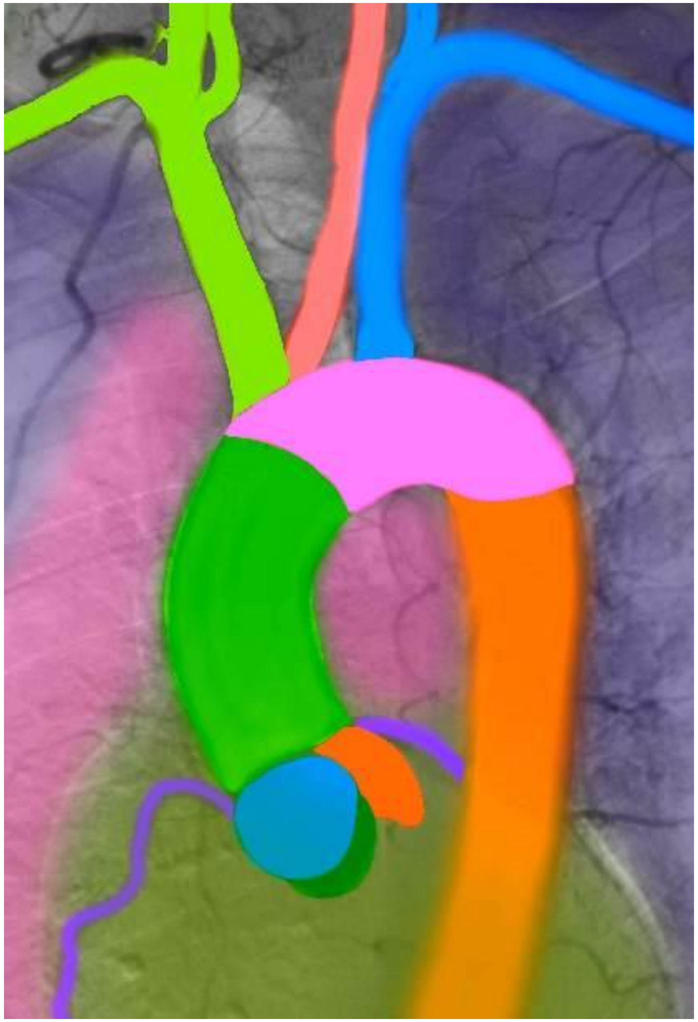
ARCH OPEN REPAIR – STATE OF THE ART



Davide Pacini

CARDIAC SURGERY DEPARTMENT –
St. ORSOLA HOSPITAL
UNIVERSITY OF BOLOGNA - ITALY

Disclosure

FINANCIAL DISCLOSURE: NONE

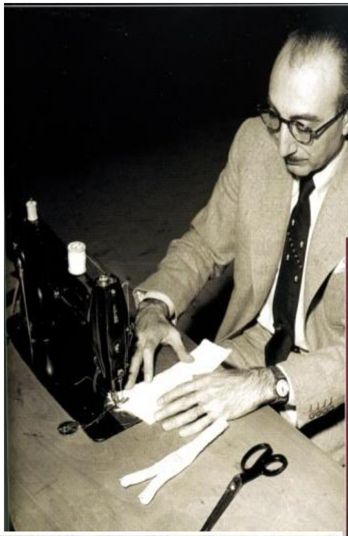
THERE’S NO FUTURE WITHOUT PAST

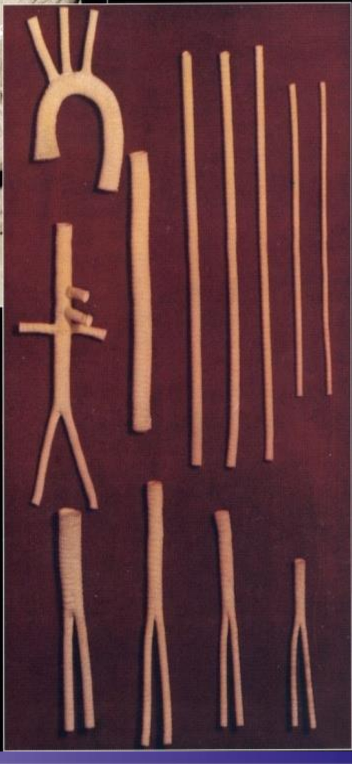
„Every time has a season“

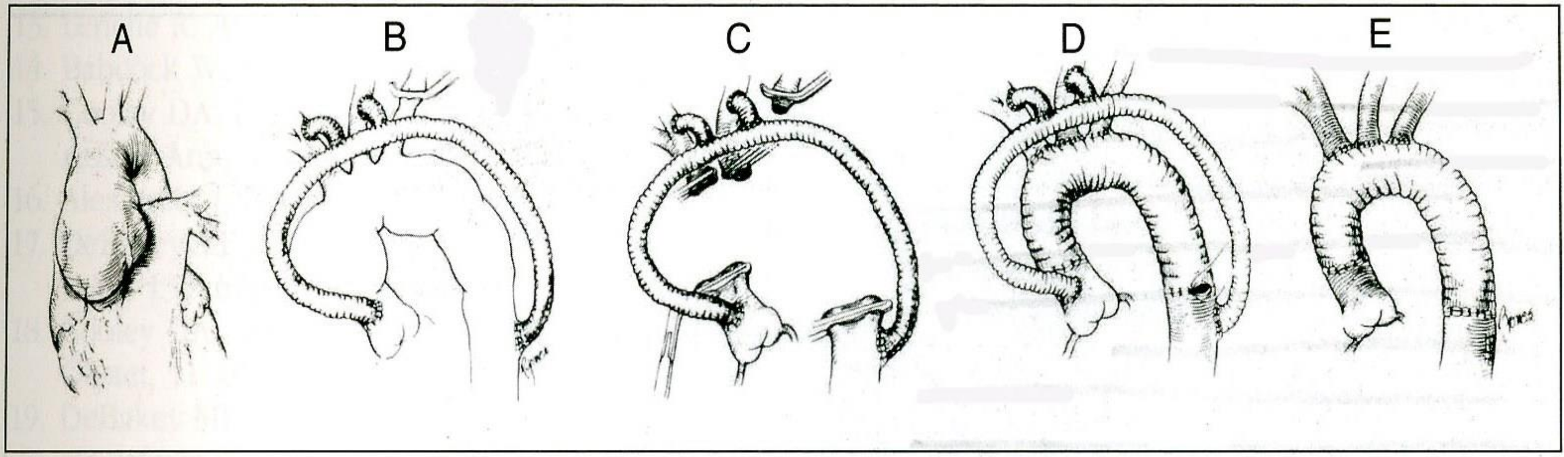
Historical landmarks in Open aortic surgery

1955

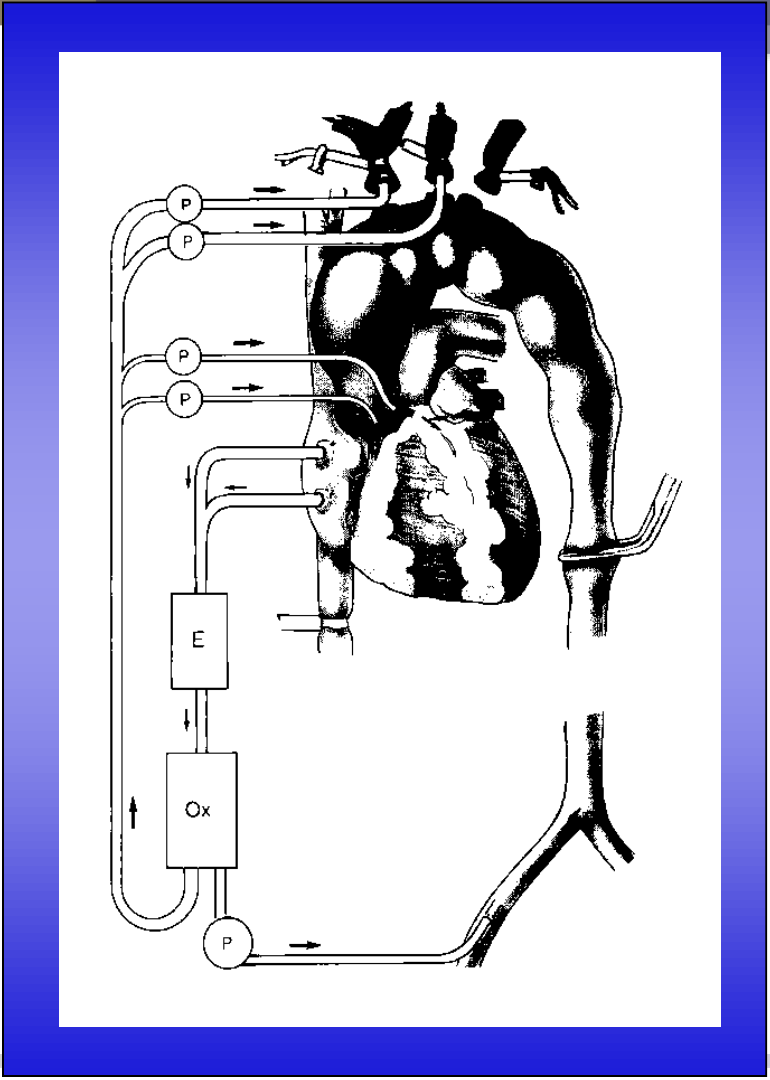
Total excision of the aortic arch for aneurysm. Cooley DA, Mahaffey DE, Debakey ME. Surg Gynecol Obstet. 1955 Dec;101(6):667-72.



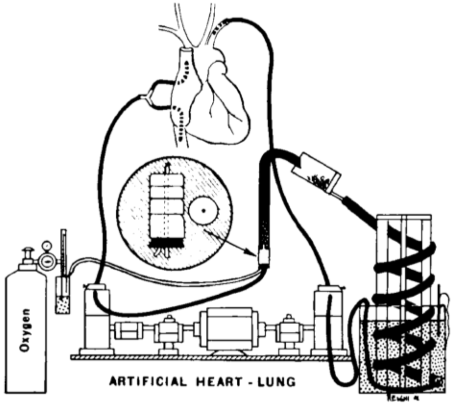


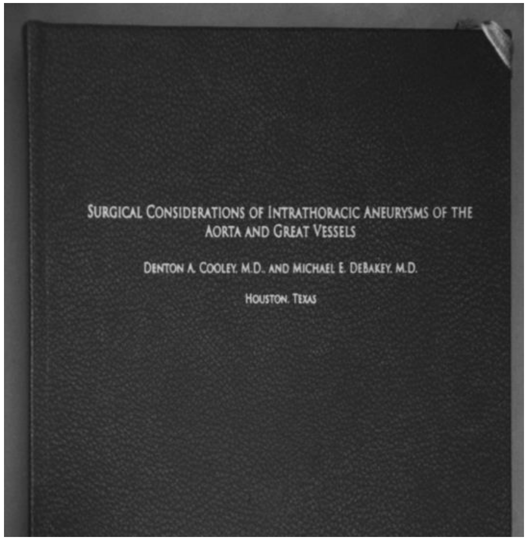


Aortic arch surgery – Brain protection



Cooley DA, De Bakey ME, Morris GC.
Ann Surg 1957; 146:473-85





Surgical Considerations of Intrathoracic Aneurysms of the
Aorta and Great Vessels

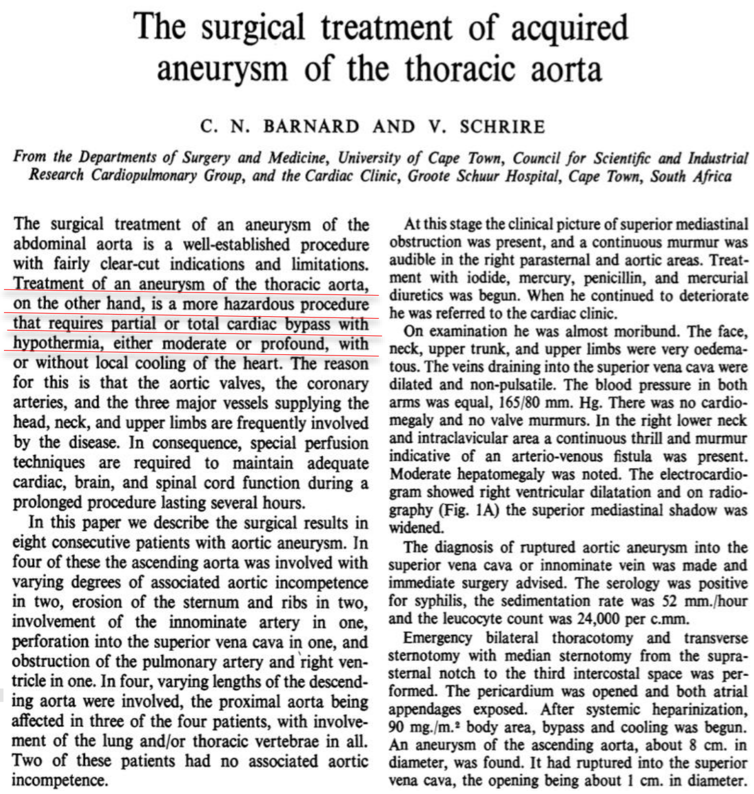
Denton A. Cooley, M.D., and Michael E. DeBakey, M.D.

Houston, Texas

Historical landmarks in Open aortic surgery

1963 – the first series on open aortic thoracic replacement

“ Treatment of an aneurysm of the thoracic aorta is an hazardous procedure that requires cardiac bypass with hypothermia, either moderate or profound….”



The surgical treatment of acquired aneurysm of the thoracic aorta

C. N. BARNARD AND V. SCHRIRE

From the Departments of Surgery and Medicine, University of Cape Town, Council for Scientific and Industrial Research Cardiopulmonary Group, and the Cardiac Clinic, Groote Schuur Hospital, Cape Town, South Africa

The surgical treatment of an aneurysm of the abdominal aorta is a well-established procedure with fairly clear-cut indications and limitations. Treatment of an aneurysm of the thoracic aorta, on the other hand, is a more hazardous procedure that requires partial or total cardiac bypass with hypothermia, either moderate or profound, with or without local cooling of the heart. The reason for this is that the aortic valves, the coronary arteries, and the three major vessels supplying the head, neck, and upper limbs are frequently involved by the disease. In consequence, special perfusion techniques are required to maintain adequate cardiac, brain, and spinal cord function during a prolonged procedure lasting several hours.

In this paper we describe the surgical results in eight consecutive patients with aortic aneurysm. In four of these the ascending aorta was involved with varying degrees of associated aortic incompetence in two, erosion of the sternum and ribs in two, involvement of the innominate artery in one, perforation into the superior vena cava in one, and obstruction of the pulmonary artery and right ventricle in one. In four, varying lengths of the descending aorta were involved, the proximal aorta being affected in three of the four patients, with involvement of the lung and/or thoracic vertebrae in all. Two of these patients had no associated aortic incompetence.

At this stage the clinical picture of superior mediastinal obstruction was present, and a continuous murmur was audible in the right parasternal and aortic areas. Treatment with iodide, mercury, penicillin, and mercurial diuretics was begun. When he continued to deteriorate he was referred to the cardiac clinic.

On examination he was almost moribund. The face, neck, upper trunk, and upper limbs were very oedematous. The veins draining into the superior vena cava were dilated and non-pulsatile. The blood pressure in both arms was equal, 165/80 mm. Hg. There was no cardiomegaly and no valve murmurs. In the right lower neck and intraclavicular area a continuous thrill and murmur indicative of an arterio-venous fistula was present. Moderate hepatomegaly was noted. The electrocardiogram showed right ventricular dilatation and on radiography (Fig. 1A) the superior mediastinal shadow was widened.

The diagnosis of ruptured aortic aneurysm into the superior vena cava or innominate vein was made and immediate surgery advised. The serology was positive for syphilis, the sedimentation rate was 52 mm./hour and the leucocyte count was 24,000 per c.mm.

Emergency bilateral thoracotomy and transverse sternotomy with median sternotomy from the suprasternal notch to the third intercostal space was performed. The pericardium was opened and both atrial appendages exposed. After systemic heparinization, 90 mg./m.² body area, bypass and cooling was begun. An aneurysm of the ascending aorta, about 8 cm. in diameter, was found. It had ruptured into the superior vena cava, the opening being about 1 cm. in diameter.

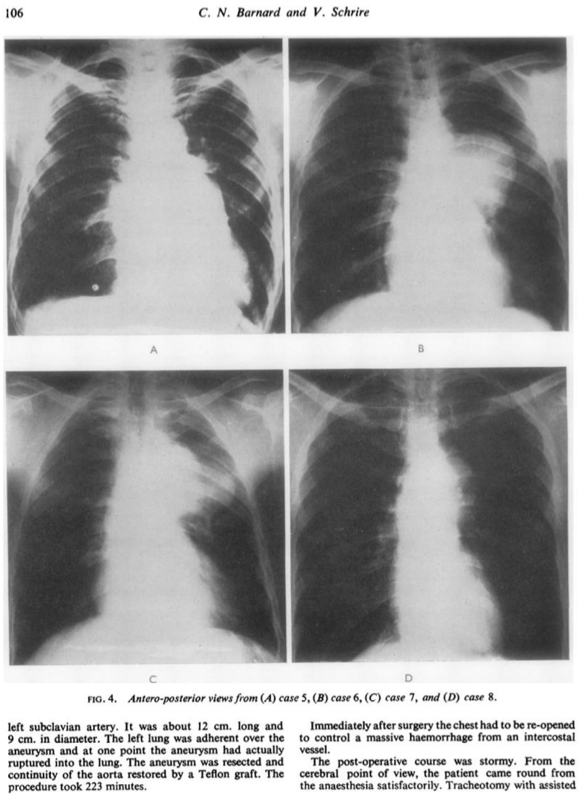


FIG. 4. *Antero-posterior views from (A) case 5, (B) case 6, (C) case 7, and (D) case 8.*

left subclavian artery. It was about 12 cm. long and 9 cm. in diameter. The left lung was adherent over the aneurysm and at one point the aneurysm had actually ruptured into the lung. The aneurysm was resected and continuity of the aorta restored by a Teflon graft. The procedure took 223 minutes.

Immediately after surgery the chest had to be re-opened to control a massive haemorrhage from an intercostal vessel.

The post-operative course was stormy. From the cerebral point of view, the patient came round from the anaesthesia satisfactorily. Tracheotomy with assisted

Historical landmarks in Open aortic surgery

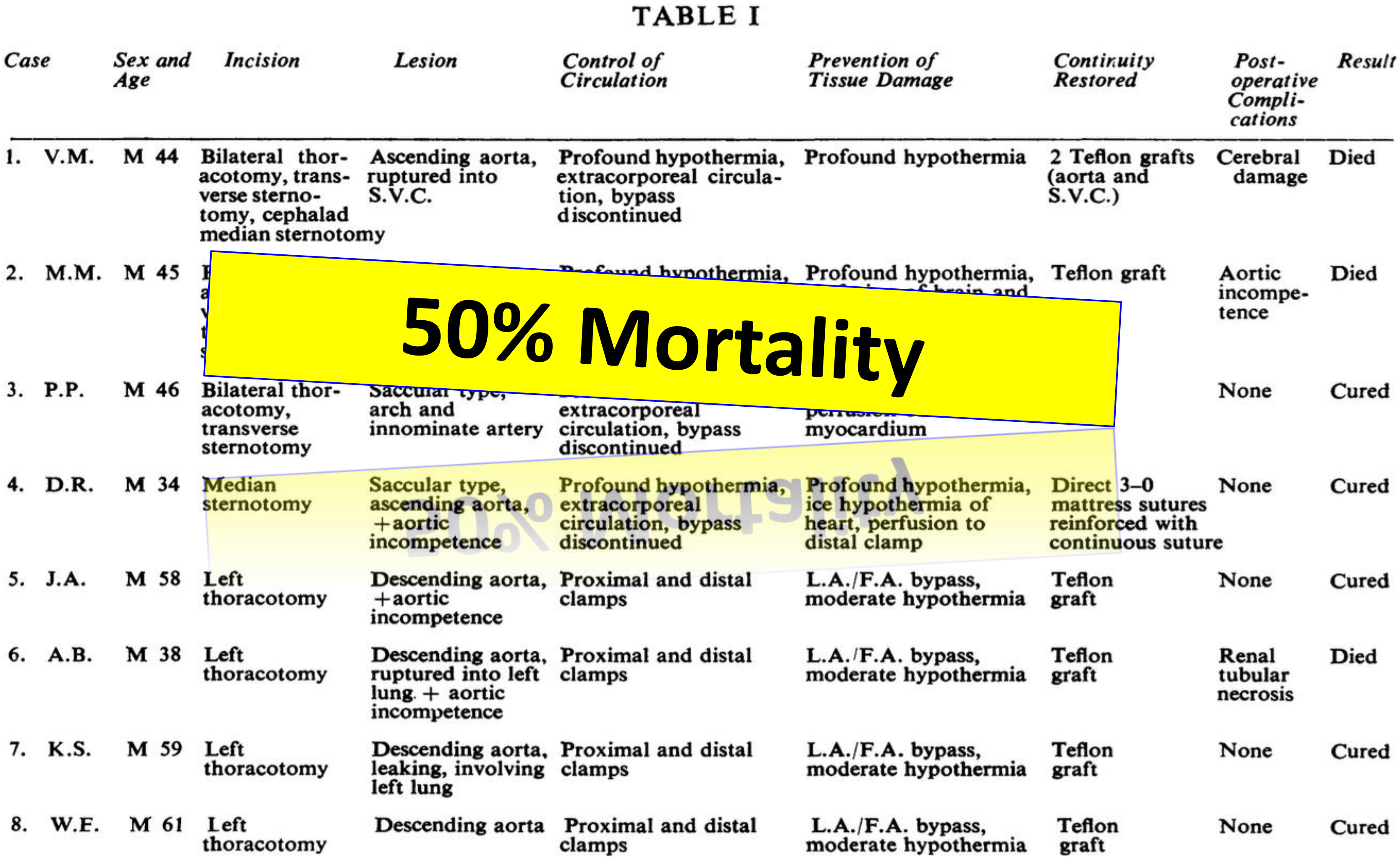
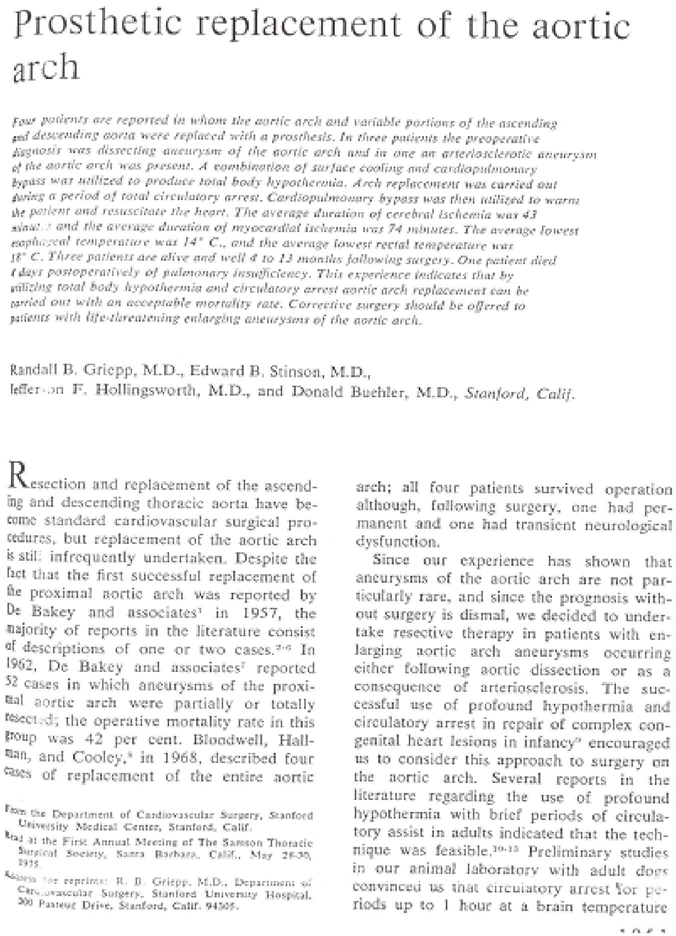


TABLE I

Case		*Sex and Age*	*Incision*	*Lesion*	*Control of Circulation*	*Prevention of Tissue Damage*	*Continuity Restored*	*Post-operative Compli-cations*	*Result*
1.	V.M.	M 44	Bilateral thoracotomy, transverse sternotomy, cephalad median sternotomy	Ascending aorta, ruptured into S.V.C.	Profound hypothermia, extracorporeal circulation, bypass discontinued	Profound hypothermia	2 Teflon grafts (aorta and S.V.C.)	Cerebral damage	Died
2.	M.M.	M 45	[illegible]	[illegible]	Profound hypothermia, [illegible]	Profound hypothermia, [illegible] brain and [illegible]	Teflon graft	Aortic incompetence	Died
3.	P.P.	M 46	Bilateral thoracotomy, transverse sternotomy	Saccular type, arch and innominate artery	[illegible] extracorporeal circulation, bypass discontinued	[illegible] perfusion [illegible] myocardium	[illegible]	None	Cured
4.	D.R.	M 34	Median sternotomy	Saccular type, ascending aorta, +aortic incompetence	Profound hypothermia, extracorporeal circulation, bypass discontinued	Profound hypothermia, ice hypothermia of heart, perfusion to distal clamp	Direct 3–0 mattress sutures reinforced with continuous suture	None	Cured
5.	J.A.	M 58	Left thoracotomy	Descending aorta, +aortic incompetence	Proximal and distal clamps	L.A./F.A. bypass, moderate hypothermia	Teflon graft	None	Cured
6.	A.B.	M 38	Left thoracotomy	Descending aorta, ruptured into left lung + aortic incompetence	Proximal and distal clamps	L.A./F.A. bypass, moderate hypothermia	Teflon graft	Renal tubular necrosis	Died
7.	K.S.	M 59	Left thoracotomy	Descending aorta, leaking, involving left lung	Proximal and distal clamps	L.A./F.A. bypass, moderate hypothermia	Teflon graft	None	Cured
8.	W.F.	M 61	Left thoracotomy	Descending aorta	Proximal and distal clamps	L.A./F.A. bypass, moderate hypothermia	Teflon graft	None	Cured

50% Mortality

Historical landmarks in Open aortic surgery - DHCA



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.*

Resection and replacement of the ascending and descending thoracic aorta have become standard cardiovascular surgical procedures, but replacement of the aortic arch is still infrequently undertaken. Despite the fact that the first successful replacement of the proximal aortic arch was reported by De Bakey and associates[1] in 1957, the majority of reports in the literature consist of descriptions of one or two cases.[2-6] In 1962, De Bakey and associates[7] reported 52 cases in which aneurysms of the proximal aortic arch were partially or totally resected; the operative mortality rate in this group was 42 per cent. Bloodwell, Hallman, and Cooley,[8] in 1968, described four cases of replacement of the entire aortic arch; all four patients survived operation although, following surgery, one had permanent and one had transient neurological dysfunction.

Since our experience has shown that aneurysms of the aortic arch are not particularly rare, and since the prognosis without surgery is dismal, we decided to undertake resective therapy in patients with enlarging aortic arch aneurysms occurring either following aortic dissection or as a consequence of arteriosclerosis. The successful use of profound hypothermia and circulatory arrest in repair of complex congenital heart lesions in infancy[9] encouraged us to consider this approach to surgery on the aortic arch. Several reports in the literature regarding the use of profound hypothermia with brief periods of circulatory assist in adults indicated that the technique was feasible.[10-13] Preliminary studies in our animal laboratory with adult dogs convinced us that circulatory arrest for periods up to 1 hour at a brain temperature

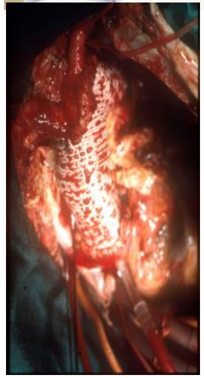
From the Department of Cardiovascular Surgery, Stanford University Medical Center, Stanford, Calif.

Read at the First Annual Meeting of The Samson Thoracic Surgical Society, Santa Barbara, Calif., May 28-30, 1975.

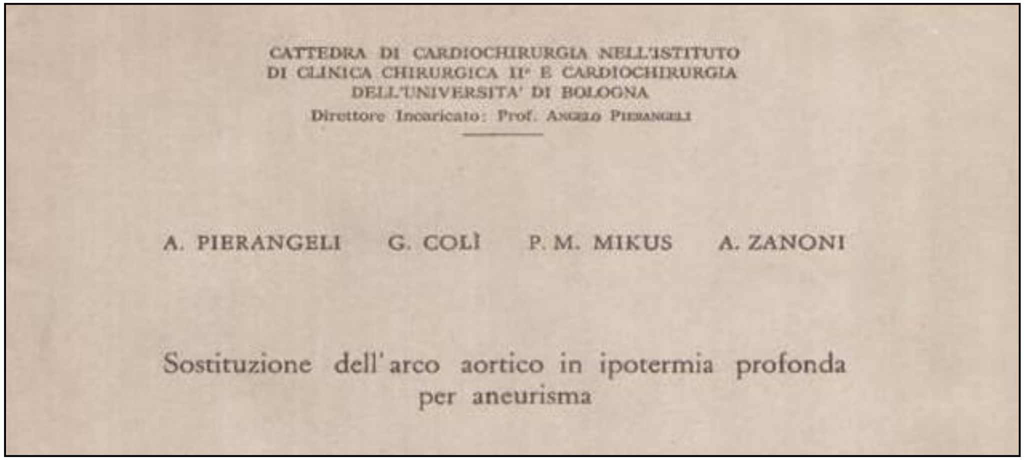
Address for reprints: R. B. Griepp, M.D., Department of Cardiovascular Surgery, Stanford University Hospital, 300 Pasteur Drive, Stanford, Calif. 94305.

GRIEPP RB., STINSON EB., HOLLINGSWORTH JF., BUEHLER D. ***Prosthetic replacement of the aortic arch.*** **J Thorac Cardiovasc Surg 1975; 70: 1051-63**

Historical landmarks in Open aortic surgery - DHCA



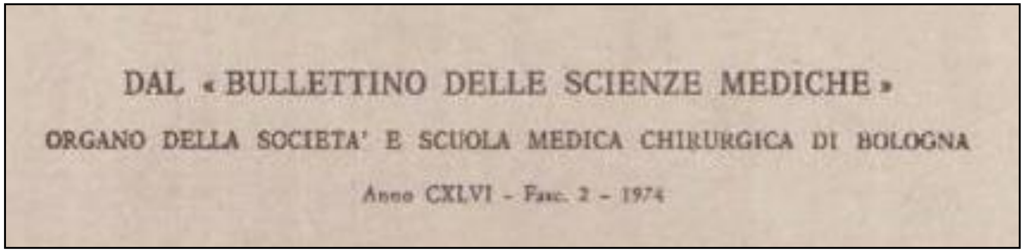
1974



CATTEDRA DI CARDIOCHIRURGIA NELL'ISTITUTO
DI CLINICA CHIRURGICA IIª E CARDIOCHIRURGIA
DELL'UNIVERSITA' DI BOLOGNA
Direttore Incaricato: Prof. ANGELO PIERANGELI

A. PIERANGELI G. COLÌ P. M. MIKUS A. ZANONI

Sostituzione dell'arco aortico in ipotermia profonda
per aneurisma

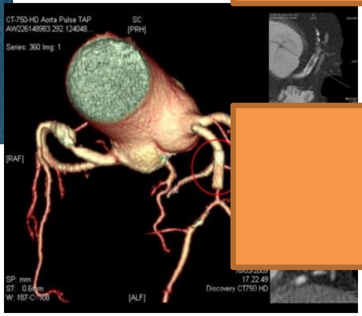


DAL « BULLETTINO DELLE SCIENZE MEDICHE »
ORGANO DELLA SOCIETA' E SCUOLA MEDICA CHIRURGICA DI BOLOGNA
Anno CXLVI - Fasc. 2 - 1974

1. Disease processes

2.Natural course

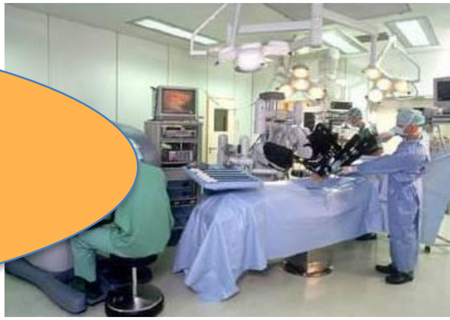
3.Pathophysiology



4.Imaging

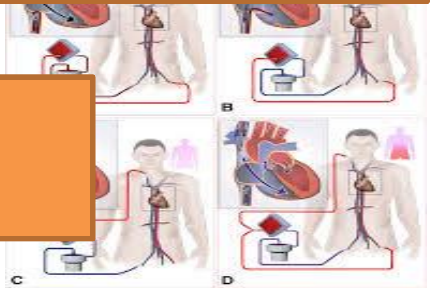
5.All treatement options

(open/endovascular/pharmacological)



7.Hypothermia and organ protection

6.Perfusion



8.Post treatment surveillance

Aortic arch surgery

“The challenge”

Myocardial – visceral - brain protection

Techniques of aortic repair

Aortic arch surgery – Brain protection

Deep Hypothermic Circulatory Arrest

Retrograde Cerebral Perfusion

Antegrade Selective Cerebral Perfusion

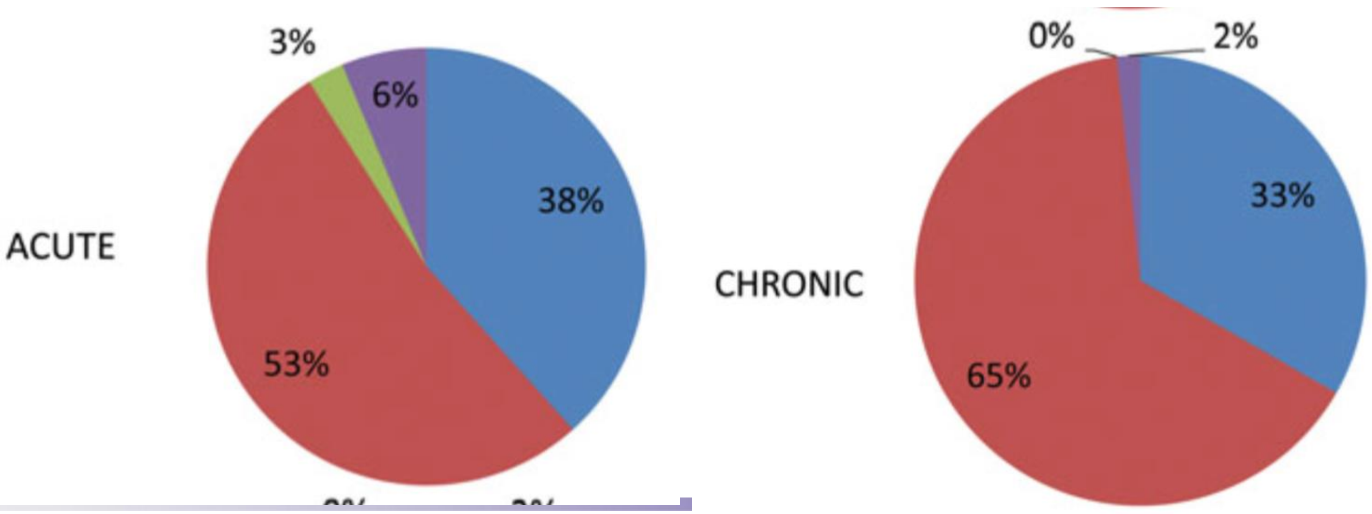
Aortic arch surgery – Type of cerebral perfusion

EUROPEAN JOURNAL OF
CARDIO-THORACIC SURGERY

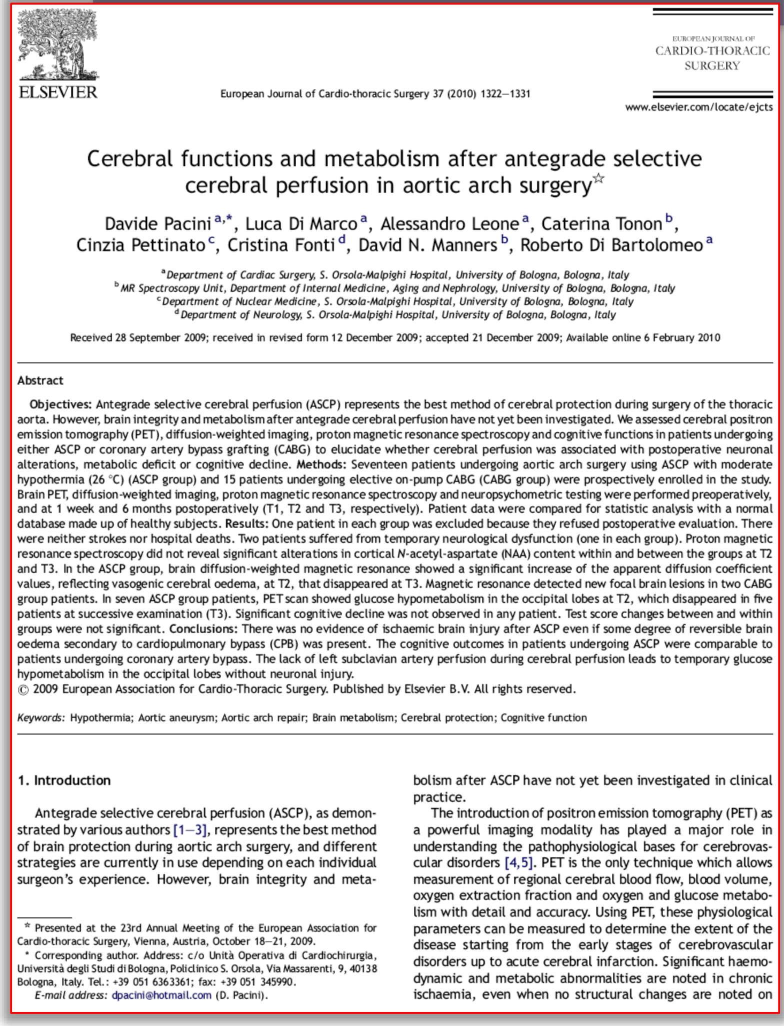
Current trends in cannulation and neuroprotection during surgery of the aortic arch in Europe[†‡]

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

> 90 % ASCP



Aortic arch surgery – Antegrade Selective Cerebral Perfusion



ELSEVIER

European Journal of Cardio-thoracic Surgery 37 (2010) 1322—1331

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

www.elsevier.com/locate/ejcts

Cerebral functions and metabolism after antegrade selective cerebral perfusion in aortic arch surgery☆

Davide Pacini[a,*], Luca Di Marco[a], Alessandro Leone[a], Caterina Tonon[b],
Cinzia Pettinato[c], Cristina Fonti[d], David N. Manners[b], Roberto Di Bartolomeo[a]

[a] *Department of Cardiac Surgery, S. Orsola-Malpighi Hospital, University of Bologna, Bologna, Italy*
[b] *MR Spectroscopy Unit, Department of Internal Medicine, Aging and Nephrology, University of Bologna, Bologna, Italy*
[c] *Department of Nuclear Medicine, S. Orsola-Malpighi Hospital, University of Bologna, Bologna, Italy*
[d] *Department of Neurology, S. Orsola-Malpighi Hospital, University of Bologna, Bologna, Italy*

Received 28 September 2009; received in revised form 12 December 2009; accepted 21 December 2009; Available online 6 February 2010

Abstract

Objectives: Antegrade selective cerebral perfusion (ASCP) represents the best method of cerebral protection during surgery of the thoracic aorta. However, brain integrity and metabolism after antegrade cerebral perfusion have not yet been investigated. We assessed cerebral positron emission tomography (PET), diffusion-weighted imaging, proton magnetic resonance spectroscopy and cognitive functions in patients undergoing either ASCP or coronary artery bypass grafting (CABG) to elucidate whether cerebral perfusion was associated with postoperative neuronal alterations, metabolic deficit or cognitive decline. **Methods:** Seventeen patients undergoing aortic arch surgery using ASCP with moderate hypothermia (26 °C) (ASCP group) and 15 patients undergoing elective on-pump CABG (CABG group) were prospectively enrolled in the study. Brain PET, diffusion-weighted imaging, proton magnetic resonance spectroscopy and neuropsychometric testing were performed preoperatively, and at 1 week and 6 months postoperatively (T1, T2 and T3, respectively). Patient data were compared for statistic analysis with a normal database made up of healthy subjects. **Results:** One patient in each group was excluded because they refused postoperative evaluation. There were neither strokes nor hospital deaths. Two patients suffered from temporary neurological dysfunction (one in each group). Proton magnetic resonance spectroscopy did not reveal significant alterations in cortical *N*-acetyl-aspartate (NAA) content within and between the groups at T2 and T3. In the ASCP group, brain diffusion-weighted magnetic resonance showed a significant increase of the apparent diffusion coefficient values, reflecting vasogenic cerebral oedema, at T2, that disappeared at T3. Magnetic resonance detected new focal brain lesions in two CABG group patients. In seven ASCP group patients, PET scan showed glucose hypometabolism in the occipital lobes at T2, which disappeared in five patients at successive examination (T3). Significant cognitive decline was not observed in any patient. Test score changes between and within groups were not significant. **Conclusions:** There was no evidence of ischaemic brain injury after ASCP even if some degree of reversible brain oedema secondary to cardiopulmonary bypass (CPB) was present. The cognitive outcomes in patients undergoing ASCP were comparable to patients undergoing coronary artery bypass. The lack of left subclavian artery perfusion during cerebral perfusion leads to temporary glucose hypometabolism in the occipital lobes without neuronal injury.

Keywords: Hypothermia; Aortic aneurysm; Aortic arch repair; Brain metabolism; Cerebral protection; Cognitive function

1. Introduction

Antegrade selective cerebral perfusion (ASCP), as demonstrated by various authors [1—3], represents the best method of brain protection during aortic arch surgery, and different strategies are currently in use depending on each individual surgeon's experience. However, brain integrity and metabolism after ASCP have not yet been investigated in clinical practice.

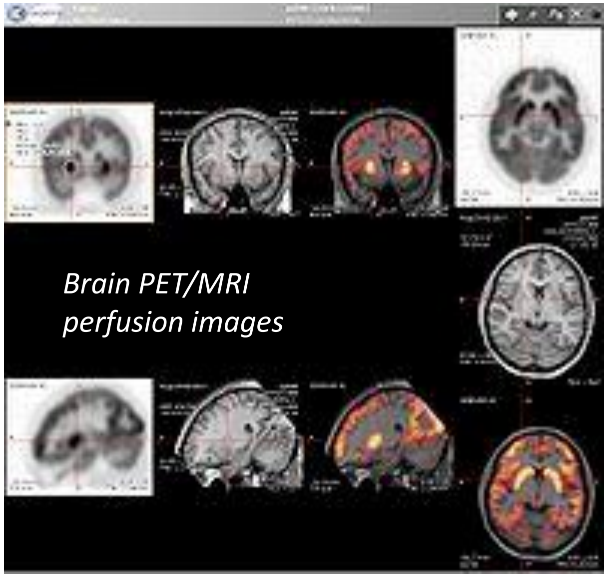
The introduction of positron emission tomography (PET) as a powerful imaging modality has played a major role in understanding the pathophysiological bases for cerebrovascular disorders [4,5]. PET is the only technique which allows measurement of regional cerebral blood flow, blood volume, oxygen extraction fraction and oxygen and glucose metabolism with detail and accuracy. Using PET, these physiological parameters can be measured to determine the extent of the disease starting from the early stages of cerebrovascular disorders up to acute cerebral infarction. Significant haemodynamic and metabolic abnormalities are noted in chronic ischaemia, even when no structural changes are noted on

---

☆ Presented at the 23rd Annual Meeting of the European Association for Cardio-thoracic Surgery, Vienna, Austria, October 18—21, 2009.

* Corresponding author. Address: c/o Unità Operativa di Cardiochirurgia, Università degli Studi di Bologna, Policlinico S. Orsola, Via Massarenti, 9, 40138 Bologna, Italy. Tel.: +39 051 6363361; fax: +39 051 345990.
E-mail address: dpacini@hotmail.com (D. Pacini).

Diffusion-weighted MR: measures the diffusion of water molecules in biological tissues. It has been extensively used to assess brain microstructure and metabolism.

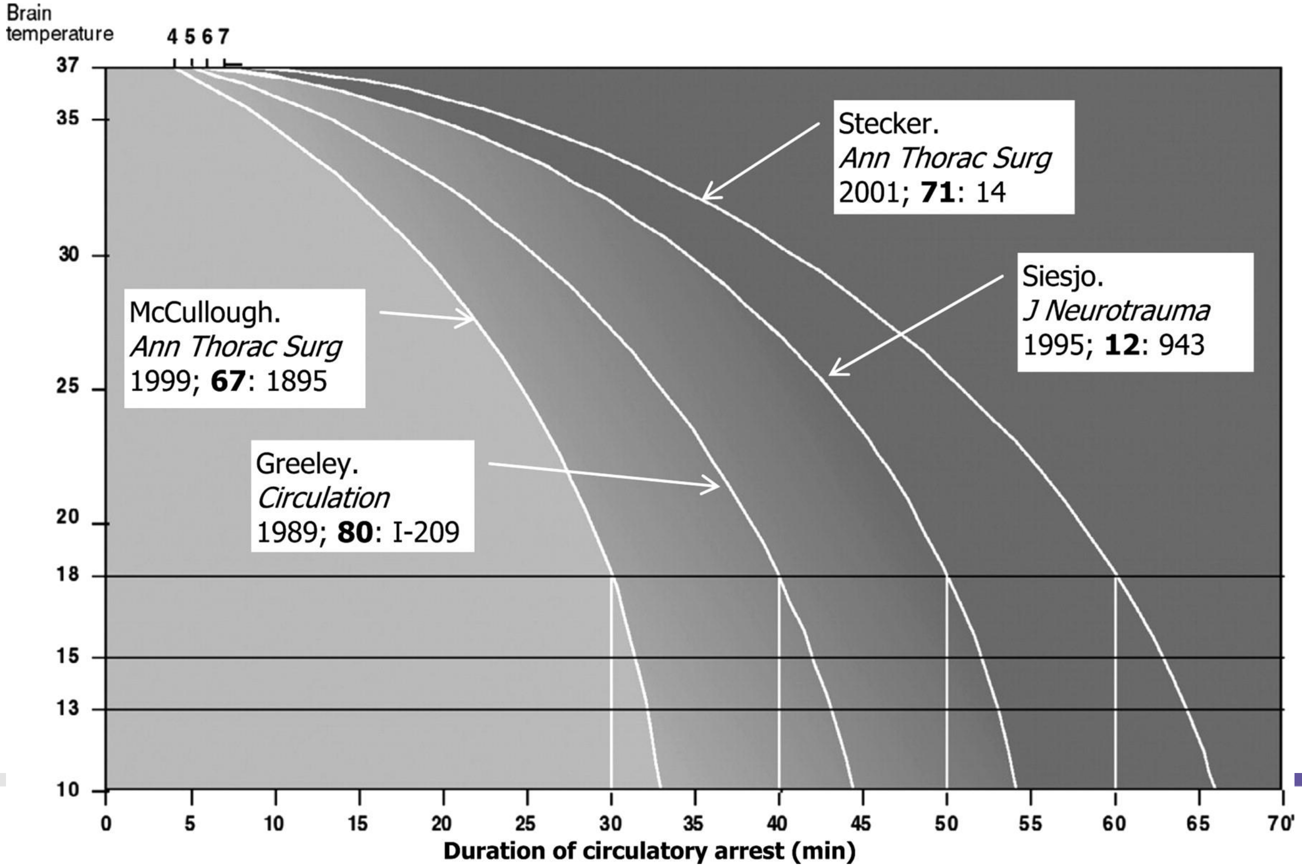


Brain PET/MRI perfusion images

Eur J Cardiothorac Surg. 2010;37:1322-31

Aortic arch surgery – Temperature management

Consequences of circulatory arrest in relation to temperature and duration of cerebral ischemia



Stecker.
Ann Thorac Surg
2001; **71**: 14

Siesjo.
J Neurotrauma
1995; **12**: 943

McCullough.
Ann Thorac Surg
1999; **67**: 1895

Greeley.
Circulation
1989; **80**: I-209

Aortic arch surgery – Temperature management

Mild to moderate hypothermia

doi:10.1016/j.ejcts.2011.03.060

Mild-to-moderate hypothermia in aortic arch
circulatory arrest: a change of paradig

Paul P. Urbanski*, Aristidis Lenos, Petros Bougioukakis, Ioannis Neophy
and Anno Diegeler

Cardiovascular Clinic Bad Neustadt, Bad Neustadt, Germany

* Corresponding author. Tel: +49-9771-662416; fax: +49-9771-651219; e-mail: p.urbanski@kardiochirurgie.de, p.urbanski

Received 24 January 2011; received in revised form 4 March 2011; accepted 7 March 2011

Abstract

OBJECTIVES: Antegrade cerebral perfusion makes deep hypothermia non-essential for neuroprot
tendency to increase the body temperature during circulatory arrest with selective brain perfusion
the clinical efficacy of mild-to-moderate hypothermia for ischemic organ protection during circula
to evaluate the safety and efficiency of mild-to-moderate hypothermia for lower-body protection
latory arrest and antegrade cerebral perfusion.

METHODS: Between January 2005 and December 2009, a total of 347 patients underwent non-e
the systematic cooling was adapted to the expected time of circulatory arrest, and cerebral pe
blood temperature of 28°C. There were 40 cardiac or aortic re-operations, 312 patients had con
and 10 patients had replacement of the descending aorta. All examined data were collected prosp

RESULTS: The duration of circulatory arrest and the deepest rectal temperature were 18±11 mi
(range, 26.0-35.0 °C) for all 347 patients, and 34±12 min (range, 17-70 min) and 29.9±1.7°C
having total/subtotal arch replacement. The maximum serum lactate level on the first posto
1.2 mmol l^{-1}. In the statistical analysis, no association between the duration of temperature-adap
atinine, or lactate dehydrogenase levels after surgery could be demonstrated. The 30-day morta
deficit or temporary dysfunction occurred in three (0.9%) and eight (2.3%) patients, respectively.
were reported; however, mesenteric ischemia occurred in one patient with severe stenosis of t
ies. Temporary dialysis was necessary primarily after surgery in five patients. All of them under
four patients had an increased creatinine level before surgery.

CONCLUSION: Systemic mild-to-moderate hypothermia that is adapted to the duration of c
effective method of organ protection and can be recommended in routine aortic arch surge
perfusion.

Keywords: Aortic arch • Circulatory arrest • Hypothermia • Organ protection

INTRODUCTION

The tolerance of cerebral ischemia is restricted under normothermia to very few minutes and, even under profound hypothermia, it can only be prolonged with limitation. Yet, hypothermia is associated with extended time of cardiopulmonary bypass (CPB) needed for cooling and rewarming and with serious negative side effects, such as coagulopathy or organ dysfunction. On the other hand, after the introduction of antegrade cerebral perfusion, deep hypothermia became non-essential for neuroprotection, which led to a growing interest in increasing the body temperature during circulatory arrest (CA). Even if the

ischemic tolerance time
kidneys, or even the sp
longer than the brain, ve
clinical efficacy of mild-to
tection during the avera
repair [1]. This study was
mild-to-moderate hypot
arch surgery using CA wi

PATIENTS AND ME

Between January 2005
patients underwent aor
the defined protocol, p

[1] Presented at the 40th Annual Meeting of the German Society for Thoracic and Cardiovascular Surgery, Stuttgart, Germany, 13–16 February 2011.

ADULT CARDIAC

Aortic Arch Repair With Antegrade Selec
Cerebral Perfusion Using Mild to Moder
Hypothermia of More Than 28°C

Satoshi Numata, MD, PhD, Yasushi Tsutsumi, MD, Osamu Monta, M
Sachiko Yamazaki, MD, Hiroyuki Seo, MD, Ryo Sugita, MD, Shohei
Hirokazu Ohashi, MD, PhD

Department of Cardiovascular Surgery, Fukui Cardiovascular Center, Shinpo Fukui, Japan

Background. The temperature at circulatory arrest during open distal anastomosis is the most significant issue for aortic arch repair. In many institutions, there has been trend toward raising the temperature during circulatory arrest.

Methods. Between 2004 and 2011, 164 consecutive patients underwent aortic arch repair with antegrade selective cerebral perfusion (ASCP) and moderate hypothermia. The patients were divided into two subsets (n = 84 each): group A (circulatory arrest at less than 27.9°C) and group B (at more than 28°C).

Results. In group A compared with group B, mean temperature at circulatory arrest was 26° ± 1.0°C vs 29° ± 1.0°C, mean ASCP time was 72 ± 23 minutes vs 67 ± 17 minutes, and mean circulatory arrest time was 47 ± 21 minutes vs 44 ± 13 minutes. The 30-day mortality was

6.1% in both groups. Perma
curred in 8 patients (9.8%) in
group B ($p = 0.39$). The incid
ing hemodialysis was 14.6%
group B ($p = 0.02$). Postop
requiring mechanical ventil
curred in 12.2% of patients
group B ($p = 0.04$).

Conclusions. The temper
safely increased to more than
rate of mortality and morb
hypothermia offered sufficie
protection.

(An
© 2012 by The S

Organ protection during circulatory arrest for aortic arch operations has been well established in many institutions, and surgical results of aortic arch repair have improved significantly [1–8]. Selective antegrade cerebral perfusion is the most reliable brain protection method for aortic arch repair, although there are many controversial problems such as temperature at circulatory arrest, perfusion volume, perfusion pressure, and side of perfusion. The temperature at circulatory arrest may affect surgical results dramatically in terms of organ protection.

In our institution, selective cerebral perfusion with hypothermic circulatory arrest at 24°C was applied in 2004. Since then, the temperature at circulatory arrest has been raised as the safety of "warmer" hypothermic circulatory arrest has been reported by other institutions. Since 2008, circulatory arrest in our institution has been obtained at 28°C in elective and emergency settings, although warmer or cooler temperatures may be applied, depending on the complexity of the patient's aortic arch anatomy. For example, a proximal aortic arch aneurysm

only requires partial arch
and in this situation, we onl
25°C for repairing a thor
extended to the distal diste
anastomosis is expected to
ing. This study evaluated
repair with hypothermia a

Patients and Methods

Patient Profile

Between 2004 and 2011, co
went aortic arch repair
arrest and selective cereb
placement was performed
remaining 143 (87%) und
Eighty-two patients (50%)
Thirty-one patients (19%)
ing the operating theater.
12 years (range, 19 to 89
The patients were div
each) according to the d
received circulatory arres
B received circulatory re
tive characteristics of th

Accepted for publication March 1, 2012.

Presented at the Forty-eighth Annual Meeting of The Society of Thoracic Surgeons, Fort Lauderdale, FL, Jan 28–Feb 1, 2012.

Address correspondence to Dr Numata, Department of Cardiovascular Surgery, Fukui Cardiovascular Center, 2-228 Shinpo Fukui 918-0835,

---

ADULT CARDIAC

Antegrade Cerebral Perfusion With Mild Hypothermia for Aortic Arch Replacement: Single-Center Experience in 245 Consecutive Patients

Andreas Zierer, MD, Faisal Detho, MD, Omer Dzemali, MD, Tayfun Aybek, MD,
Anton Moritz, MD, and Farhad Bakhtiary, MD

Division of Thoracic and Cardiovascular Surgery, Johann Wolfgang Goethe University, Frankfurt/Main, Germany; and Division of Cardiovascular Surgery, Mesa Hospital, Ankara, Turkey

Background. Aortic arch replacement remains a surgical challenge because of prolonged operative times, bleeding complications, and a considerable risk of neurologic morbidity and mortality. This study investigates our clinical results after modification of perfusion technique for cardiopulmonary bypass as well as temperature management for these high- risk patients.

Methods. Between January 2000 and January 2009, 245 consecutive patients underwent aortic arch repair during selective antegrade cerebral perfusion (ACP) with mild systemic hypothermia (30.5°C ± 1.4°C). Mean age was 63 ± 12 years, 175 patients (71%) were men and 141 patients (58%) had acute type A dissection. Hemiarch replacement was performed in 152 patients (62%) while the remaining 93 patients (38%) underwent total arch replacement.

Results. Cardiopulmonary bypass time accounted for 168 ± 62 minutes, and myocardial ischemic time was 103 ± 45 minutes. Isolated ACP was performed for 38 ± 27 (range 12 to 135) minutes. Chest tube drainage during the first 24 hours was 563 ± 248 mL. Mean ventilation time was 44 ± 22 hours. Serum lactate levels at 1, 12, and 24 hours postoperatively rose to 19 ± 11, 33 ± 14, and 20 ± 8 mg/dL, respectively. We observed new postoperative permanent neurologic deficits in 14 patients (6%) and transient neurologic deficits in 12 patients (5%). The operative mortality rate was 8% (n = 20). Among patients with ACP times 60 minutes or greater (n = 28; 92 ± 29 minutes), permanent neurologic deficits occurred in 2 individuals (n = 2 of 28; 7%) and operative mortality was 7% (n = 2 of 28). At late follow-up (3.8 ± 3.2 years, 98% complete), 196 patients (80%) were still alive.

Conclusions. Selective ACP in combination with mild hypothermia offered sufficient cerebral as well as distal organ protection in our patient cohort. Thus, current data suggest that this standardized perfusion and temperature management protocol can safely be applied to complex aortic arch surgery requiring up to 90 minutes of isolated ACP times.

(Ann Thorac Surg 2011;91:1868–74)
© 2011 by The Society of Thoracic Surgeons

Historically, reconstruction of the aortic arch has been exclusively performed during deep hypothermic circulatory arrest (DHCA) [1–4]. Well-documented drawbacks of deep hypothermia include disturbance of the coagulation system, temperature-related systemic vasoconstriction causing diminished organ perfusion leading to lactate acidosis [5], and impairment of cerebral autoregulation [6–8]. Furthermore, DHCA alone gives the surgeon only a limited time to complete the aortic repair. A core temperature of 18°C should theoretically allow for 30 to 40 minutes of safe HCA, but HCA times beyond this limit have been associated with increased incidence of adverse neurologic outcome [9–11].

In an attempt to prolong the safe limits of DHCA, retrograde cerebral perfusion through the superior vena cava has been advocated, although this technique failed to demonstrate sufficient cerebral blood flow [12, 13]. Antegrade cerebral perfusion (ACP) has been popularized, offering a more physiologic method of perfusion and extending the safe limits for arch repair [14, 15]. Initially, deep hypothermia has been used as an adjunct to ACP almost universally [3, 16]. More recently, the absolute necessity for deep hypothermia during aortic surgery once ACP with flow rates and pressures within the physiologic range is provided has been questioned from our and other institutions [17–22]. However, this technical modification has not yet gained widespread acceptance for treatment of pathologies affecting the aortic arch. The purpose of the current investigation was to review and analyze our institutional experience using a standardized ACP technique in combination with mild hypothermia in 245 consecutive patients requiring aortic arch replacement.

Material and Methods

Between January 2000 and January 2009, 245 consecutive adult patients presenting with diseased aortic arch un-

---

Accepted for publication Feb 23, 2011.

Address correspondence to Dr Zierer, Division of Thoracic and Cardiovascular Surgery, Johann Wolfgang Goethe University, Theodor Stern Kai 7, 60590 Frankfurt am Main, Germany; e-mail: andreaszierer@gmx.at.

Aortic arch surgery – Temperature management

European Journal of Cardio-Thoracic Surgery 46 (2014) 438–443
doi:10.1093/ejcts/ezt665 Advance Access publication 3 February 2014

ORIGINAL ARTICLE

Visceral organ protection in aortic arch surgery: safety of moderate hypothermia†

Davide Pacini[a,*], Antonio Pantaleo[a], Luca Di Marco[a], Alessandro Leone[a], Giuseppe Barberio[a], Giacomo Murana[a], Sebastiano Castrovinci[a], Sandra Sottili[b] and Roberto Di Bartolomeo[a]

304 patients enrolled in the study

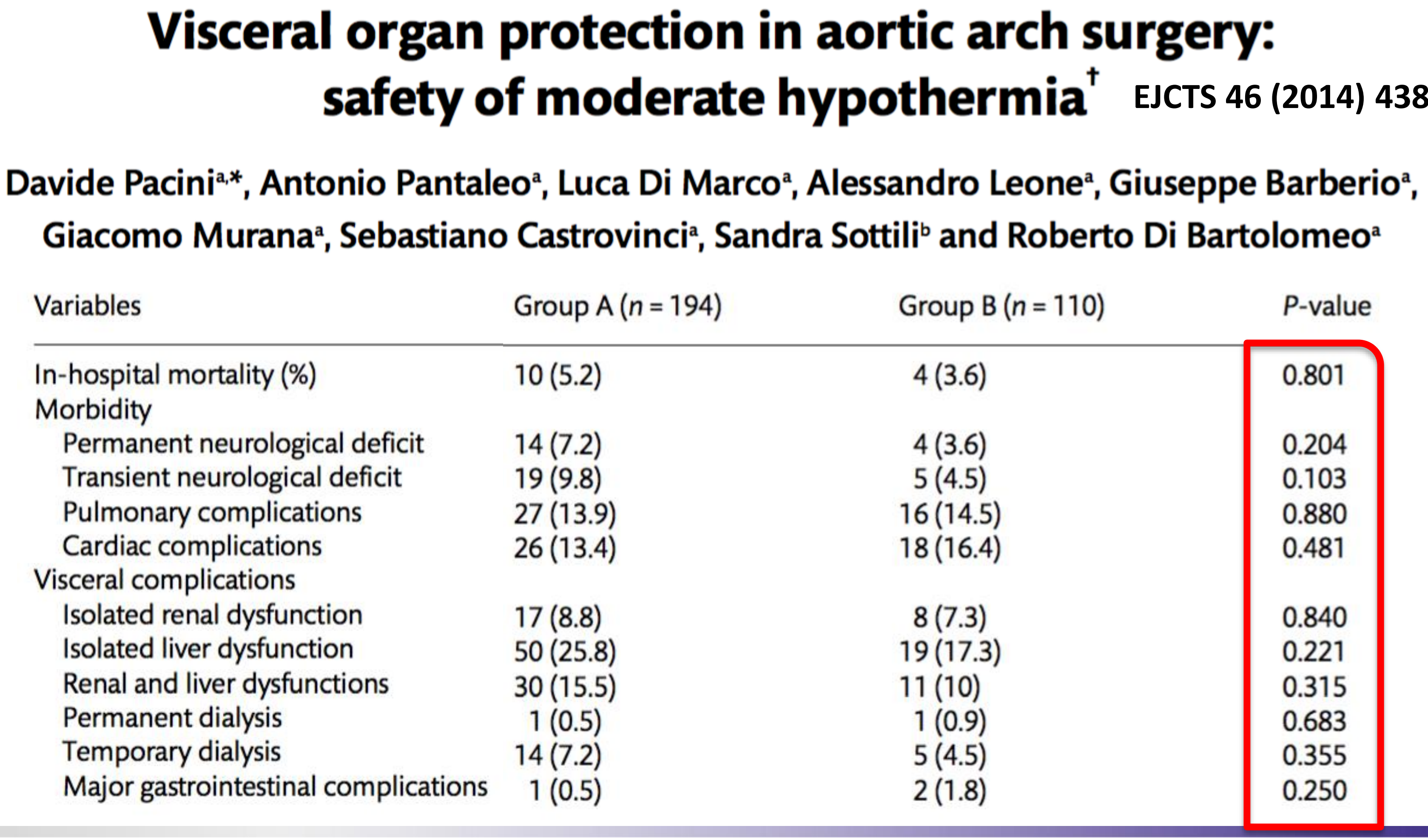
194 pts
Group A

110 pts
Group B

Nasopharyngeal temperature
≤ 25°C

Nasopharyngeal temperature
> 25°C

Aortic arch surgery – Temperature management



Visceral organ protection in aortic arch surgery: safety of moderate hypothermia[†]

EJCTS 46 (2014) 438–443

Davide Pacini[a,*], Antonio Pantaleo[a], Luca Di Marco[a], Alessandro Leone[a], Giuseppe Barberio[a], Giacomo Murana[a], Sebastiano Castrovinci[a], Sandra Sottili[b] and Roberto Di Bartolomeo[a]

Variables	Group A (*n* = 194)	Group B (*n* = 110)	*P*-value
In-hospital mortality (%)	10 (5.2)	4 (3.6)	0.801
Morbidity			
Permanent neurological deficit	14 (7.2)	4 (3.6)	0.204
Transient neurological deficit	19 (9.8)	5 (4.5)	0.103
Pulmonary complications	27 (13.9)	16 (14.5)	0.880
Cardiac complications	26 (13.4)	18 (16.4)	0.481
Visceral complications			
Isolated renal dysfunction	17 (8.8)	8 (7.3)	0.840
Isolated liver dysfunction	50 (25.8)	19 (17.3)	0.221
Renal and liver dysfunctions	30 (15.5)	11 (10)	0.315
Permanent dialysis	1 (0.5)	1 (0.9)	0.683
Temporary dialysis	14 (7.2)	5 (4.5)	0.355
Major gastrointestinal complications	1 (0.5)	2 (1.8)	0.250

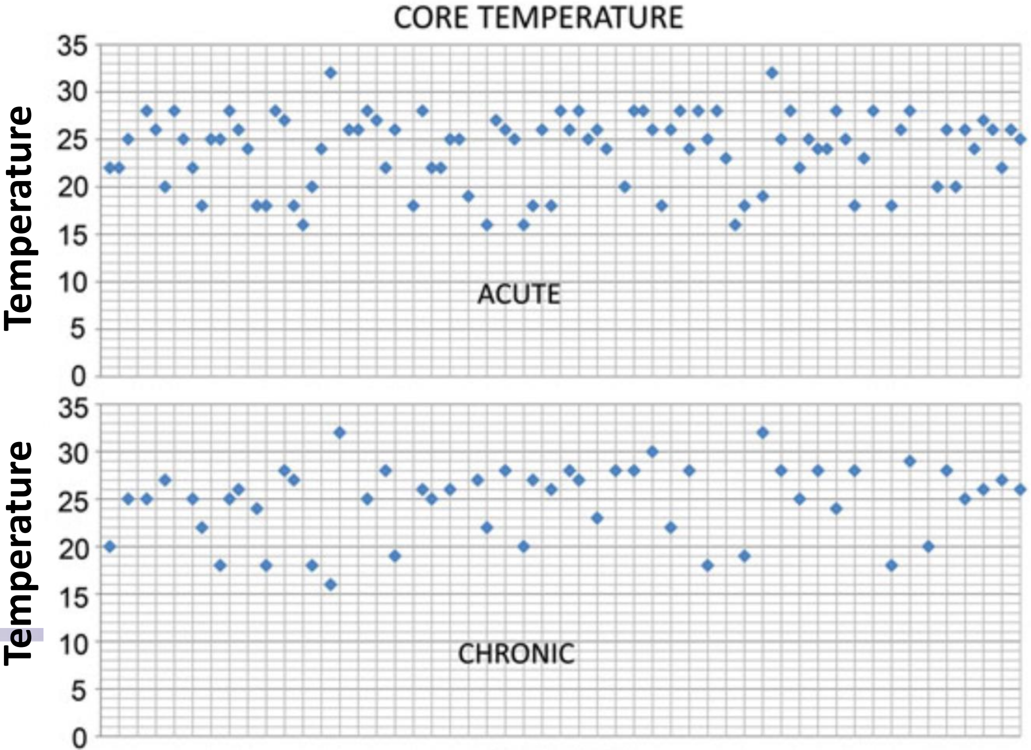
Aortic arch surgery – Temperature management

Current trends in cannulation and neuroprotection during surgery of the aortic arch in Europe†‡

EUROPEAN JOURNAL OF
CARDIO-THORACIC SURGERY

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

2/3 of centres prefer a core temperature between 24 and 26° C



Aortic arch surgery – Myocardial protection

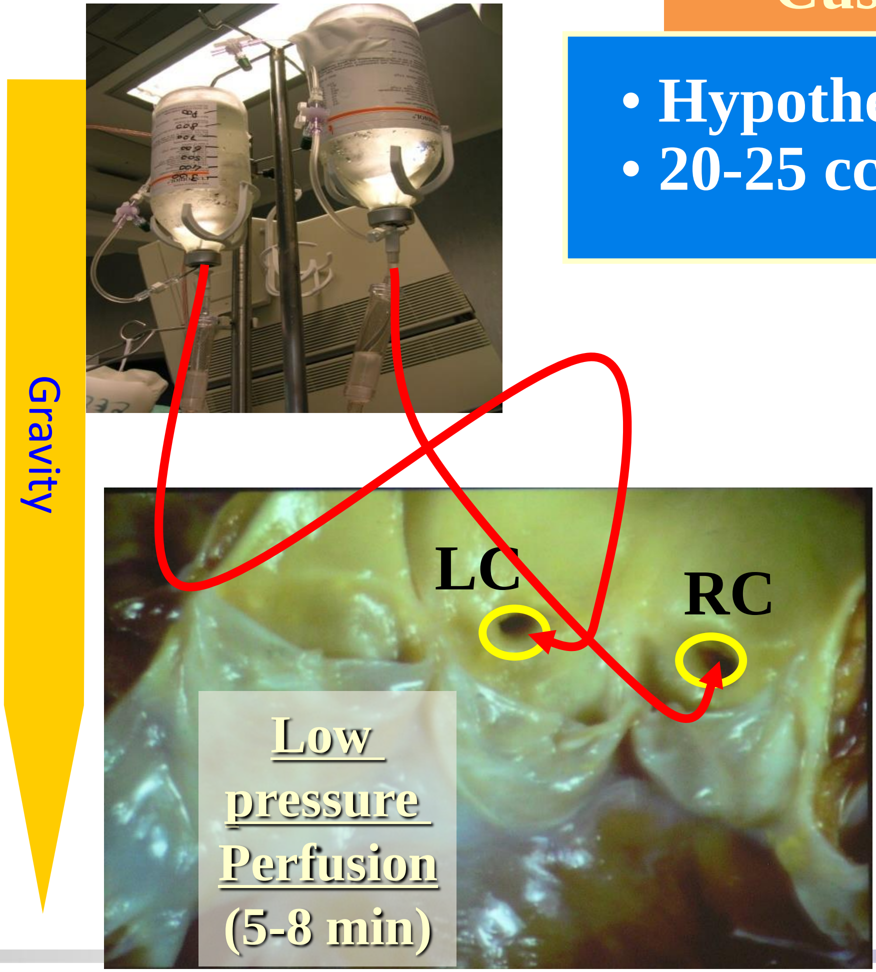
Custodiol ® Modified Bretschneider solution

- **Hypothermia (8-10° C)**
- **20-25 cc/Kg single dose**

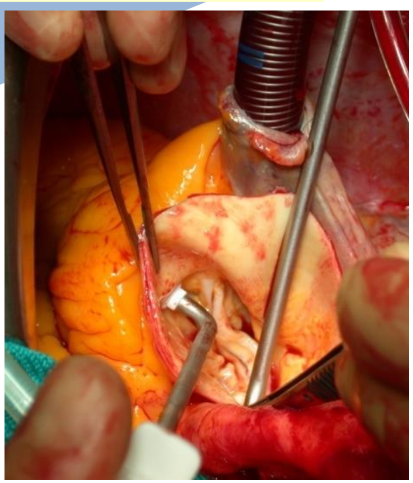
→ **180 min (3 h) ischemia**

Selective infusion

+/- retrograde perfusion



Low pressure Perfusion (5-8 min)



Aortic arch surgery – Operative technique

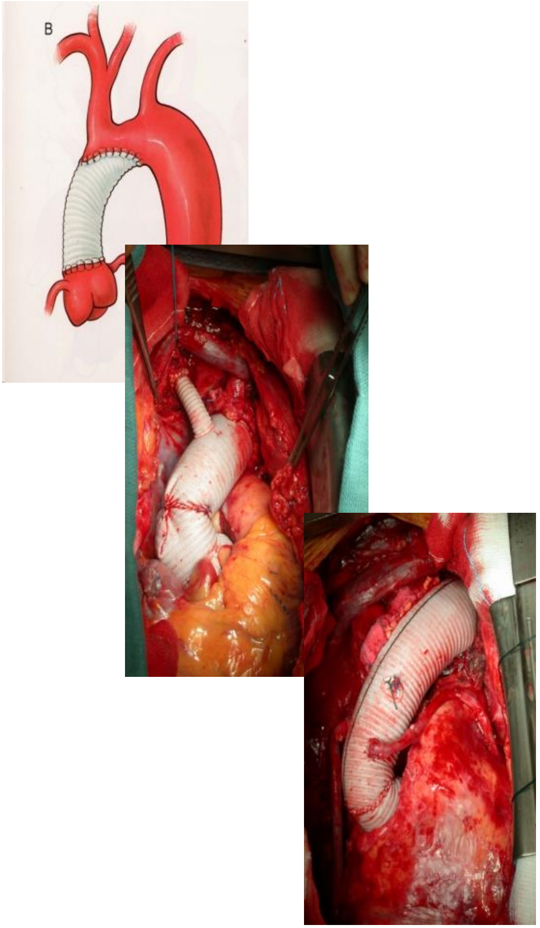
Straight prosthesis

Single branched prosthesis

Hemiarch

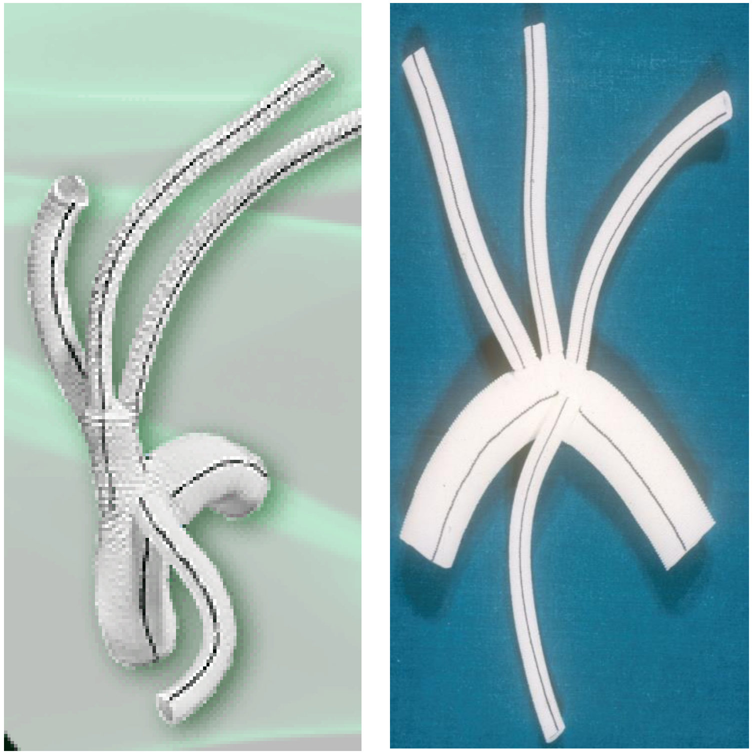
Partial Arch

Total Arch
(Carrel patch)



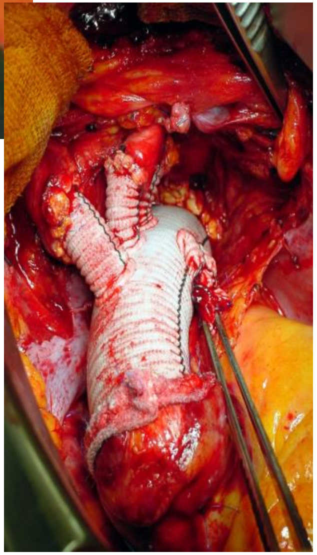
Aortic arch surgery – Operative technique

Branched prosthesis



Partial Arch

Total Arch
(Separated vessels)

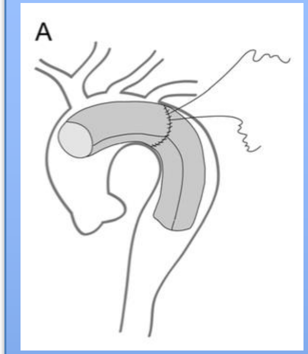


Aortic arch surgery – Operative technique

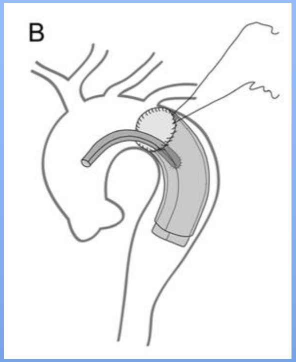
1982

THE TRUNK EVOLUTION

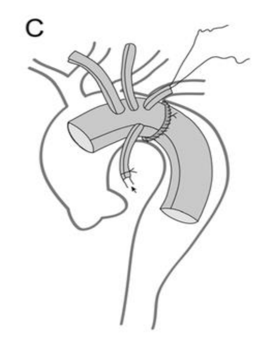
Today



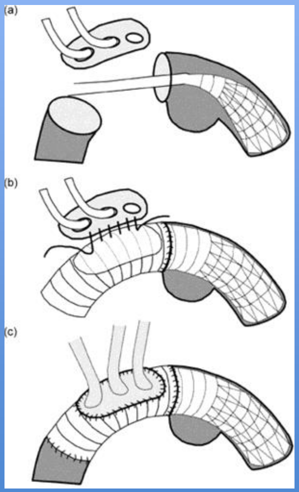
Birth of ET



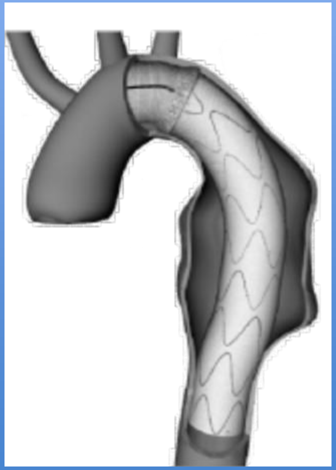
1992
ET modified
distal suture
Crawford-Svensson



2004
Branched ET
Neri



2003
Birth of FET
Chavan-Haverich



2007
FET Hybrid graft

2012
Branched FET

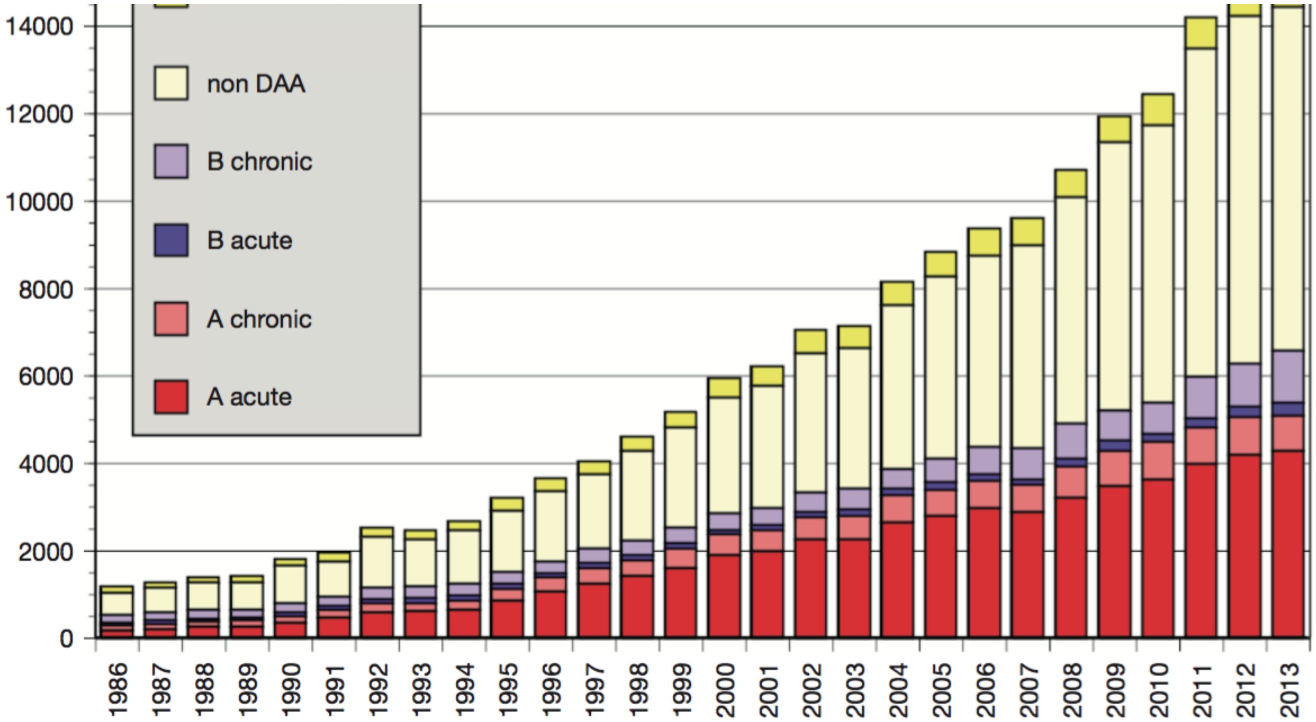
Aortic arch surgery – Current results

Perspective

Ann Cardiothorac Surg 2016;5(4):368-376

Current surgical results of acute type A aortic dissection in Japan

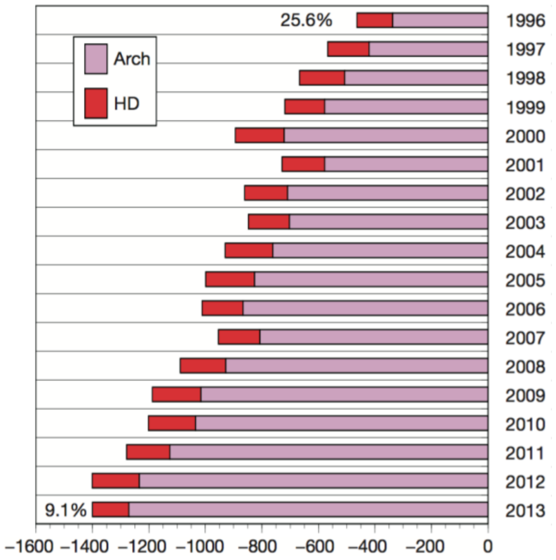
Yutaka Okita



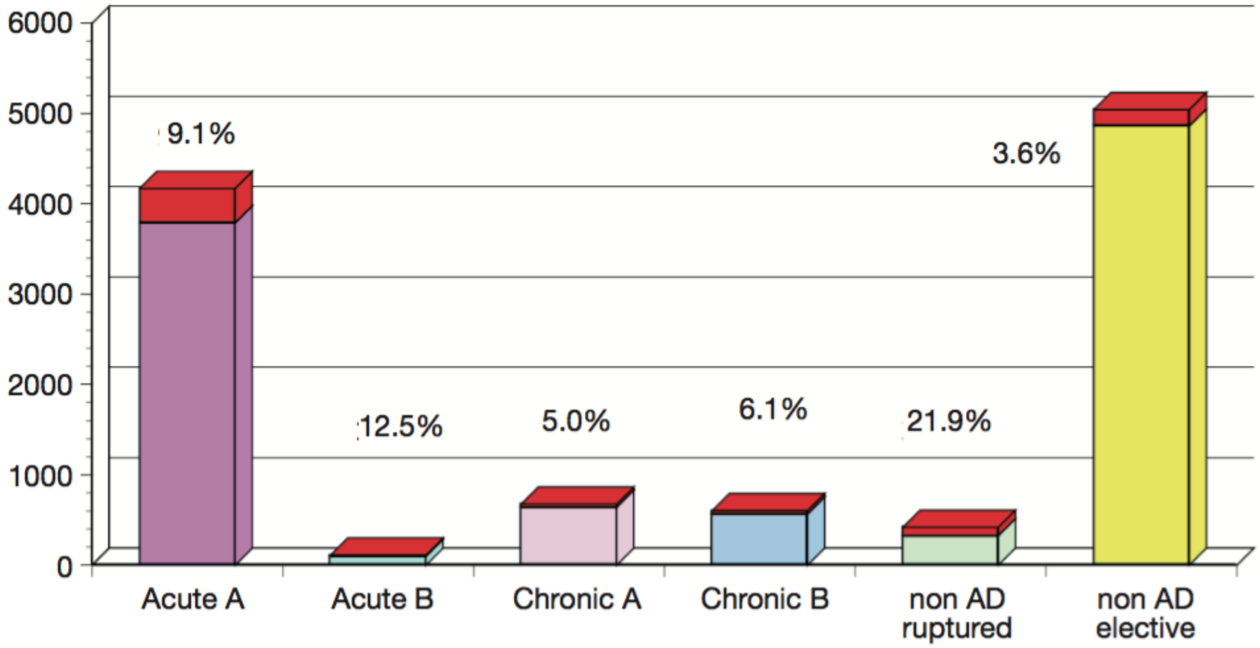
Aortic arch surgery – Current results

Current surgical results of acute type A aortic dissection in Japan

Okita Y. *Ann Cardiothorac Surg* 2016;5(4):368-376



Acute type A dissection:
Hospital mortality: 9.1%

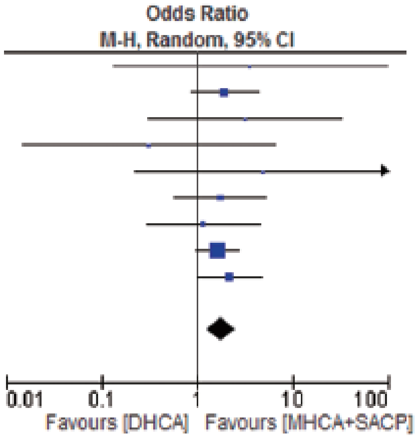


Aortic arch surgery – Current results

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

David H. Tian[1], Benjamin Wan[1], Paul G. Bannon[1,2], Martin Misfeld[3], Scott A. LeMaire[4,5], Teruhisa Kazui[6], Nicholas T. Kouchoukos[7], John A. Elefteriades[8], Joseph Bavaria[9], Joseph S. Coselli[4,5], Randall B. Griepp[10], Friedrich W. Mohr[3], Aung Oo[11], Lars G. Svensson[12], G. Chad Hughes[13], Tristan D. Yan[1,2]

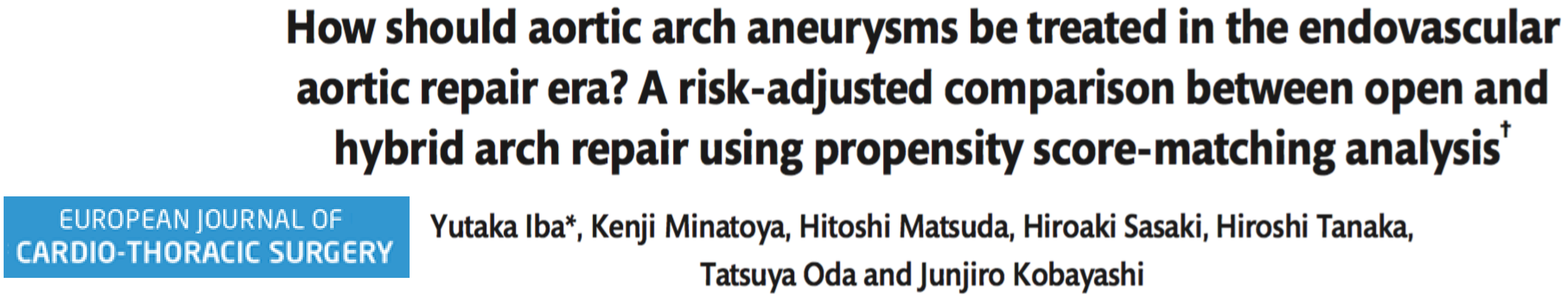
Permanent Neurological deficit (PND)



DHCA	ASCP
12,8%	7,3%

Ann Cardiothorac Surg 2013;2(2):148-158

Aortic arch surgery – Current results



How should aortic arch aneurysms be treated in the endovascular aortic repair era? A risk-adjusted comparison between open and hybrid arch repair using propensity score-matching analysis†

EUROPEAN JOURNAL OF
CARDIO-THORACIC SURGERY

Yutaka Iba*, Kenji Minatoya, Hitoshi Matsuda, Hiroaki Sasaki, Hiroshi Tanaka,
Tatsuya Oda and Junjiro Kobayashi

Propensity score matched groups

Caractheristics	Open	Hybrid
Num Patients	143	50
Age	72.1±9.2	78.6±9.3
Male gender	117 (82%)	40 (80%)

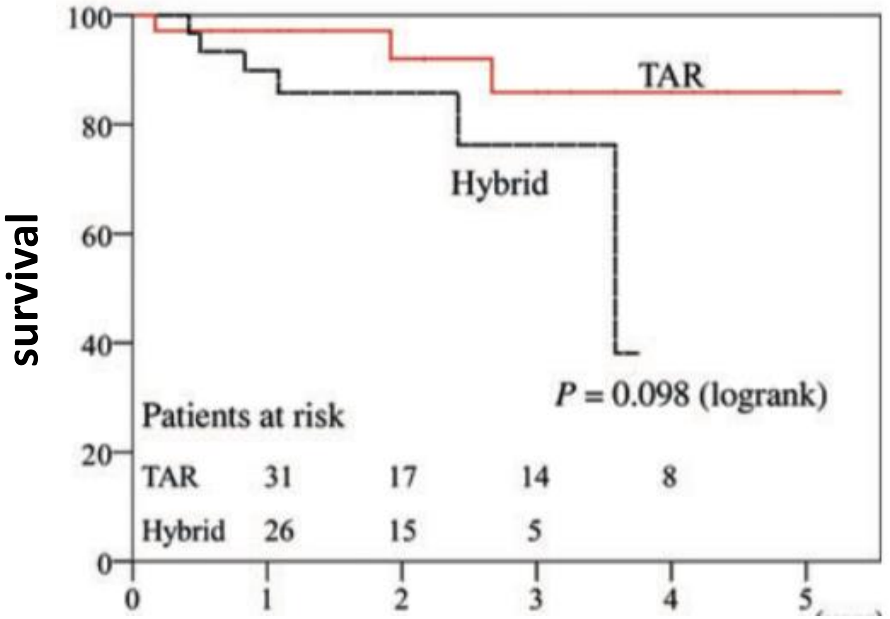
Open vs endovascular aortic repair

Aortic arch surgery – Current results

How should aortic arch aneurysms be treated in the endovascular aortic repair era? A risk-adjusted comparison between open and hybrid arch repair using propensity score-matching analysis†

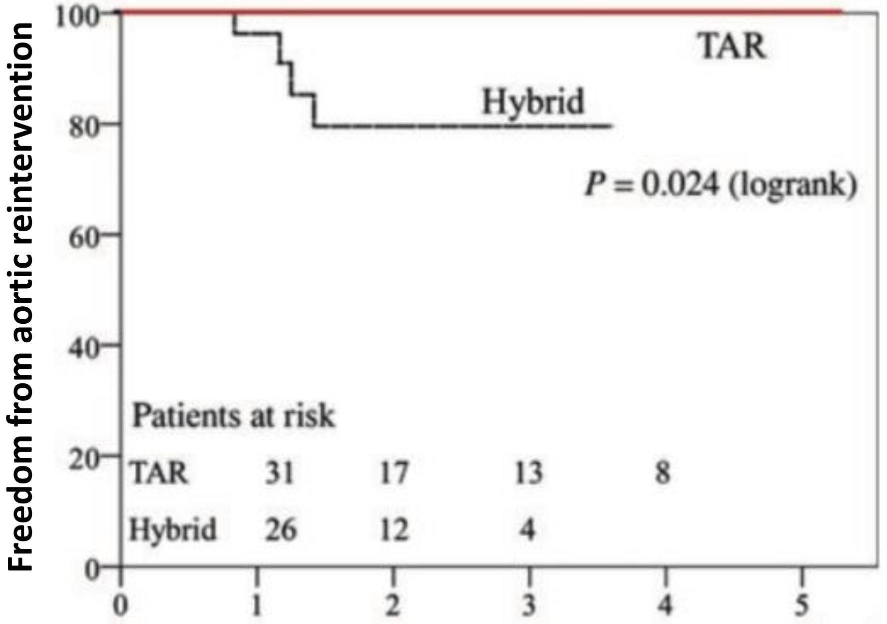
EUROPEAN JOURNAL OF
CARDIO-THORACIC SURGERY

Yutaka Iba*, Kenji Minatoya, Hitoshi Matsuda, Hiroaki Sasaki, Hiroshi Tanaka,
Tatsuya Oda and Junjiro Kobayashi



Patients at risk

TAR	31	17	14	8
Hybrid	26	15	5	



Patients at risk

TAR	31	17	13	8
Hybrid	26	12	4	

CONCLUSIONS

1. Conventional arch surgery can be safely performed
2. The results are excellent when appropriate principles of neurologic and organ protection are followed using ASCP and moderate-mild hypothermia
3. Compared to hybrid/endovascular treatments, open surgery offers more definitive repair

First announcement

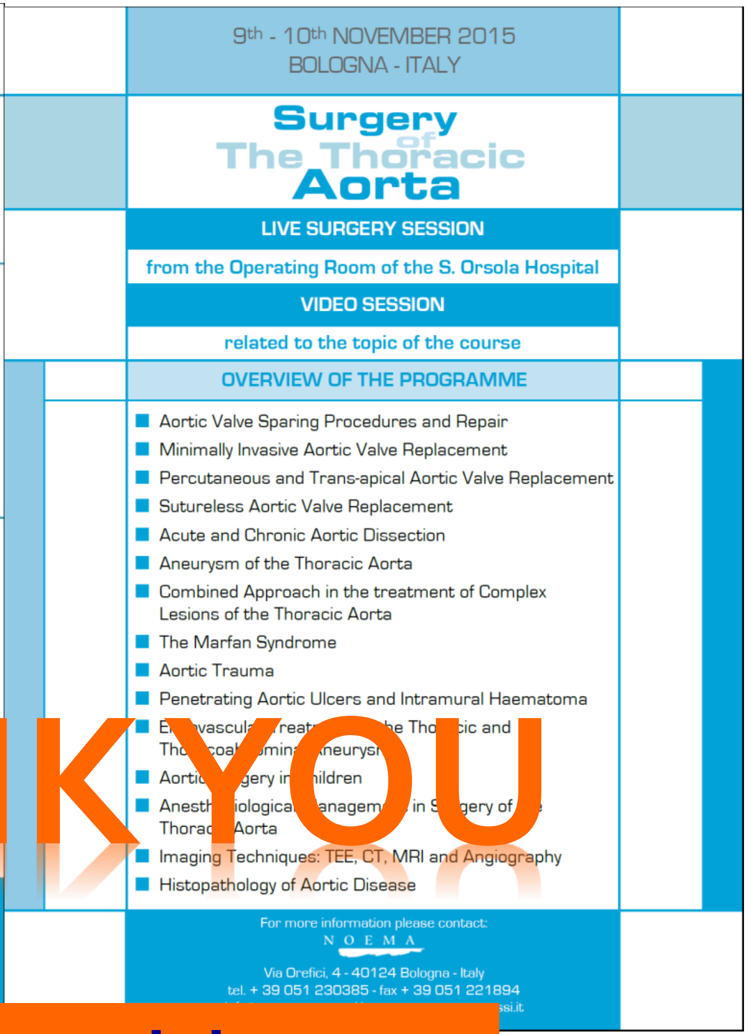
Surgery of The Thoracic Aorta

EIGHT POSTGRADUATE COURSE

13-14 Nov 2017
Bologna, Italy

Course Director:
Roberto Di Bartolomeo

Cardiac Surgery Department
University of Bologna
S. Orsola - Malpighi Hospital



9th - 10th NOVEMBER 2015
BOLOGNA - ITALY

Surgery of The Thoracic Aorta

LIVE SURGERY SESSION

from the Operating Room of the S. Orsola Hospital

VIDEO SESSION

related to the topic of the course

OVERVIEW OF THE PROGRAMME

- Aortic Valve Sparing Procedures and Repair
- Minimally Invasive Aortic Valve Replacement
- Percutaneous and Trans-apical Aortic Valve Replacement
- Sutureless Aortic Valve Replacement
- Acute and Chronic Aortic Dissection
- Aneurysm of the Thoracic Aorta
- Combined Approach in the treatment of Complex Lesions of the Thoracic Aorta
- The Marfan Syndrome
- Aortic Trauma
- Penetrating Aortic Ulcers and Intramural Haematoma
- E[illegible]vascula[illegible]reat[illegible]he Tho[illegible]cic and Tho[illegible]coa[illegible]mina[illegible]neurys[illegible]
- Aorti[illegible]gery i[illegible]ildren
- Anesth[illegible]iologica[illegible]anagem[illegible] in S[illegible]gery of [illegible] Thorac[illegible] Aorta
- Imaging Techniques: TEE, CT, MRI and Angiography
- Histopathology of Aortic Disease

For more information please contact:
NOEMA
Via Orefici, 4 - 40124 Bologna - Italy
tel. + 39 051 230385 - fax + 39 051 221894

THANK YOU

Davide Pacini

CARDIAC SURGERY DEPARTMENT - St. ORSOLA HOSPITAL
UNIVERSITY OF BOLOGNA – ITALY
davide.pacini@unibo.it

Aortic arch surgery – Current results of stented grafts

DEVICES

Total
> 28180

	Cronus	E-vita Open (Plus)	Thoraflex Hybrid	J Graft Open
Year of marketing	2003	2008	2012	2014
Manufacturer	MicroPort	Jotec	Vascutek	Japan Lifeline
Avalaibility	China, South America	Europe, Asia Pacific	Europe, Asia Pacific, Canada	Japan
N. of implants by Dec 2015	>18000	>5000	>1180	>2200

Ma WG, *Aorta, Aug 2015, Vol 3, Issue 4*

Aortic arch surgery – Current results of stented grafts

Clinical Outcomes	Cronus	E-vita Open (Plus)	Thoraflex Hybrid	J Graft Open
Patient age (years)	46	61	59	72
CBP time	193	239	241	178
Cerebral perfusion time	25	71	85	40
Early mortality	6.4	15.8	8.7	5
Early spinal cord injury	2.4	3.5	4	6.7
Late survival	89	69-85	77	78
Late reintervention	6.5	2-27	14.1	8.3

Ma WG, *Aorta, Aug 2015, Vol 3, Issue 4*