Cerebral oximetry in cardiac surgery

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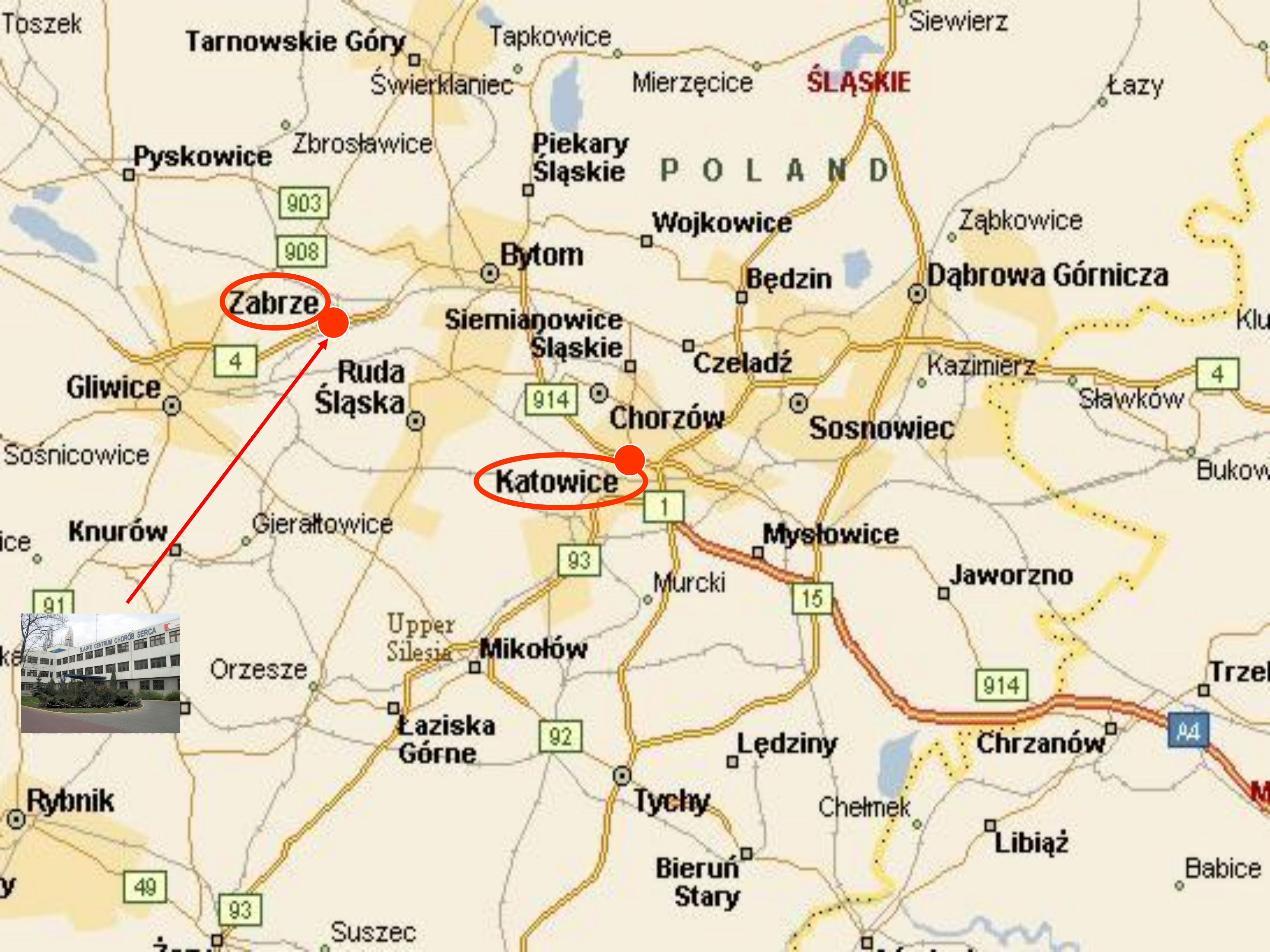
ŚLĄSKIE CENTRUM CHORÓB SERCA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Lędziny
Chrzanów
A4
Rybnik
Tychy
Chełmek
Libiąż
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Babice
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Suszec

Why additional monitoring?

Why additional monitoring?

40% of patients folowing myocardial revascularization has evidence of persistent congnitive decline.

Serious neurological complication is a disaster for the patient, patient’s family and the medical team involved.

The central nervous system is the least monitored physiological system during anesthesia.

Mortality and permament disability

TABLE 3. MORTALITY AND POSTOPERATIVE RESOURCE USE, ACCORDING TO CEREBRAL OUTCOME.*

VARIABLE	TYPE I OUTCOME (N=66)	TYPE II OUTCOME (N=63)	NO ADVERSE CEREBRAL EVENT (N=1979)
Death during hospitalization — no. (%)	14 (21)	6 (10)	38 (2)
Duration of postoperative hospital stay — days			
Mean ±SD	25.3±22.2	20.5±25.2	9.5±12.4
Median	17.6	10.9	7.7
Duration of ICU stay — days			
Mean ±SD	11.1±15.4	6.6±7.9	2.6±3.5
Median	5.8	3.2	1.9
Discharged to home — no. (%)†	21 (32)	38 (60)	1773 (90)

*P<0.001 for all comparisons among the groups. ICU denotes intensive care unit.

†Patients not discharged to their homes either died or were discharged to intermediate- or long-term care facilities.

!

Roach, N Engl J Med 1996;335:1857

Presence of neurological complication is usually obvious as soon as the patient recovers from general anaesthesia.

Complications that appear later are not that common.

Neurological complications present a wide spectrum...

...from minor disorders...

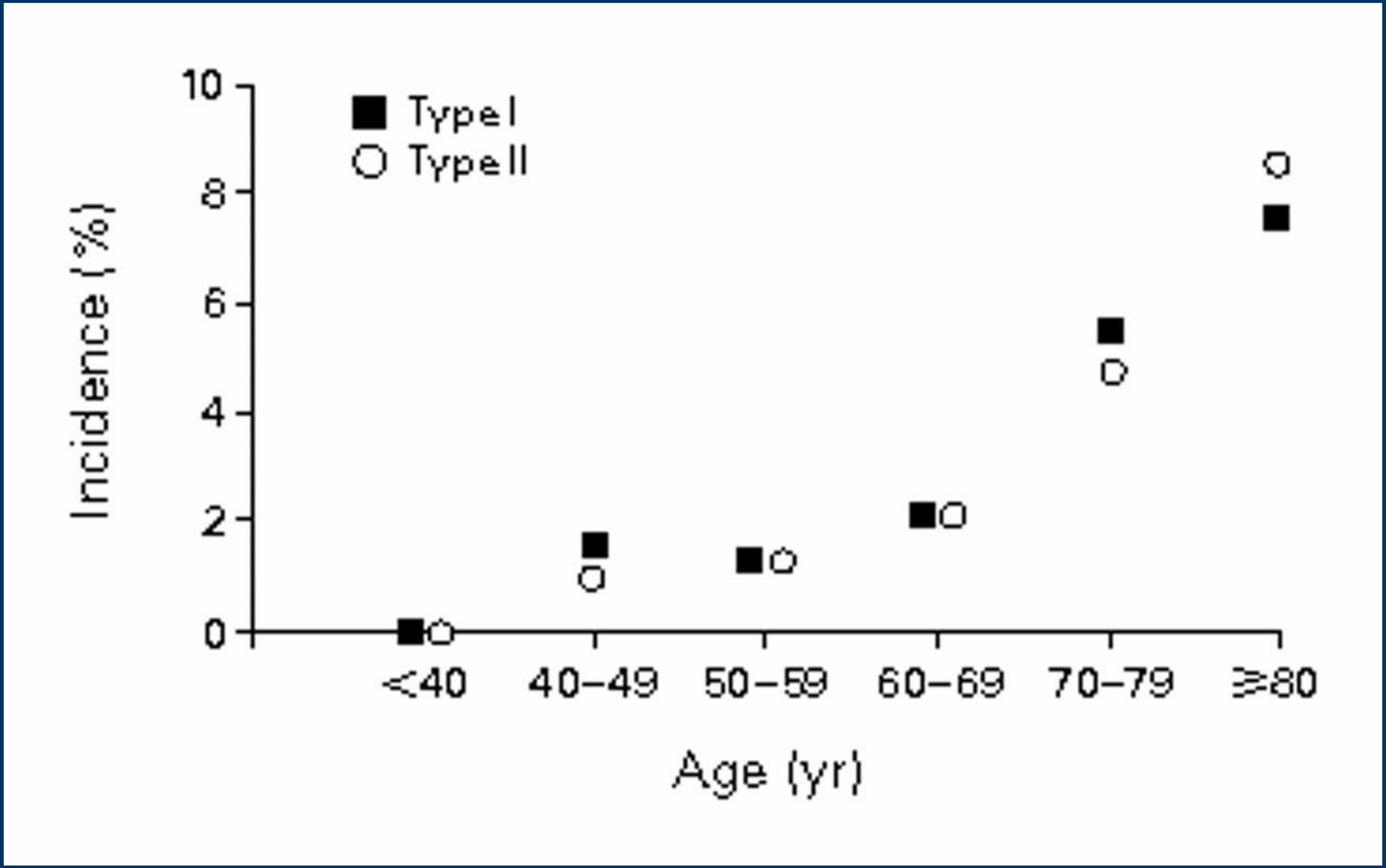
...to a major stroke.

Frequency: from 3 % to 80% (depends how the deficit is defined!)

There are two types of neurological injury – type I and II

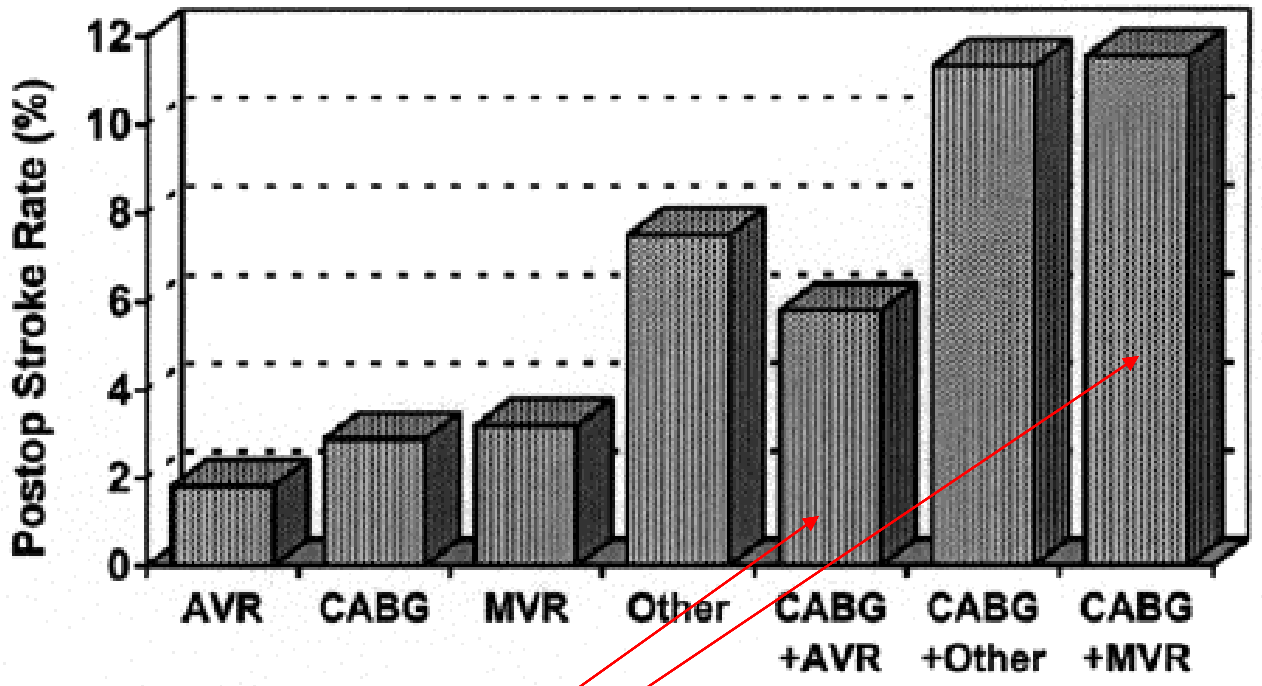
- type I - stroke or anoxaemic encephalopathy (resulting or not resulting in the patient's death), stupor or coma on discharge, TIA.
- type II – new deterioration of intelectual function, confusion, agitation, disorientation, impairment of recent or remote memory.

Frequency of neurological injury increases with age



Roach, N Engl J Med 1996;335:1857.

Type of the procedure matters



4941 patients

Almassi, Ann Thorac Surg 1999; 68: 391.

Epidemiology of stroke after cardiac surgery in the current era

Ani C. Anyanwu, MD,
David H. Adams, MD[a]

Stroke occurs in 2 – 3% of patients

J Thorac Cardiovasc Surg, 2007, 134, 1121.

Methods: Retrospective analysis was conducted of a prospective database of 5085 adults (coronary bypass 2401, isolated valve 1003, valve/coronary bypass 546, thoracic aorta 517, transplant/assist device 179, adult congenital 124, other 315) who had cardiac surgery at a single institution over a 6-year period (1998–2004).

Results: Stroke occurred in 134 (2.6%) patients. Incidence varied according to procedure (coronary bypass 1.7%, isolated valve 1.8%, valve/coronary bypass 4.4%, and ascending aorta 4.6%). Patients who had a stroke had a higher perioperative mortality rate than that of patients who did not (32.8% vs 4.9%; $P < .0001$) [redacted]

TABLE 4. Multivariate predictors of postoperative stroke

Factor	Coefficient	Odds ratio
Aortic surgery	1.36	3.9
Previous stroke	0.74	2.1
Critical preop state	0.90	2.5
Age > 60 y (per 5-y intervals)	0.14	1.2
Left ventricle function, poor	0.69	2.0
Gender, female	0.50	1.7
Diabetes	0.50	1.7
Peripheral vascular disease	0.58	1.8
Unstable angina	0.51	1.7
Pulmonary hypertension	0.79	2.2

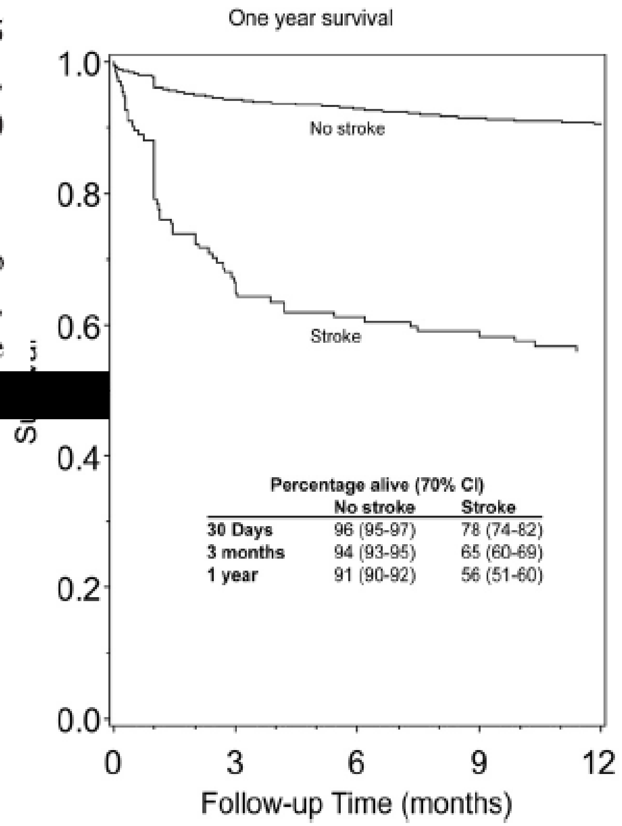
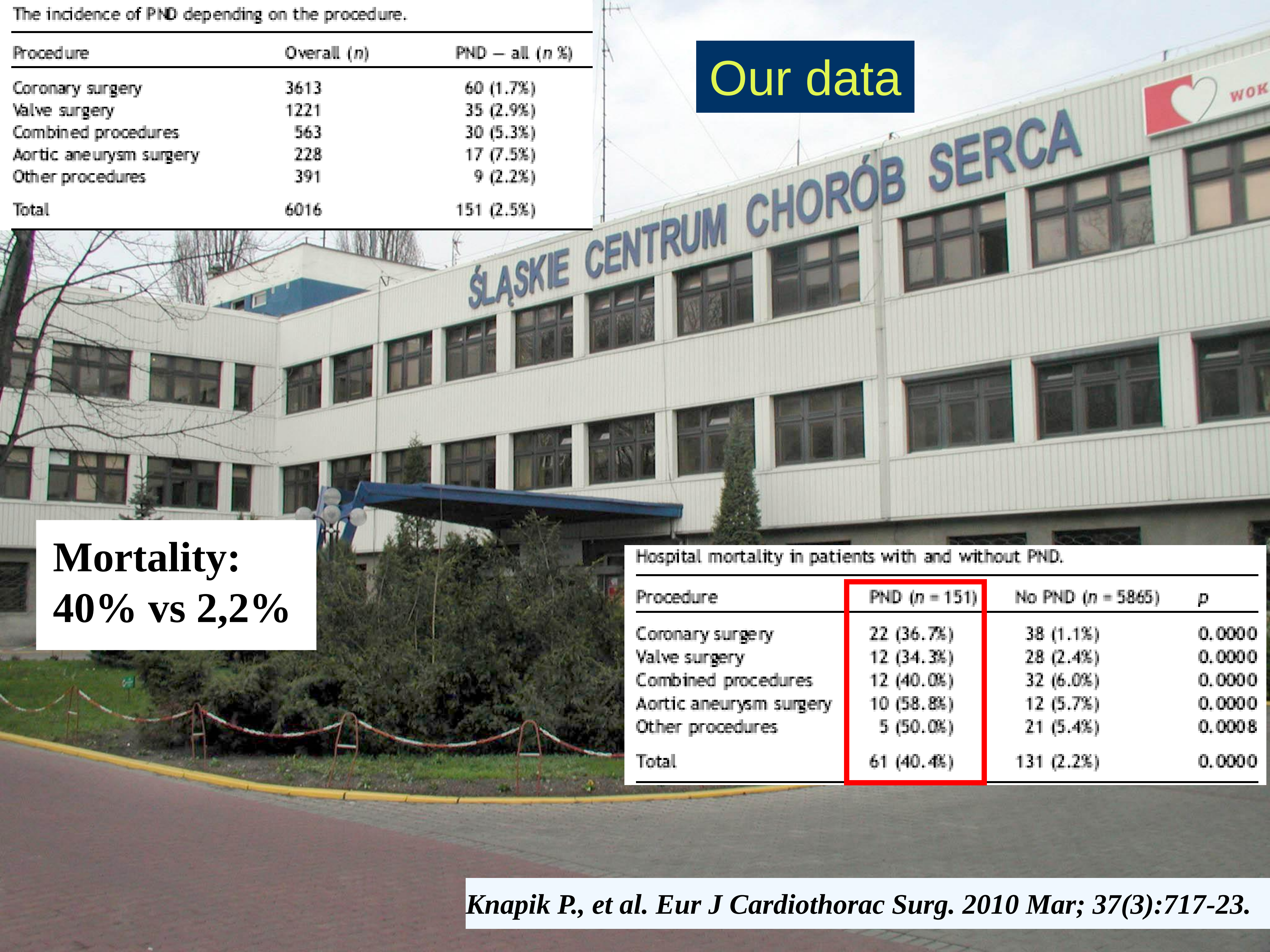


Figure 2. One-year survival after heart surgery stratified by occurrence of stroke. *CI*, Confidence interval.

The incidence of PND depending on the procedure.

Procedure	Overall (*n*)	PND — all (*n* %)
Coronary surgery	3613	60 (1.7%)
Valve surgery	1221	35 (2.9%)
Combined procedures	563	30 (5.3%)
Aortic aneurysm surgery	228	17 (7.5%)
Other procedures	391	9 (2.2%)
Total	6016	151 (2.5%)

Our data



Mortality:
40% vs 2,2%

Hospital mortality in patients with and without PND.

Procedure	PND (*n* = 151)	No PND (*n* = 5865)	*p*
Coronary surgery	22 (36.7%)	38 (1.1%)	0.0000
Valve surgery	12 (34.3%)	28 (2.4%)	0.0000
Combined procedures	12 (40.0%)	32 (6.0%)	0.0000
Aortic aneurysm surgery	10 (58.8%)	12 (5.7%)	0.0000
Other procedures	5 (50.0%)	21 (5.4%)	0.0008
Total	61 (40.4%)	131 (2.2%)	0.0000

Knapik P., et al. Eur J Cardiothorac Surg. 2010 Mar; 37(3):717-23.

Our data

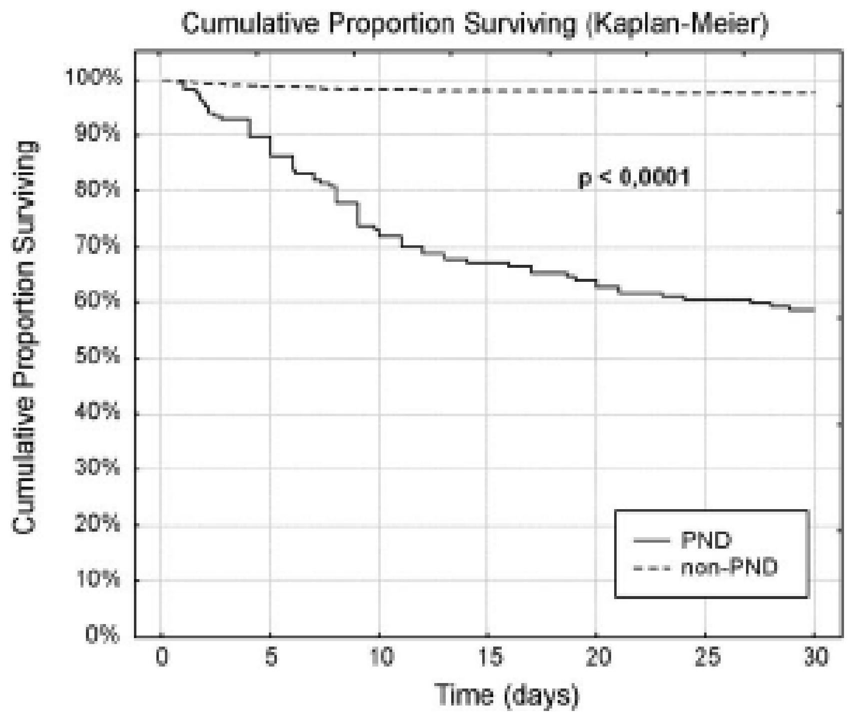


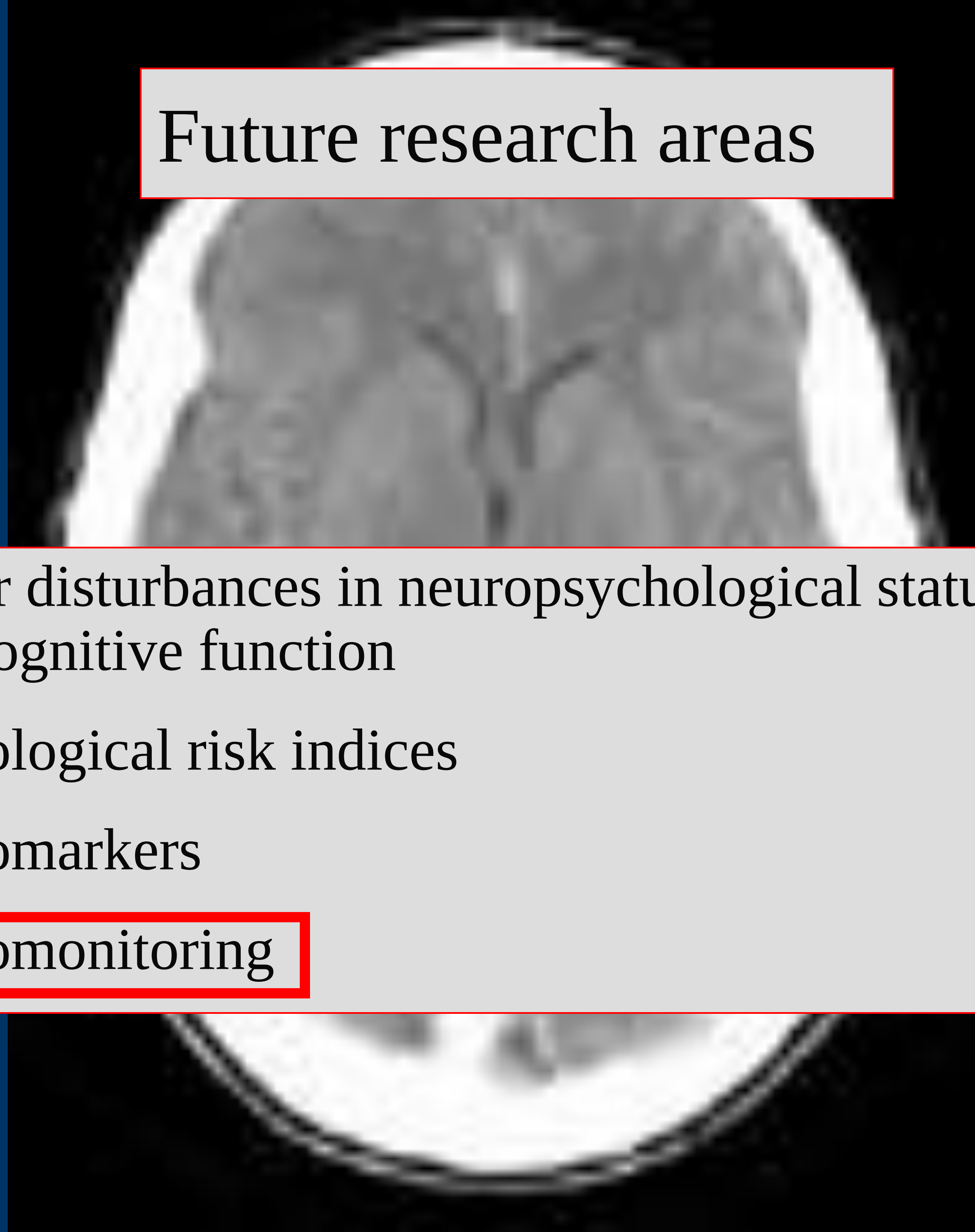
Fig. 1. Early survival analysis.

Multivariate predictors of PND after cardiac surgery.

Variable	OR	95% CI	p
CPB >2 h	3.35	2.40–4.68	<0.001
Emergency surgery	3.34	1.91–5.82	<0.001
Early rethoracotomy	3.17	1.96–5.12	<0.001
Age >65 years	1.70	1.22–2.37	0.002
Unstable course of disease	1.60	1.15–2.25	0.006

Knapik P., et al. Eur J Cardiothorac Surg. 2010 Mar; 37(3):717-23.

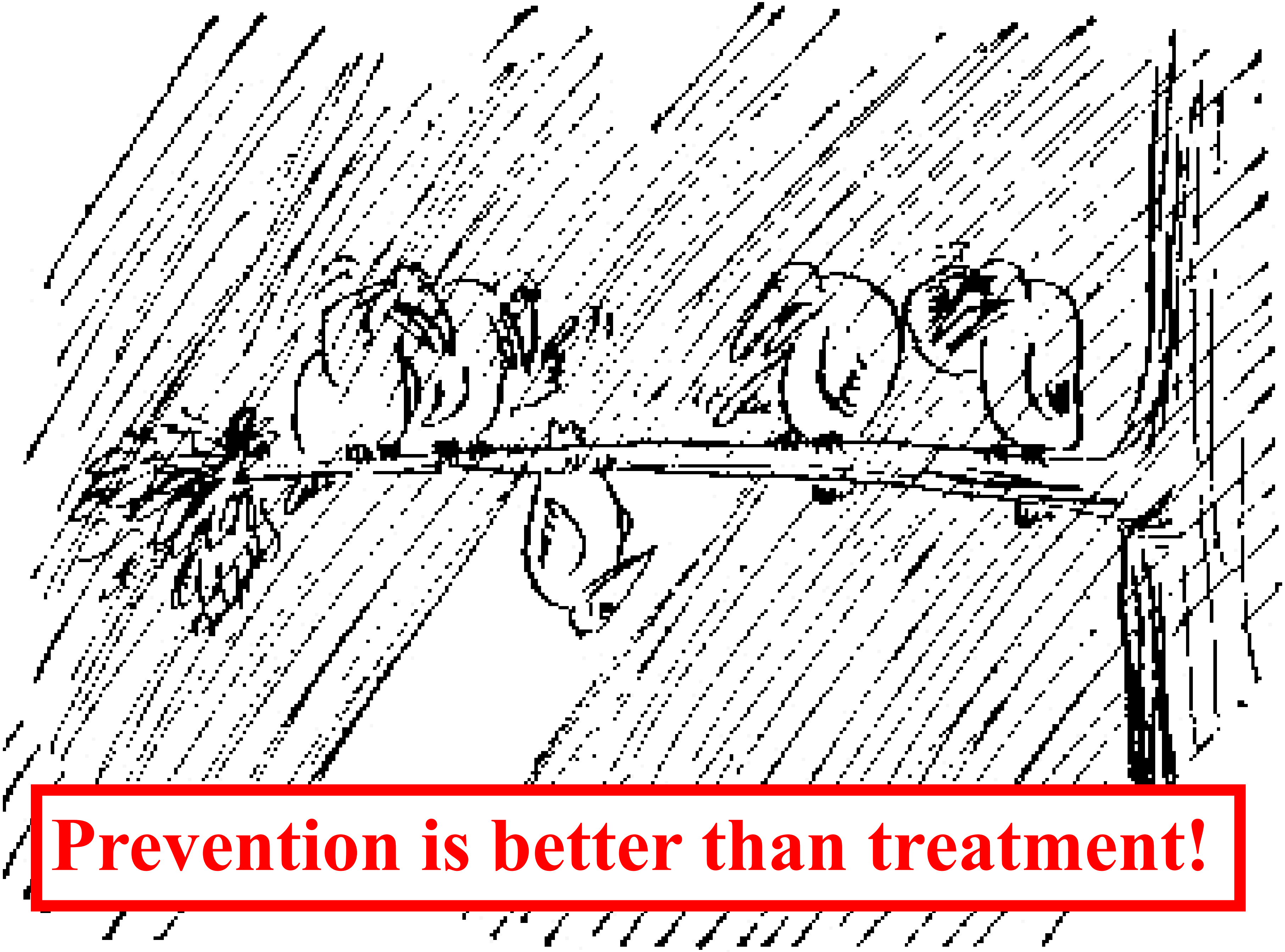
Future research areas



- Minor disturbances in neuropsychological status and cognitive function
- Neurological risk indices
- Neuromarkers
- Neuromonitoring

Facts

- Serious neurological injuries after cardiac surgery are quite rare, but their consequences are devastating.
- **In this particular medical field prevention seems to be far more important than further treatment.**



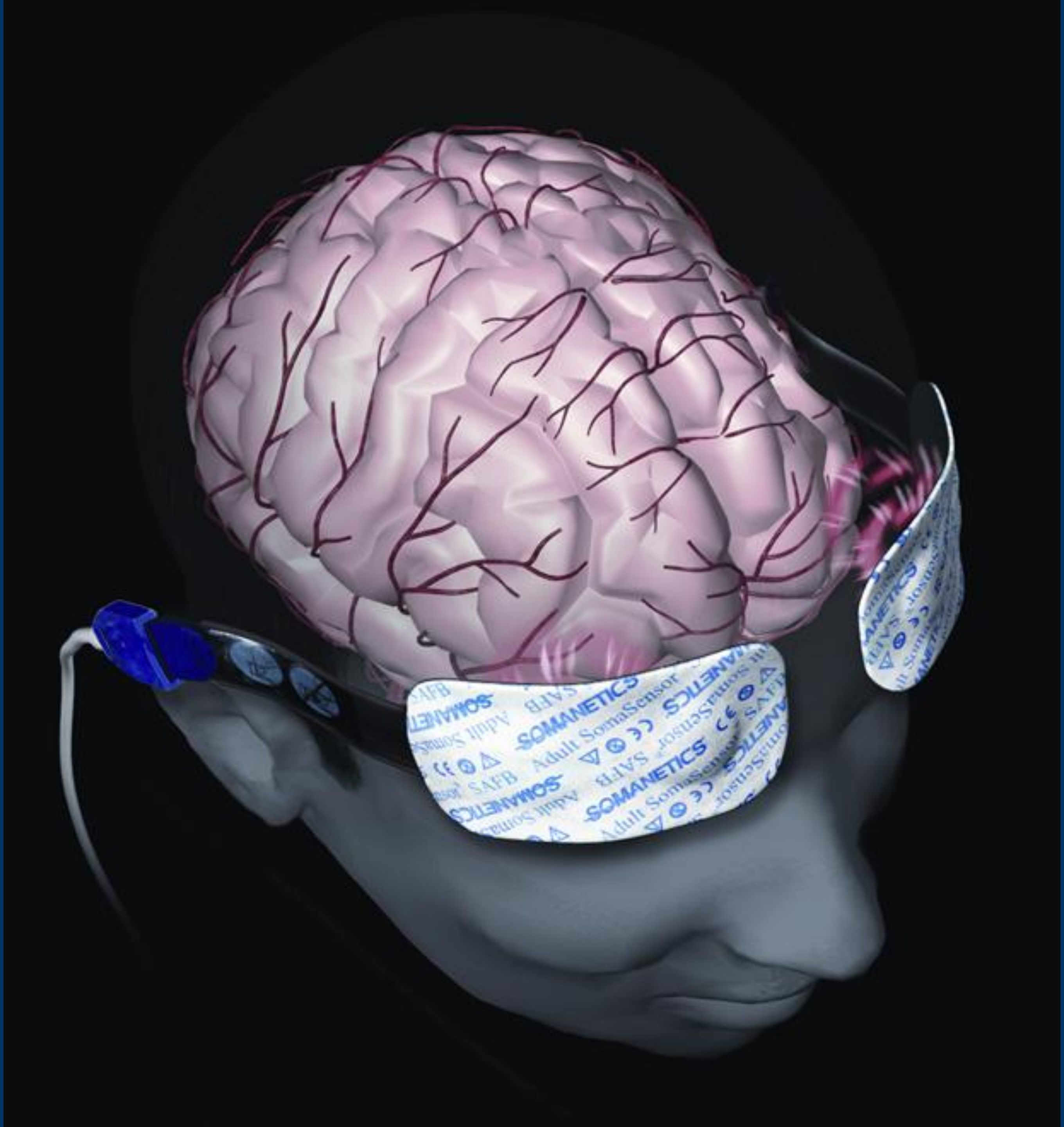
Prevention is better than treatment!

Options for the surgeon

- Subclavian or femoral location of aortic canniula
- VF arrest instead of cross clamping
- Change of location for proximal anastomoses
- Single clamp technique
- Total arterial revascularisation
- Cancellation of surgical option in precisely defined groups of patients

CABG Guidelines 2010

Option for the anaesthesiologist?


SOMANETICS
Adult SomaSensor
SAFB


SOMANETICS

What is Cerebral Oximetry?

- Utilizes Near-Infrared Spectroscopy (NIRS) and various wavelengths of infrared light that are transmitting through the skull into the cerebral tissue
- Monitoring regional saturation of oxygen (rSO2) of grey matter in brain (75% venous and 25% arterial volume)
- Healthy levels of rSO2= 58% to 82%.
- Data collected and displayed every 4-5 sec.

Theoretical background

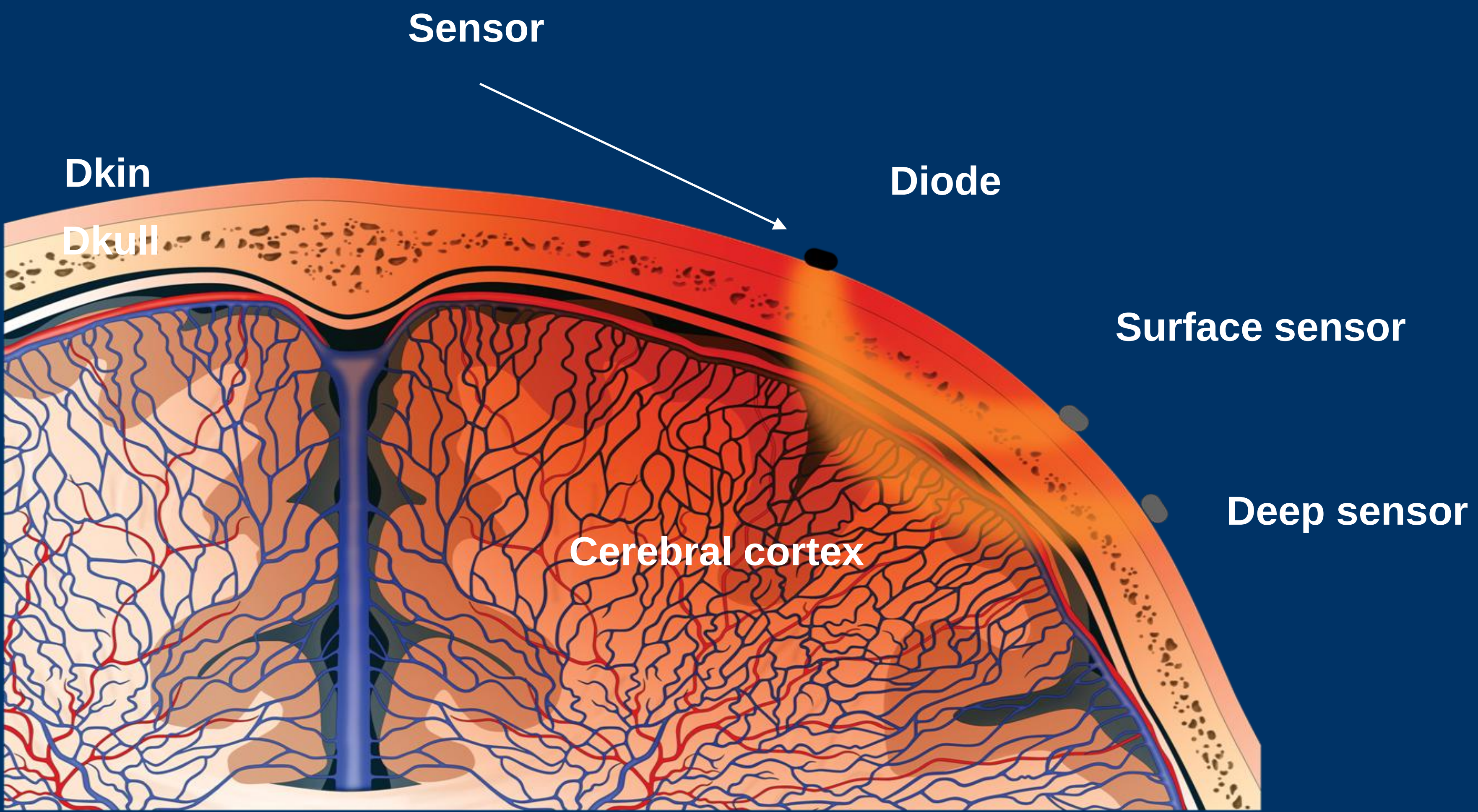
- Technology utilizes two different wavelengths of light: 730nm and 810nm
- Beer-Lambert Law: with a known intensity of light with a known dimension of chamber > concentration of dissolved substance can be measured
- The difference between oxyhemoglobin and deoxyhemoglobin can be therefore estimated
- **<u>This is the same concept as pulse oximetry</u>**

Human skull is readily permeable to infrared light, however the size of an adult human skull excludes translumination.

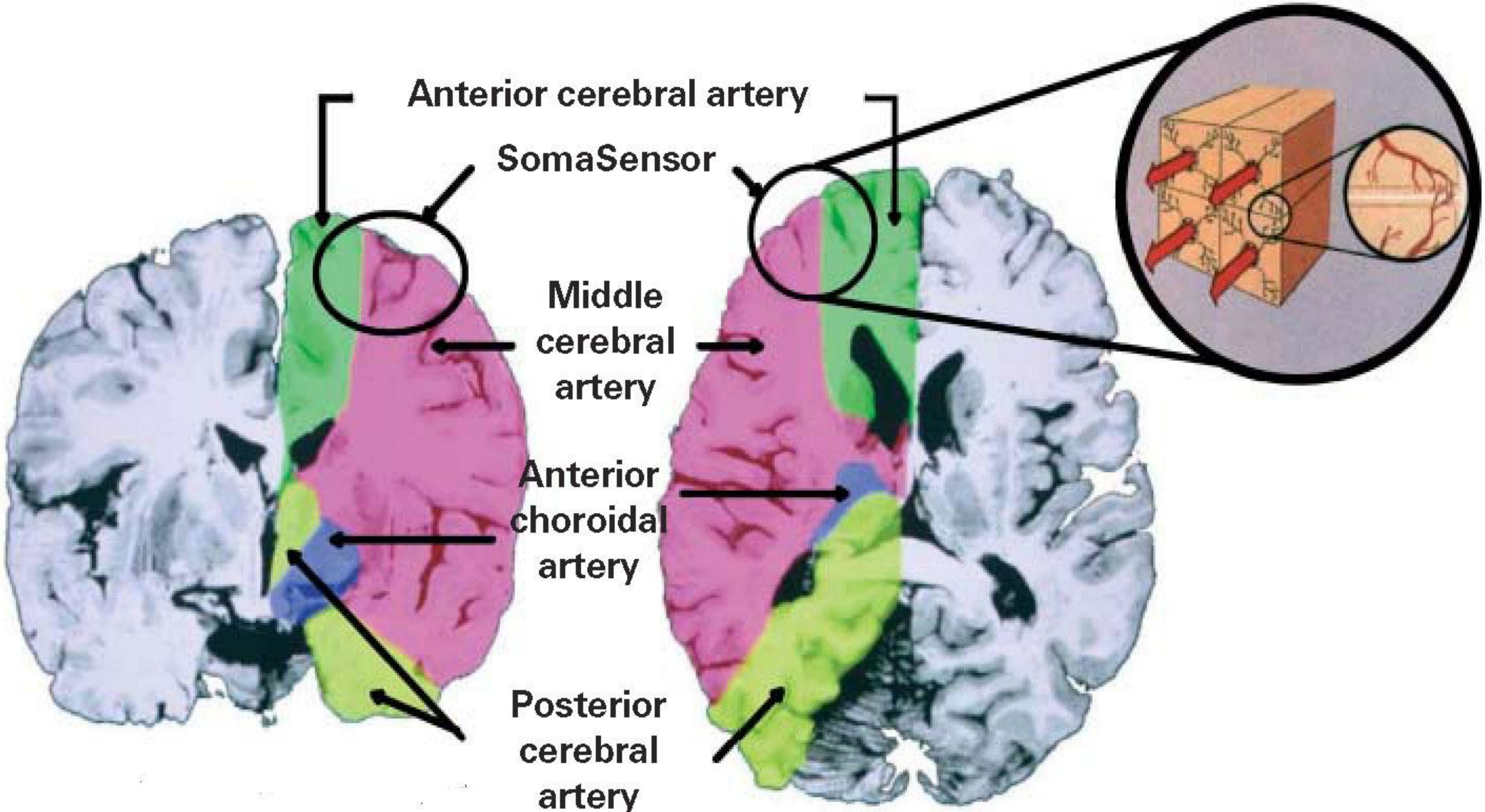
In the 80s, Ferrari showed a possibility of measuring the light reflected and scattered along the arc returning to the vicinity of the emission source.

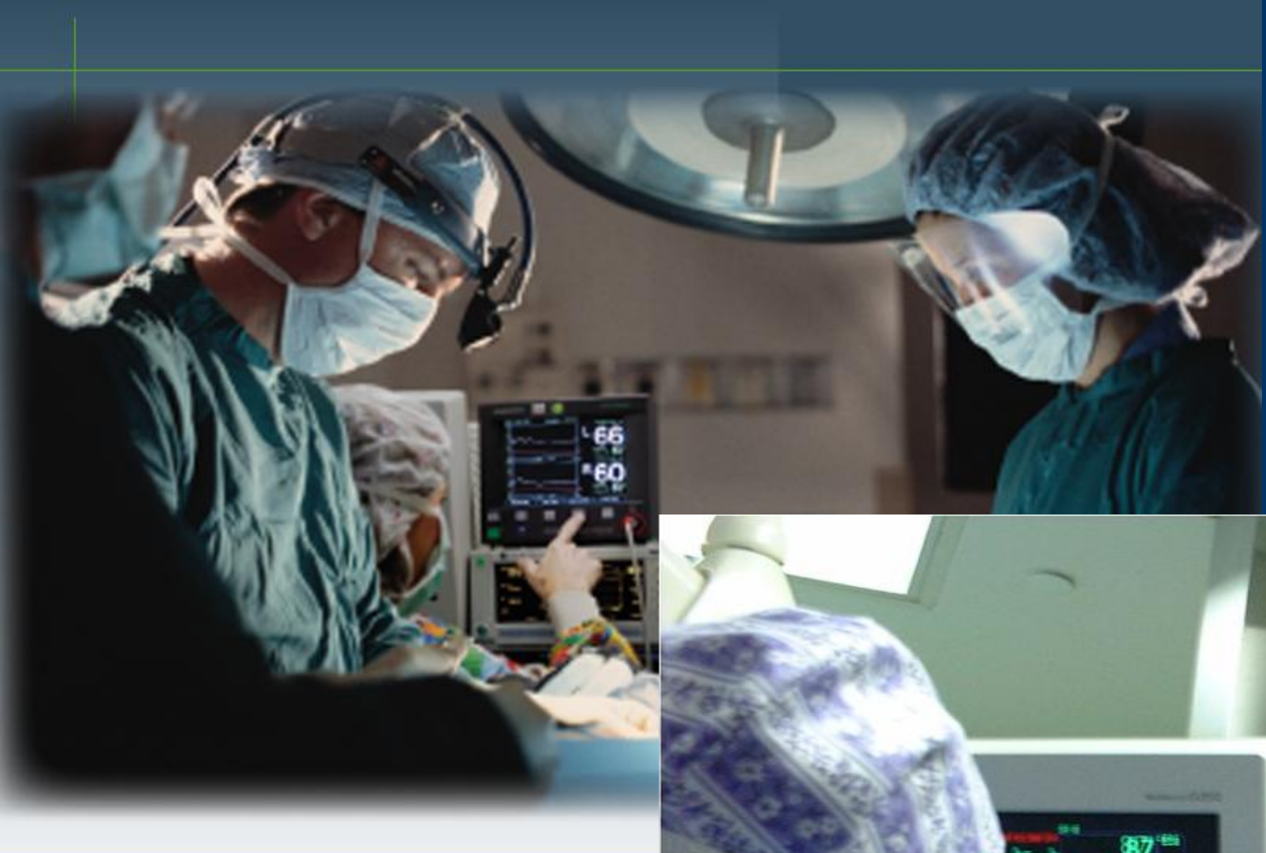
NIRS method uses the absorption of infrared light and gives the possibility of non-invasive assessment of frontal cortex oxygenation.

Cerebral oximeter has been equipped with two infrared detectors. Closer detector counts photons reflected from the superficial tissues, more remote detector counts photons reflected and partly absorbed by the cortex of the brain.



NIRS allows continuous, noninvasive assessment of oxygenation of the cerebral cortex in the border areas, that are particularly vulnerable to decreases in perfusion




L 66
R 60

SOMANETICS
INVOS OXIMETER
01/24/06 06:35:30 ADULT rSO2 INDEX
L 50
R 70
S1 90
S2 90
BASELINE MENU
EVENT MARK
ALARM AUDIO ON/OFF
NEXT MENU

SOMANETICS

L 69
R 68

Other methods?

- Current neurological monitoring modalities include cerebral oximetry, EEG and transcranial Doppler.

- Sensitivity:
  Cerebral oximetry > EEG> transcranial Doppler

Basic information

- Normal cerebral saturation: 58%-82%
- Intervention threshold: anything < 50% or decrease of 20% from baseline
- Very important to have established baseline cerebral saturations

Interventions

- Reasons for low cerebral saturation:
  - High cerebral metabolism, hyperthermia
  - Low haemogobin (anaemia)
  - Low $PaCO_2$, alkalosis
  - Low cerebral blood flow (cannula or head position)
  - Hypoxia
  - Vasoconstriction

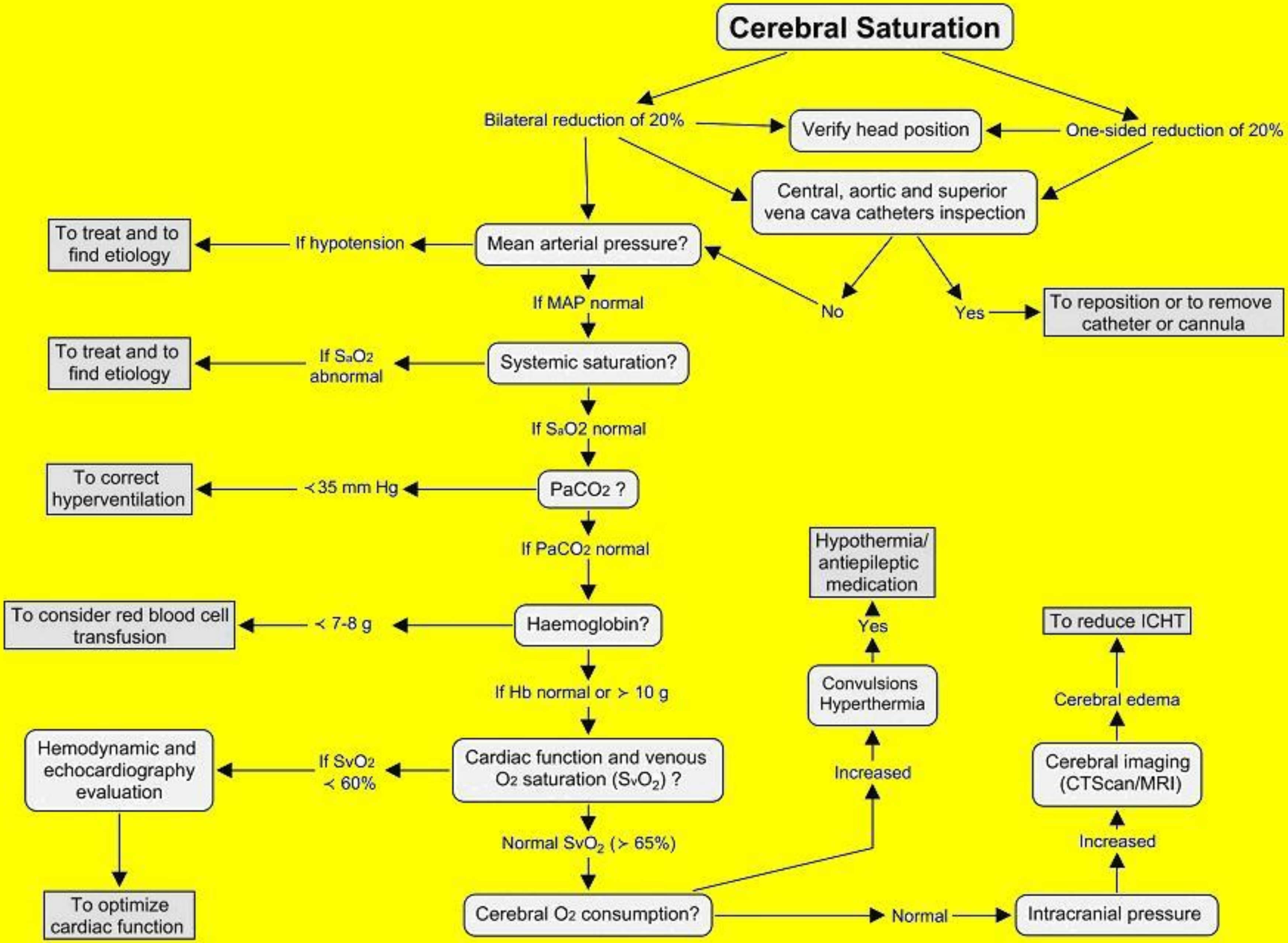
- Most common interventions:
  - Increase FiO_2
  - Increase hematocrit
  - Increase blood pressure / cardiac output
  - Increase CO_2 > increase cerebral blood flow

Full list of interventions

- Mechanical factors
  - Head position
  - Cannula position

- Decrease of metabolism
  - Increasing the depth of anesthesia
  - Decrease of temperature

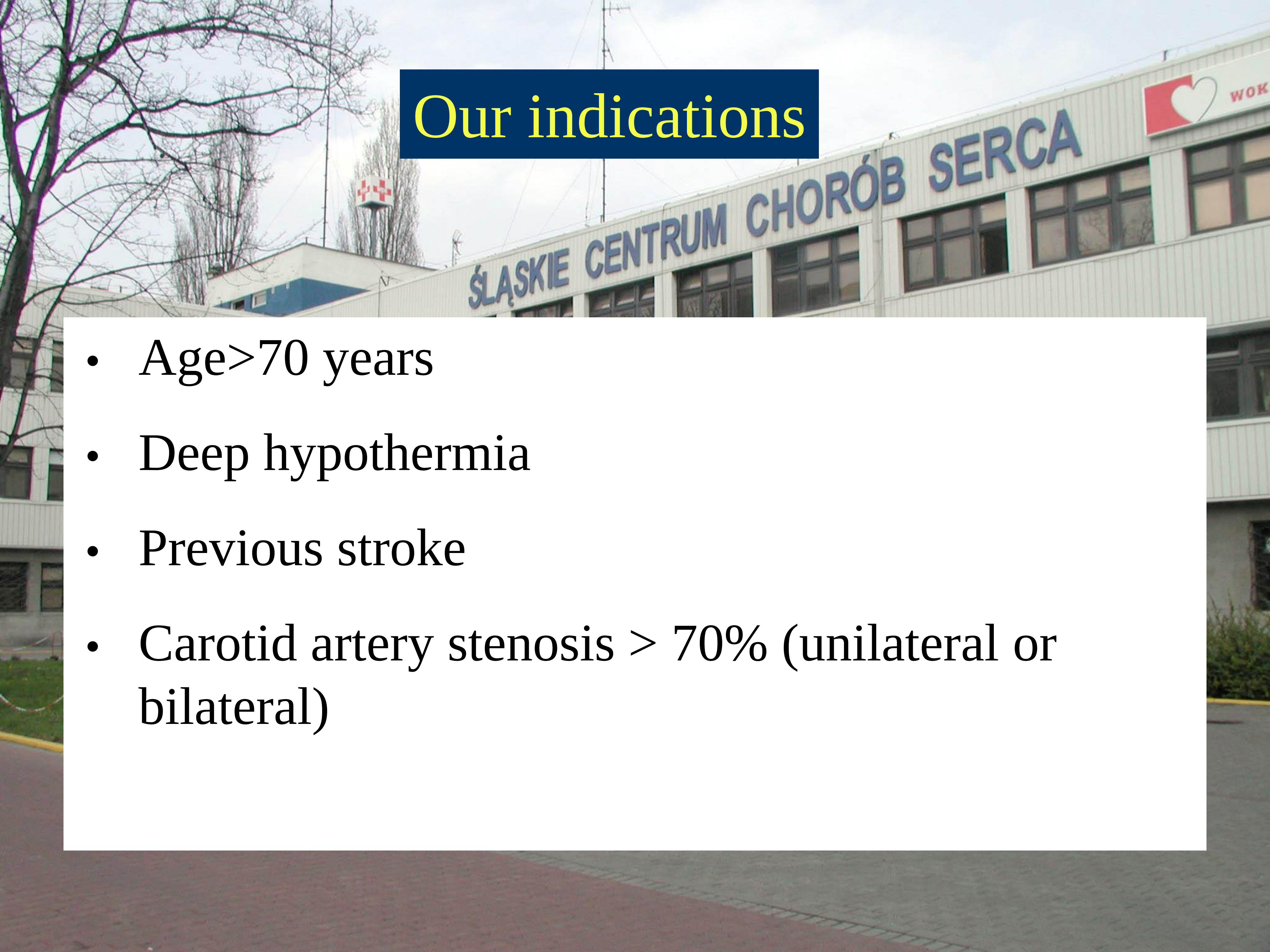
- Increase of oxygen supply
  - Increase of blood pressure
  - Increase of CO_2
  - Increase of FiO_2
  - Increase of cardiac output
  - Vasodilatation of cerebral vessels (nitroglycerin)
  - Increase of hematocrit



Cerebral Saturation
Bilateral reduction of 20%
Verify head position
One-sided reduction of 20%
Central, aortic and superior vena cava catheters inspection
To treat and to find etiology
If hypotension
Mean arterial pressure?
No
Yes
To reposition or to remove catheter or cannula
If MAP normal
To treat and to find etiology
If S_aO_2 abnormal
Systemic saturation?
If S_aO_2 normal
To correct hyperventilation
< 35 mm Hg
$PaCO_2$?
If $PaCO_2$ normal
Hypothermia/ antiepileptic medication
To consider red blood cell transfusion
< 7-8 g
Haemoglobin?
Yes
To reduce ICHT
If Hb normal or > 10 g
Convulsions Hyperthermia
Cerebral edema
Hemodynamic and echocardiography evaluation
If SvO_2 < 60%
Cardiac function and venous O_2 saturation (S_vO_2) ?
Increased
Cerebral imaging (CTScan/MRI)
Normal SvO_2 (> 65%)
Increased
To optimize cardiac function
Cerebral O_2 consumption?
Normal
Intracranial pressure

Our experience

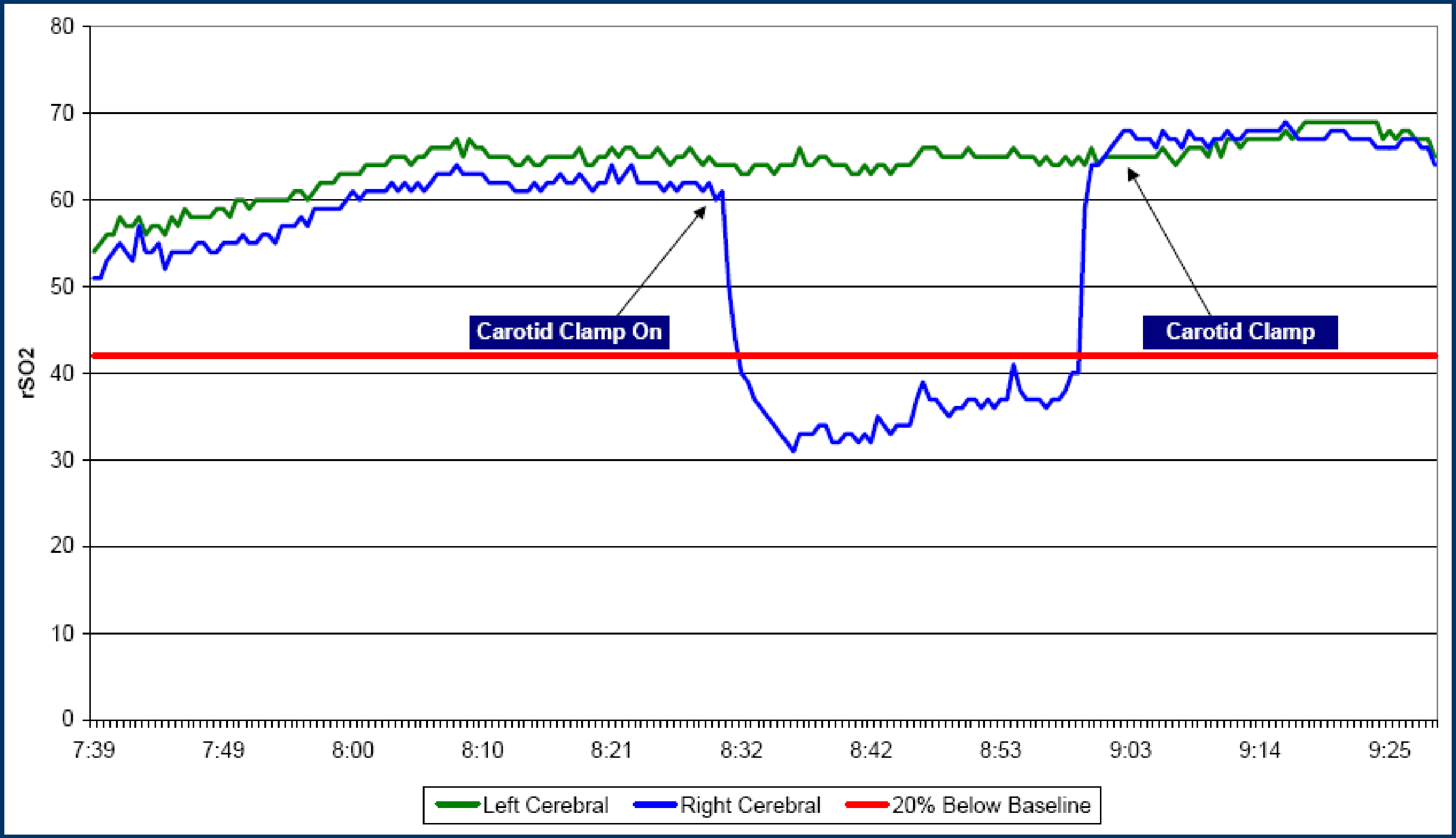
- cerebral oximetry is used since November 2006
- > 500 patients studied
- two monitors are in everyday use

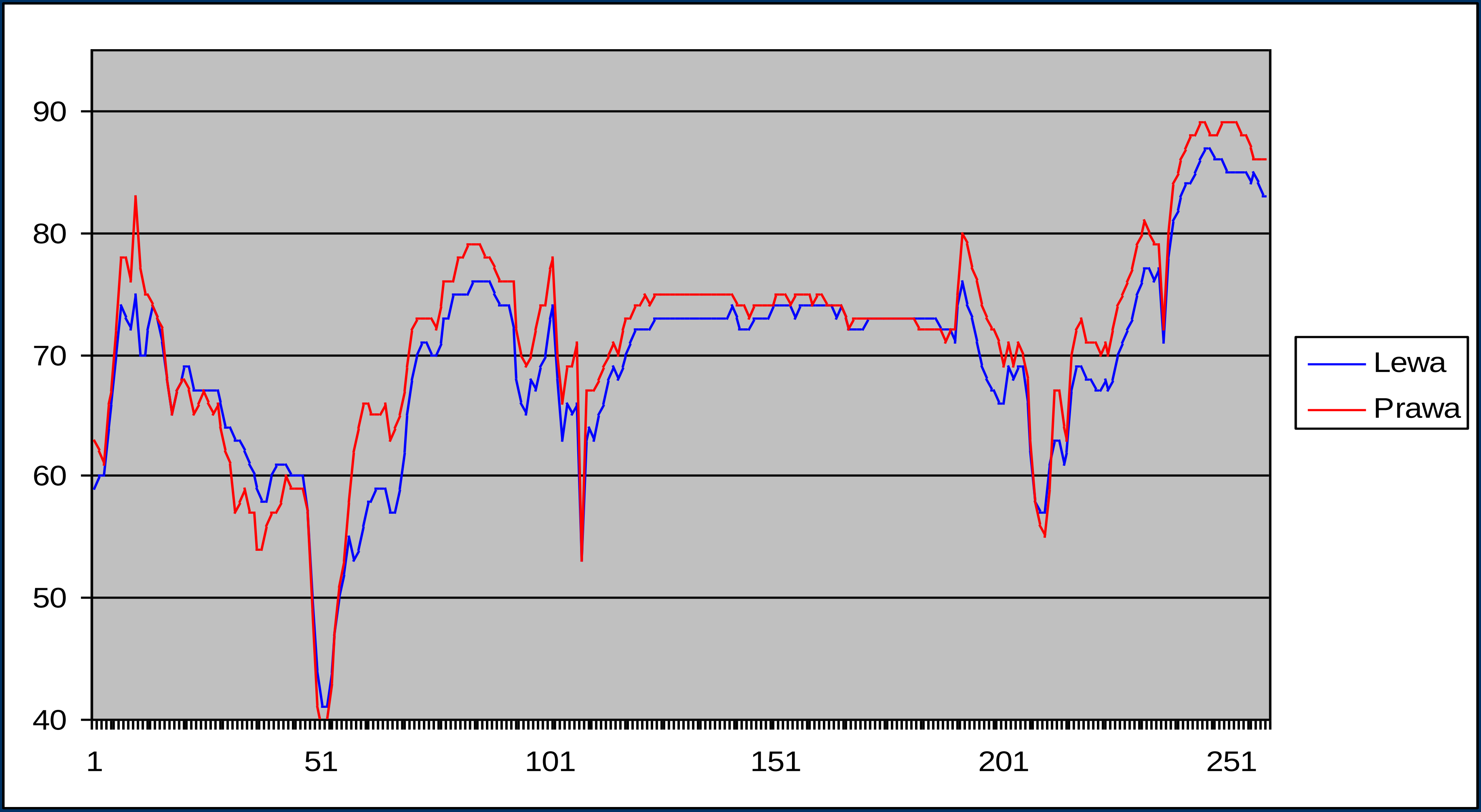


Our indications

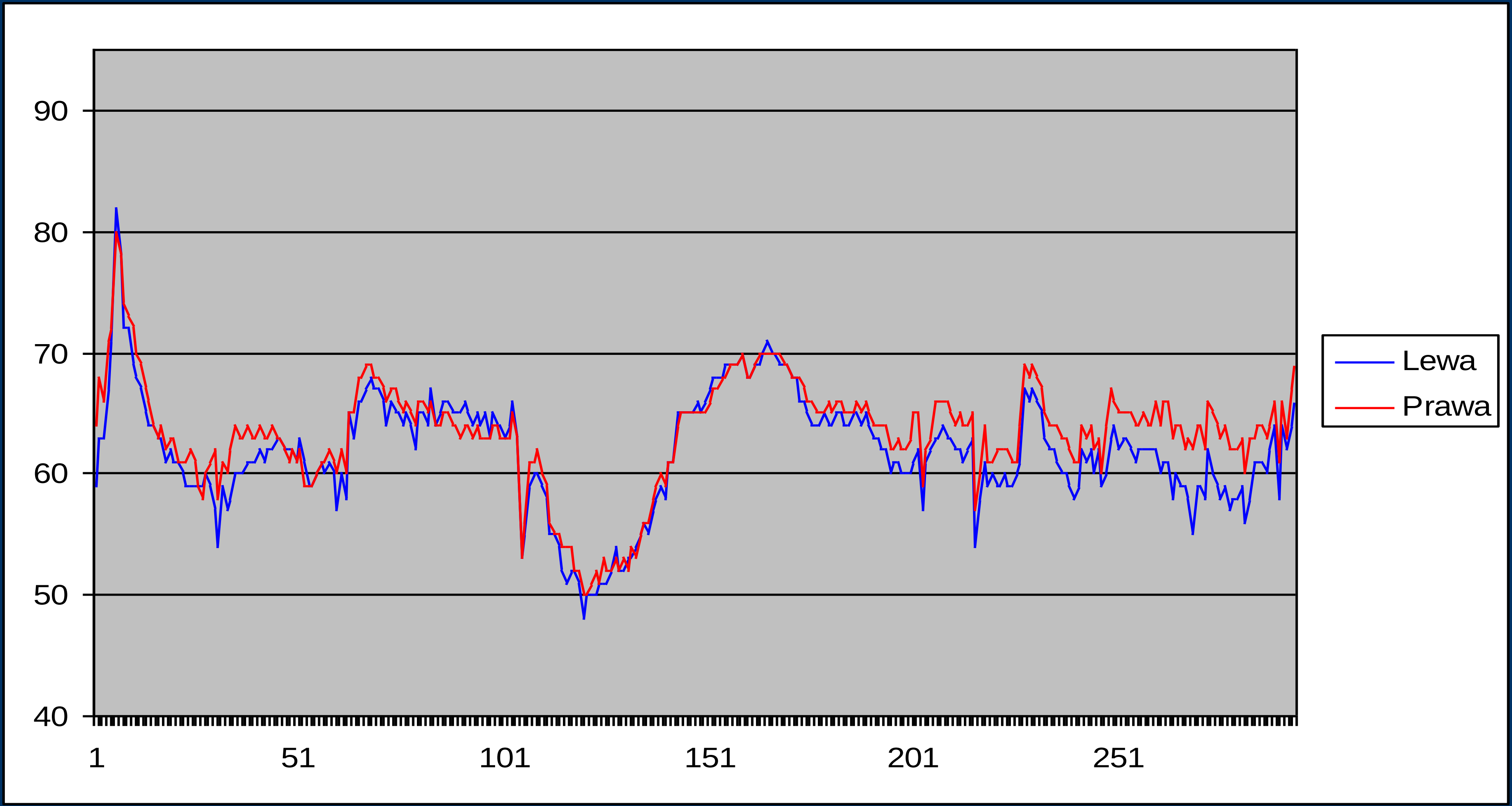
- Age>70 years
- Deep hypothermia
- Previous stroke
- Carotid artery stenosis > 70% (unilateral or bilateral)

Carotid endarterectomy

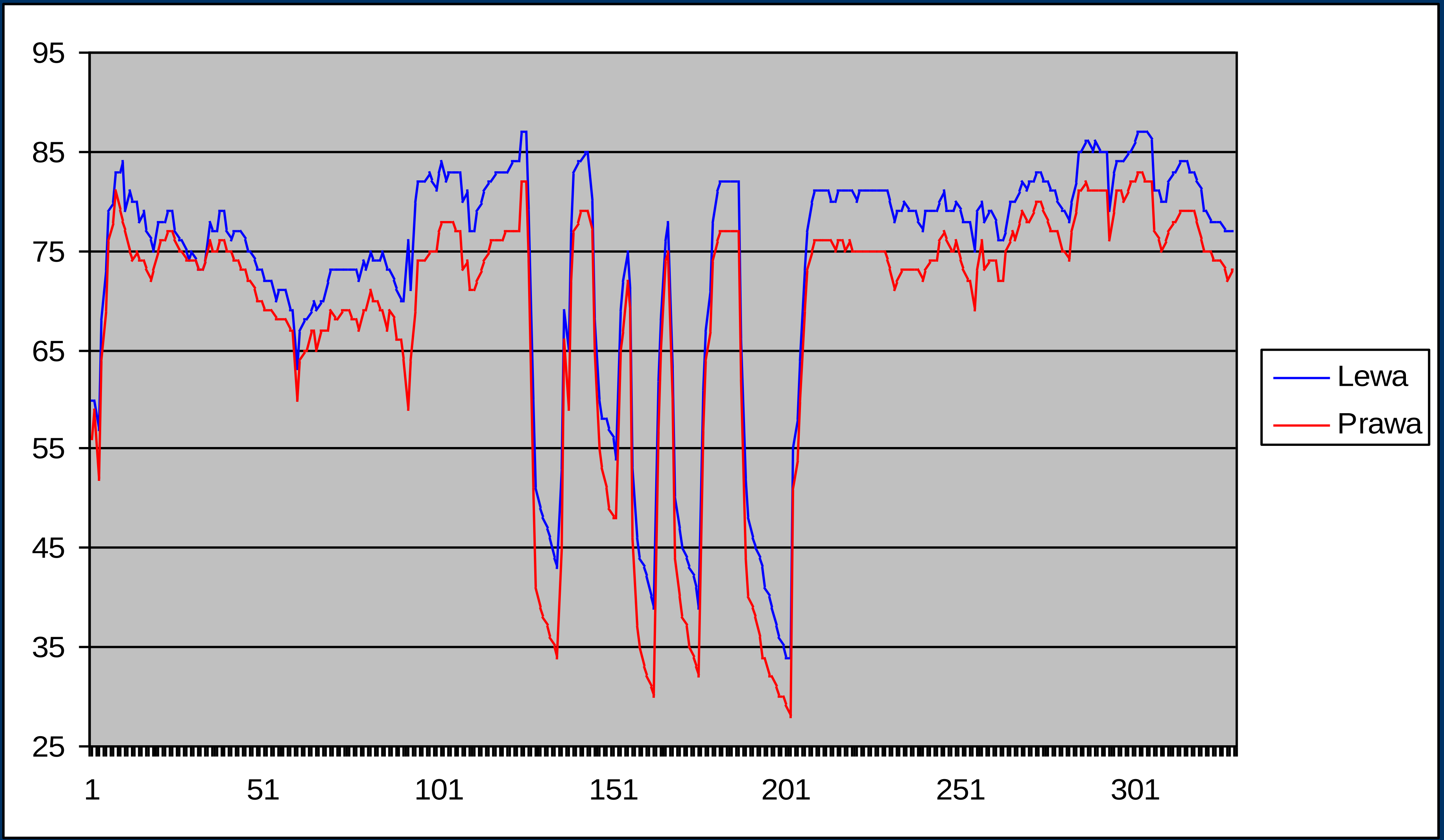




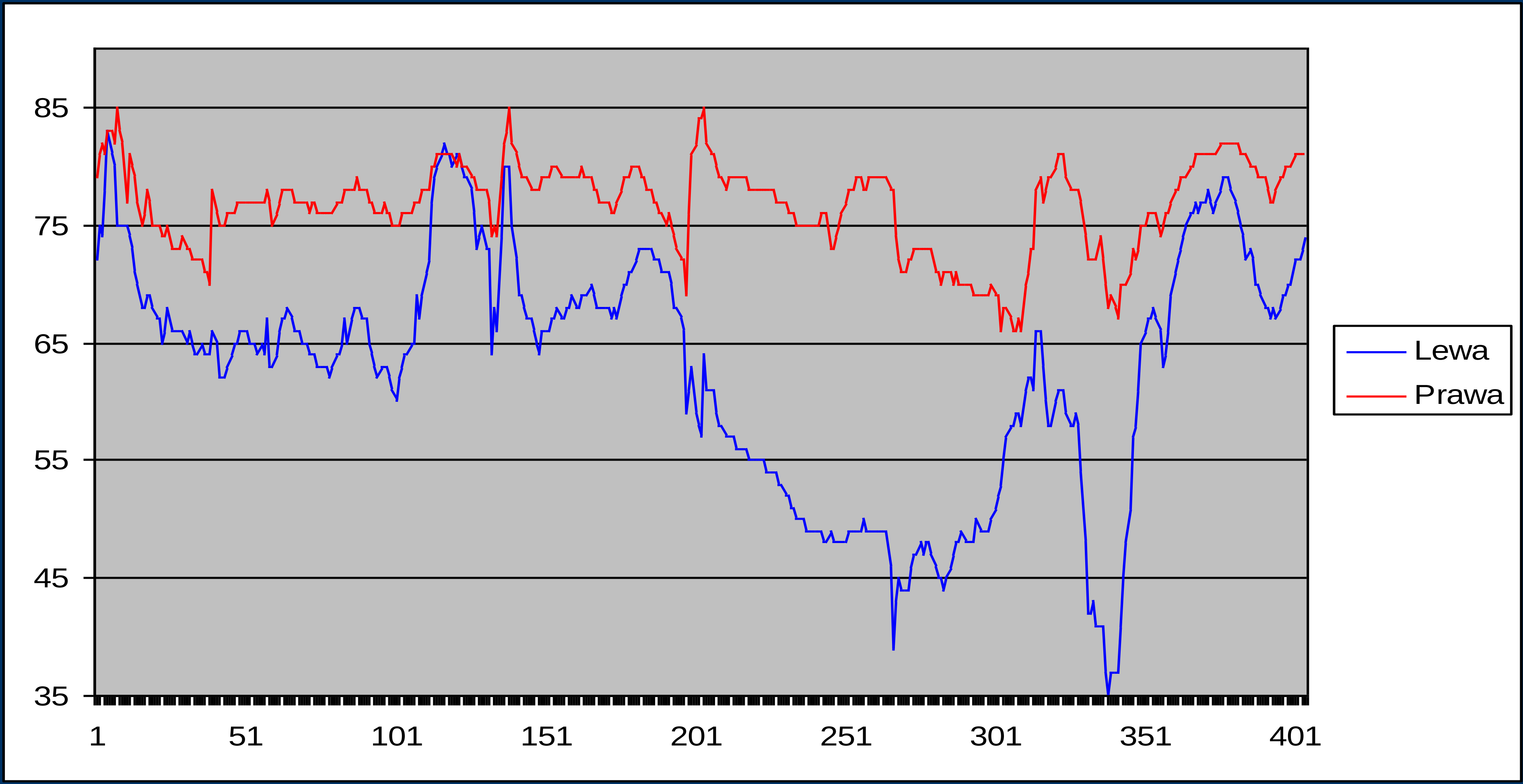
Aortic valve replacement. Steep fall of RSO2 before CPB induced by hyperventilation. Reduction in ventilation and increase of PaCO 2 did not restore the initial rSO2, but administration of isoflurane finally restored baseline values. No complications.



Aortic valve replacement. Fall in rSO2 after the initiation of CPB was caused by hypocapnia and associated by the increase in MAP to 100 mm Hg. PaCO2 was raised and propofol infusion was started. No complications.



Deep hypothermia circulatory arrest (10’+7’+8’+10’).
Due to the control of rSO2 DHCA was reasonably divided



Aortic aneurysm surgery with selective brain perfusion. Imbalance between the left and right hemisphere intensified during perfusion of the brachiocephalic trunk. After declamping of aorta divergence in oxygenation between the right and left side. Normalization of rSO2 after raising MAP and infusion of mannitol. Patient developed cerebral stroke.

Evidence

I A

Casati et al, Anesth Analg 2005;101:740

Results of multi-center general surgery study, N=122. Patients >65 yrs undergoing major abdominal surgery

Randomized, blinded, with interventions to optimize rSO_2 in 56 patients. In 26 pts in the intervention group there was a shorter hospital LOS, 10 vs. 24 days, $p=0.007$

Early postoperative confusion (MMSE decline ≥ 2) reduced 35%, $p=0.02$

Evidence

Goldman et al. Heart Surg Forum 2004

Results of 3-year cardiac surgery study, N=2,279. Blinded collection of data from STS Database

Permanent stroke reduced, 0.97% vs. 2.5%, p=0.044. Total ventilator time was shorter, 4 vs. 5 hrs, p=0.0016. Proportion of pts requiring prolonged ventilation was reduced, 6.8% vs. 10.6%, p=0.0014

Evidence

Murkin et al. Heart Surg Forum 2004;7(6):515

Randomized, blinded, cardiac surgery study, N=200. Interventions to optimize rSO_2 in 100, Controls blinded

Blinded collection of data from STS Database. Control group experienced more severe desaturations, 6 vs. 0, p=0.014. Permanent stroke reduced, 1% vs. 4%, but p=NS. No differences in LOS and ventilation time.

Proportion of pts experiencing major organ morbidity or mortality (MOMM) reduced, 3% vs. 11%, p=0.048. ICU LOS 1.25 vs. 1.87 days, p=0.029

Prevention is better than treatment!