OPEN BLOODLESS PROCEDURE

- ✓ LIMITED SAFE TIME OF CIRCULATORY ARREST
- ✓ PROLONGED CARDIO-PULMONARY BYPASS TIME
- ✓ COAGULATION AND INFLAMMATORY DISORDERS

✓ Deep Hypothermic Circulatory Arrest (DHCA)



18°C

OVERALL RESULTS:

- 2.9% OPERATIVE MORTALITY
- 2% STROKE RATE

RARELY USED AS SINGLE METHOD

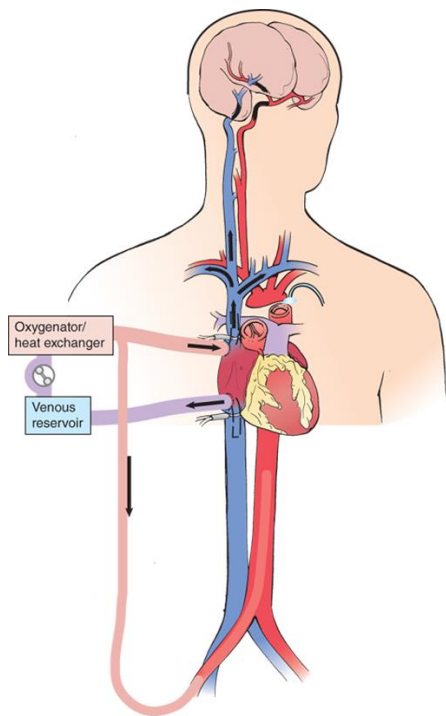
ACUTE PRESENTATION



CEREBRAL PROTECTION



✓ Retrograde Cerebral Perfusion (RCP)



**HYPOTHERMIC OXYGENATED BLOOD
PERFUSING BRAIN RETROGRADELY
VIA SUPERIOR VENA CAVA**

**DEOXYGENATED BLOOD
RETURNING VIA CAROTIDS
TO AORTIC ARCH**

VEIN PRESSURE

- 20 mmHg
- 100 – 500 mL/min
- 16-18°C

Deep hypothermic systemic circulatory arrest and continuous retrograde cerebral perfusion for surgery of aortic arch aneurysm

Y. Ueda, S. Miki, K. Kusuhara, Y. Okita, T. Tahata, and K. Yamanaka

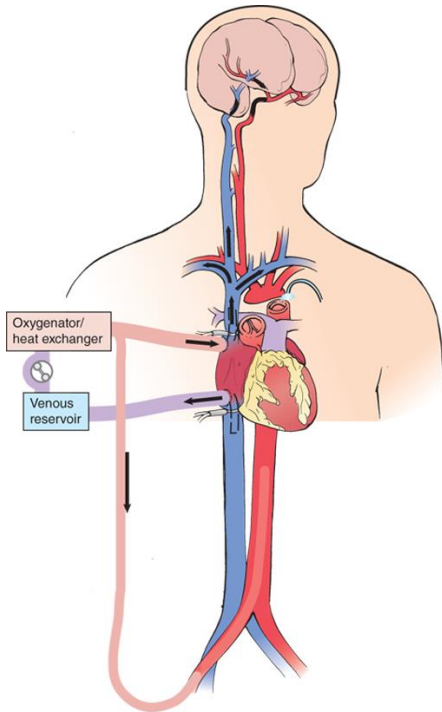
Department of Cardiovascular Surgery, Tenri Hospital, Tenri, Nara, Japan

European Journal of
**Cardiothoracic
Surgery**
© Springer-Verlag 1992

CEREBRAL PROTECTION



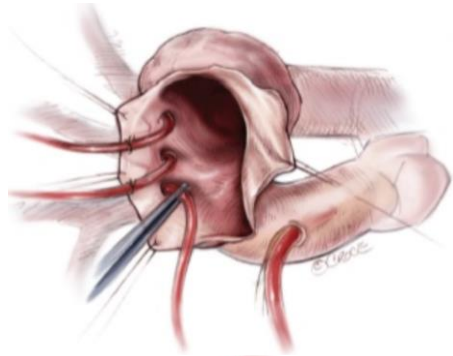
✓ Retrograde Cerebral Perfusion (RCP)



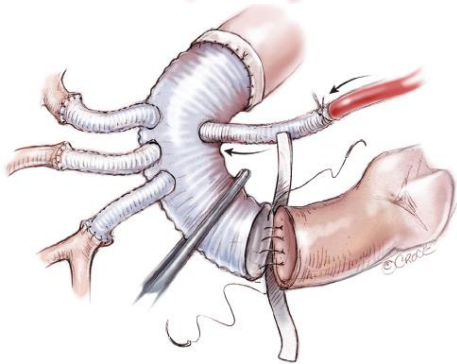
- ✓ CONTINUOUS METABOLIC SUPPORT
- ✓ HOMOGENEOUS COOLING OF THE BRAIN
- ✓ POSSIBILITY OF DEBRIS FLUSHING
- ✓ INHOMOGENEOUS DISTRIBUTION OF BLOOD FLOW
- ✓ CEREBRAL EDEMA

ADJUNCTIVE ROLE FOR BRAIN PROTECTION DURING DHCA

✓ Antegrade Selective Cerebral Perfusion (ASCP)



1. Cardio-Pulmonary Bypass
2. Moderate Hypothermia (22-25°C)
3. Cannulation of IA/RxA and LCCA

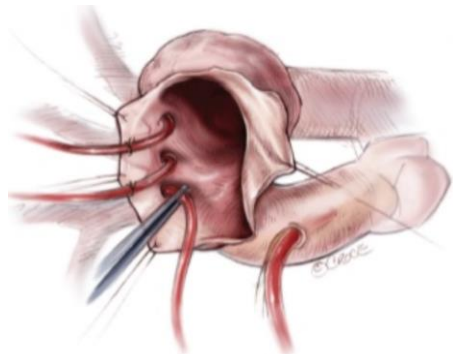


Selective Cerebral Perfusion During Operation for Aneurysms of the Aortic Arch: A Reassessment

Teruhisa Kazui, MD, Norio Inoue, MD, Osamu Yamada, MD, and Sakuzo Komatsu, MD

Department of Thoracic and Cardiovascular Surgery, Sapporo Medical College & Hospital, Sapporo, Japan ANN THOR SURG 1992

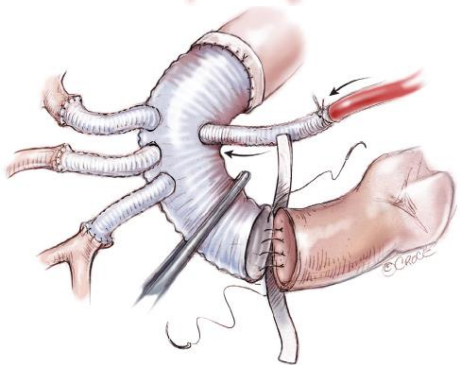
✓ Antegrade Selective Cerebral Perfusion (ASCP)



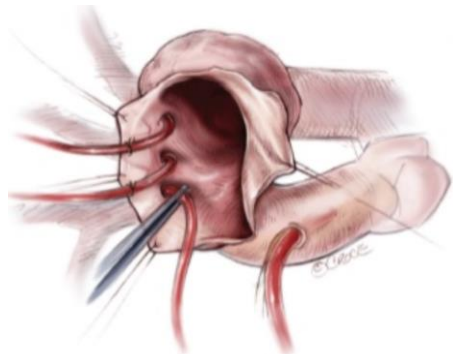
RATE OF PERFUSION:

✓ Radial Arterial Pressure 40 mmHg

✓ Total Blood Flow rate 10mL/Kg/min



✓ Antegrade Selective Cerebral Perfusion (ASCP)



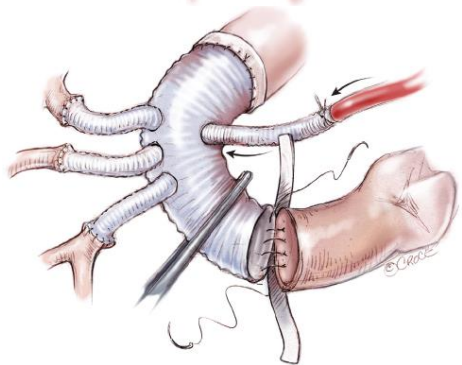
UNILATERAL vs BILATERAL ASCP ?

✓ 2/3 BILATERAL (RAXA + LCCA)

LONGER PROCEDURES 86-134 MINUTES

✓ 1/3 UNILATERAL (RAXA or IA)

SHORTER PROCEDURES 32 MINUTES



European Journal of Cardio-Thoracic Surgery Advance Access published July 17, 2014

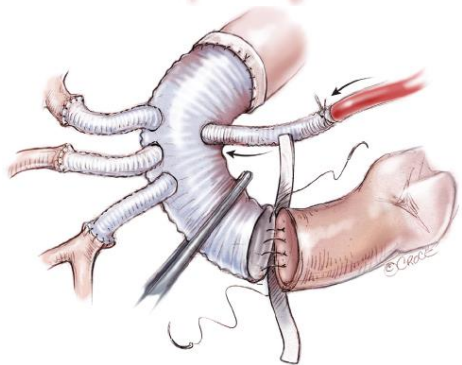
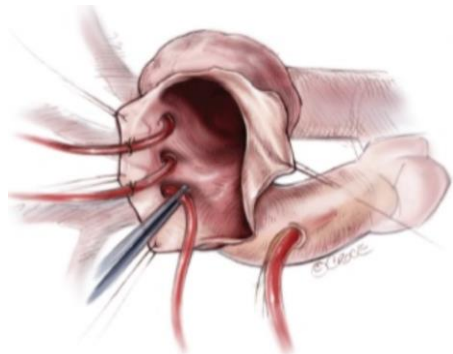
European Journal of Cardio-Thoracic Surgery (2014) 1-7
doi:10.1093/ejcts/ezu284

ORIGINAL ARTICLE

Current trends in cannulation and neuroprotection during surgery of the aortic arch in Europe^{††}

Ruggero De Paulis^{a,*}, Martin Czerny^a, Luca Weltert^a, Joseph Bavaria^a, Michael A. Borger^a, Thierry P. Carrel^a, Christain D. Etz^a, Michael Grimm^a, Mahmoud Loubani^a, Davide Pacini^b, Timothy Resch^c, Paul P. Urbanski^d and Ernst Weigang^e (EACTS Vascular Domain Group)

✓ Antegrade Selective Cerebral Perfusion (ASCP)



- ✓ PHYSIOLOGICAL CEREBRAL PROTECTION
- ✓ COMPLEX AORTIC ARCH RESECTION
- ✓ MODERATE HYPOTHERMIA
- ✓ MANIPULATION OF SUPRA-AORTIC-VESSELS
- ✓ TECHNICALLY DEMANDING

CHOICE PROCEDURE FOR CHRONIC AND ACUTE SETTING

RESULTS

- ✓ Deep Hypothermic Circulatory Arrest (DHCA)
- ✓ Retrograde Cerebral Perfusion (RCP)
- ✓ Antegrade Selective Cerebral Perfusion (ASCP)

30-day MORTALITY

5.2%

5.2%

Acquired Cardiovascular Disease

Hu et al

Similar cerebral protective effectiveness of antegrade and retrograde cerebral perfusion combined with deep hypothermia circulatory arrest in aortic arch surgery: A meta-analysis and systematic review of 5060 patients

Zhipeng Hu, PhD, Zhiwei Wang, MD, Zongli Ren, MD, Hongbing Wu, PhD, Min Zhang, MD, Hao Zhang, PhD, and Xiaoping Hu, MD

RESULTS

- ✓ Deep Hypothermic Circulatory Arrest (**DHCA**)
- ✓ Retrograde Cerebral Perfusion (**RCP**)
- ✓ Antegrade Selective Cerebral Perfusion (**ASCP**)

TRANSIENT NEUROLOGIC DYSFUNCTION

8.7%

7.5%

Acquired Cardiovascular Disease

Hu et al

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Zhipeng Hu, PhD, Zhiwei Wang, MD, Zongli Ren, MD, Hongbing Wu, PhD, Min Zhang, MD, Hao Zhang, PhD, and Xiaoping Hu, MD

CEREBRAL PROTECTION



RESULTS

TRANSIENT NEUROLOGIC DYSFUNCTION

- ✓ Deep Hypothermic Circulatory Arrest (DHCA)
- ✓ Retrograde Cerebral Perfusion (RCP)

8.7%

- ✓ Antegrade Selective Cerebral Perfusion (ASCP)

7.5%

Acquired Cardiovascular Disease

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CEREBRAL PROTECTION



RESULTS

16,218 TOTAL ARCH REPLACEMENTS

INCIDENCE OF STROKE

- ✓ Deep Hypothermic Circulatory Arrest (DHCA)
 - ✓ Retrograde Cerebral Perfusion (RCP)
 - ✓ Antegrade Selective Cerebral Perfusion (ASCP)
- 8.6%
- 6.7%

CEREBRAL PROTECTION

A study of brain protection during total arch replacement comparing antegrade cerebral perfusion versus hypothermic circulatory arrest, with or without retrograde cerebral perfusion: Analysis based on the Japan Adult Cardiovascular Surgery Database

Vascular Surgery - University of Bologna

Yutaka Okita, MD,^a Hiroaki Miyata, PhD,^b Noboru Motomura, MD,^c and Shinichi Takamoto, MD,^d The Japan Cardiovascular Surgery Database Organization

CEREBRAL PROTECTION



RESULTS

16,218 TOTAL ARCH REPLACEMENTS

INCIDENCE OF STROKE

✓ Deep Hypothermic Circulatory Arrest (DHCA)	}	8.6%
✓ Retrograde Cerebral Perfusion (RCP)		
✓ Antegrade Selective Cerebral Perfusion (ASCP)	}	6.7%

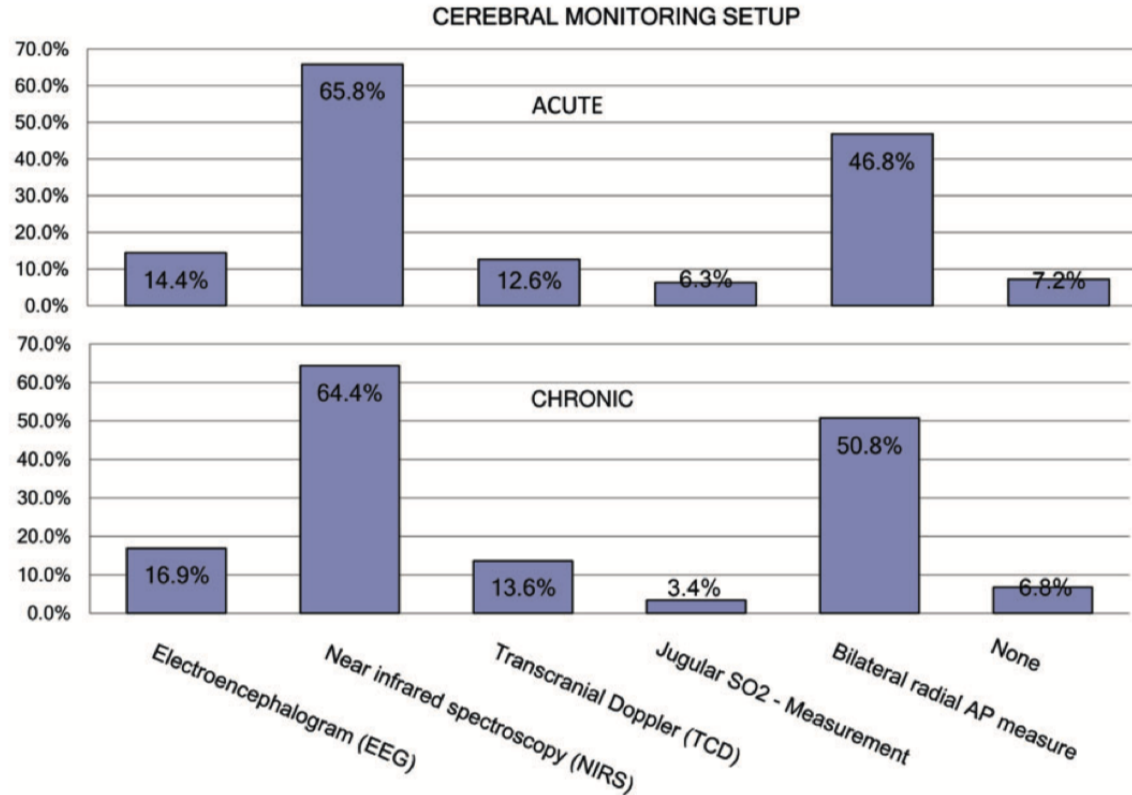
CEREBRAL PROTECTION

A study of brain protection during total arch replacement comparing antegrade cerebral perfusion versus hypothermic circulatory arrest, with or without retrograde cerebral perfusion: Analysis based on the Japan Adult Cardiovascular Surgery Database

CEREBRAL MONITORING



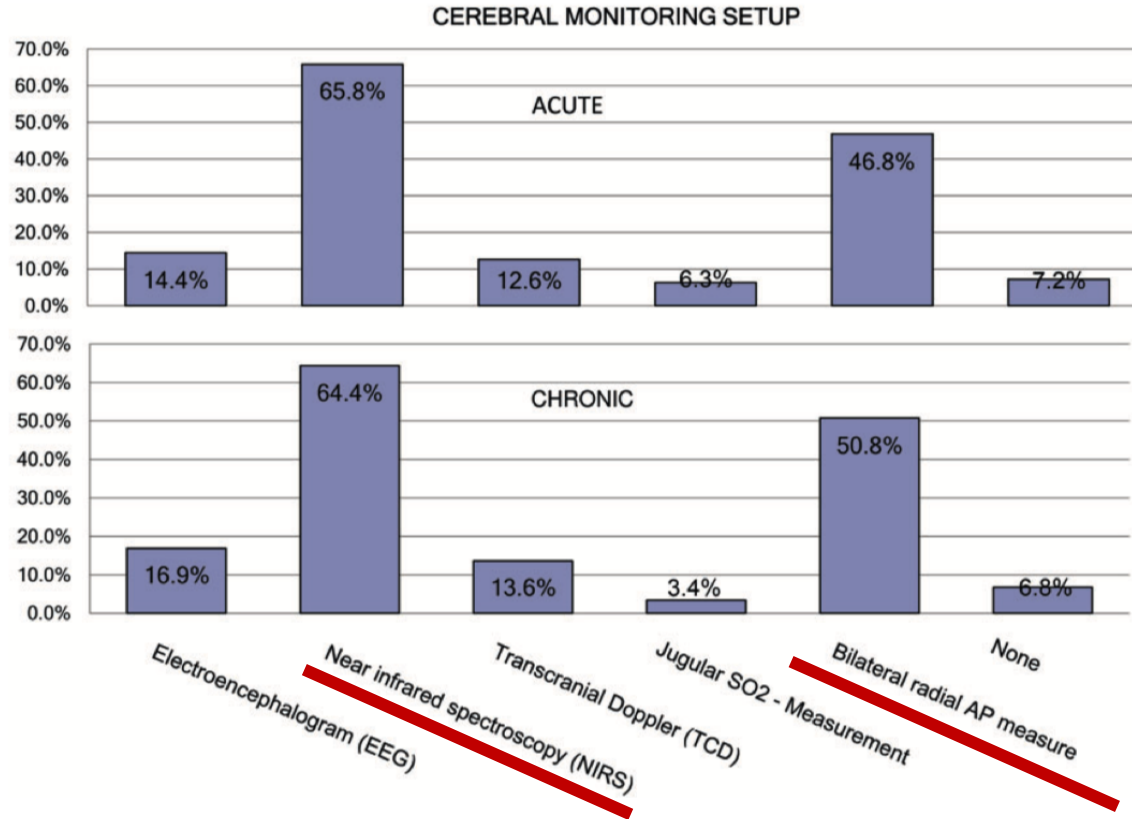
R. De Paulis *et al.* / European Journal of Cardio-Thoracic Surgery



CEREBRAL MONITORING



R. De Paulis *et al.* / European Journal of Cardio-Thoracic Surgery



Indication for treatment:

HIGH risk patients ???

✓ NO Treatment

Indication for treatment:

HIGH risk patients ???

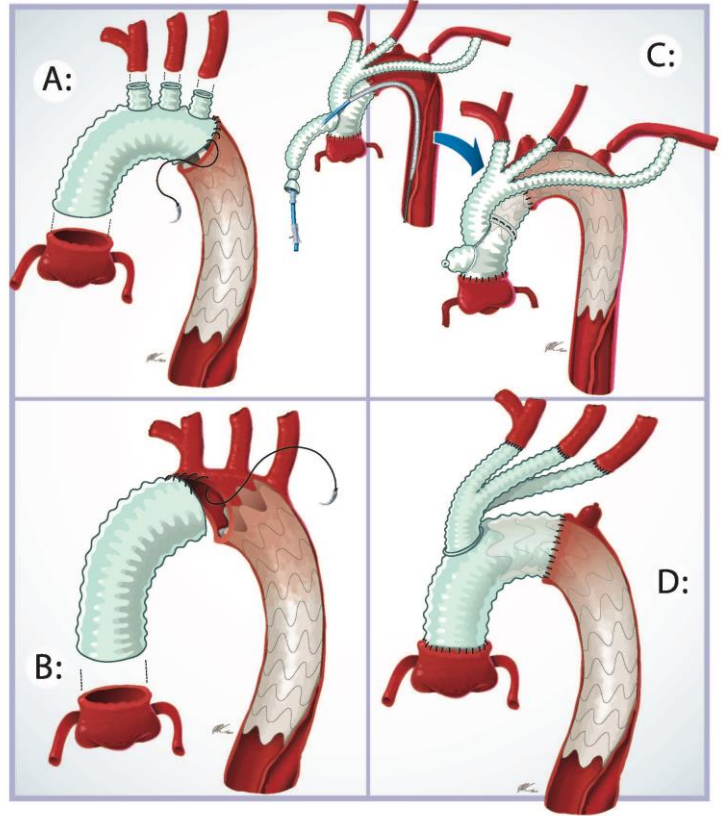
- ✓ NO Treatment
- ✓ Hybrid Arch Repairs
- ✓ Total Endovascular Aortic Arch Repair

Indication for treatment:

HIGH risk patients ???

- ✓ NO Treatment
- ✓ Hybrid Arch Repairs
- ✓ Total Endovascular Aortic Arch Repair

HYBRID ARCH REPAIR



Indication for treatment:

HIGH risk patients ???

- ✓ NO Treatment
- ✓ Hybrid Arch Repairs
- ✓ Total Endovascular Aortic Arch Repair

TOTAL ENDOVASCULAR ARCH REPAIR

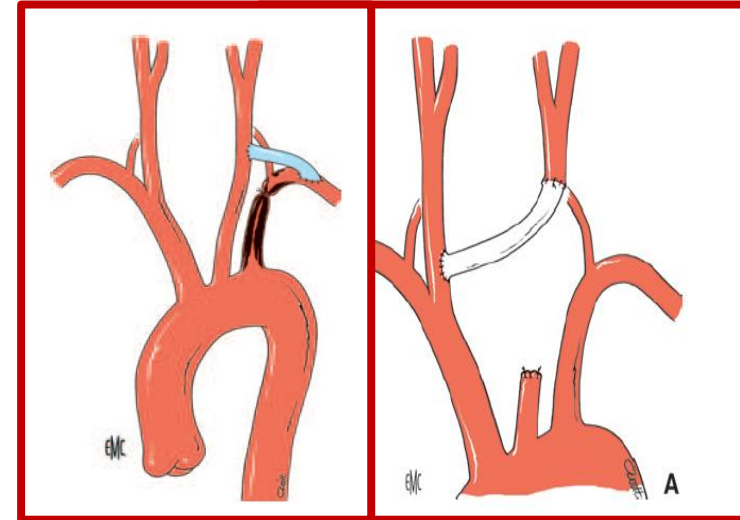


- ✓ **Chimney Grafts**
- ✓ **Custom-Made Scalloped Grafts**
- ✓ **Custom-Made Fenestrated Devices**
- ✓ **Custom-Made Inner Branched Device**
- ✓ **In-situ fenestration**

SUPRA-AORTIC VESSELS

DEBRANCHING

TECHNIQUES



BOLOGNA VASCULAR SURGERY



1



2



3



4



CEREBRAL PROTECTION

IN AORTIC ARCH SURGERY

ENDOVASCULAR SURGERY

Thank You. See You in Bologna



Vascular Surgery – University of Bologna