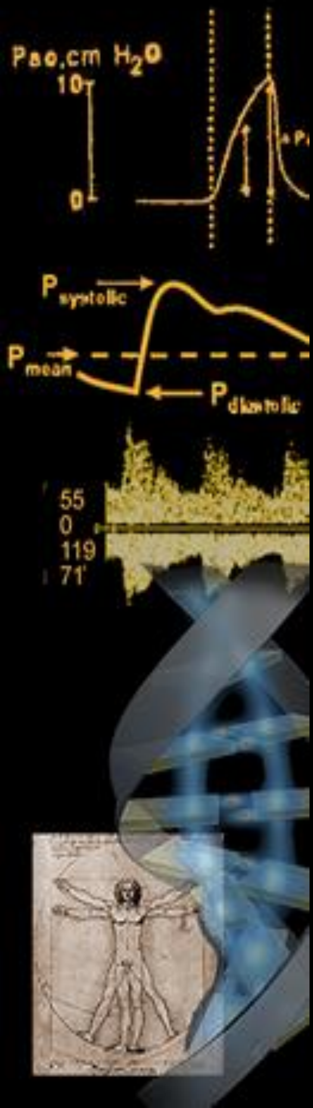
Università di Torino
Ospedale Molinette
Laboratorio di Biomeccanica
Anestesia e Rianimazione III



ANESTESIA IN NEURORADIOLOGIA

Anna Teresa Mazzeo

Assistant Professor of Anesthesia and Intensive care

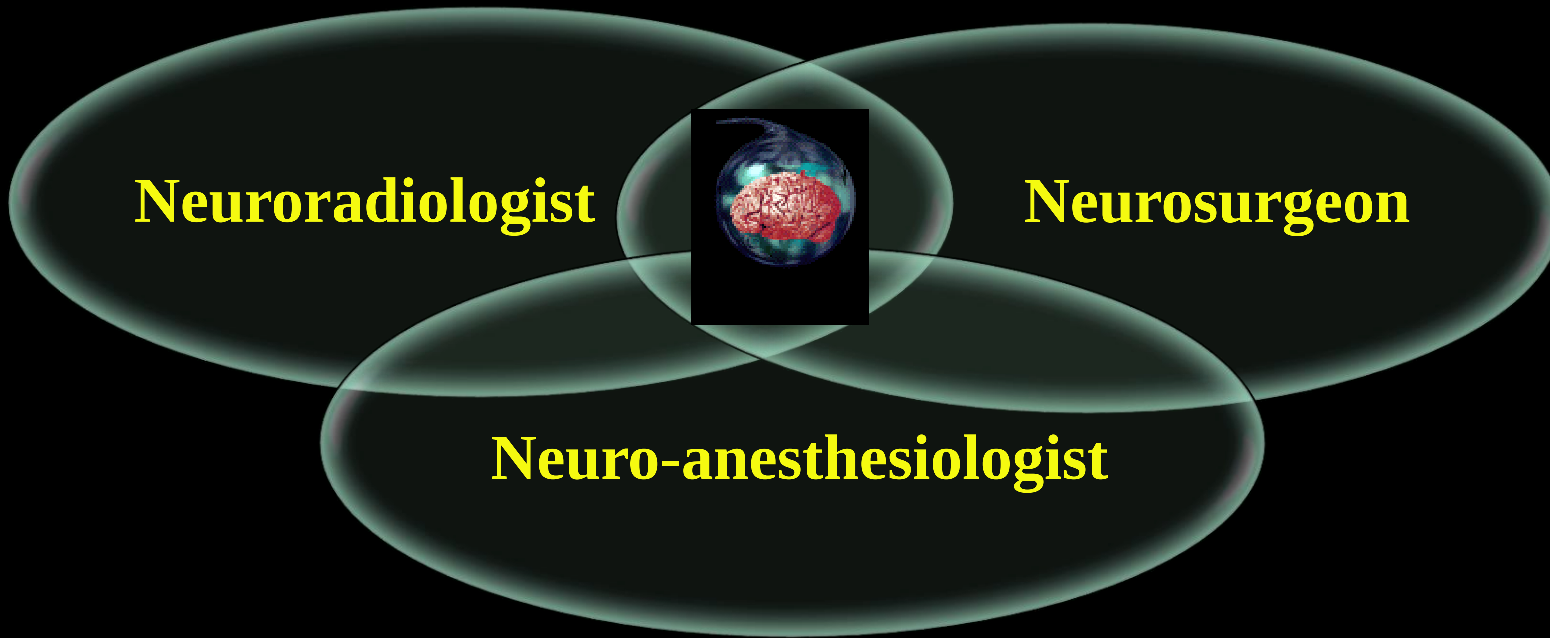
University of Torino

anna.mazzeo@unito.it

Outline

- **The Neuroradiological patient: is the same as for “general” patient?**
- **The Anesthesiologist in NRD: is the same as for “general” anesthesiologist?**
- **The Neuroradiological suite: is the same as for “general” O.R.?**
- **The Italian Consensus in Neuroradiological Anaesthesia (ICONA): managing anaesthesia during endovascular procedures**

THE CONCEPT OF NEURORADIOLOGICAL TEAM

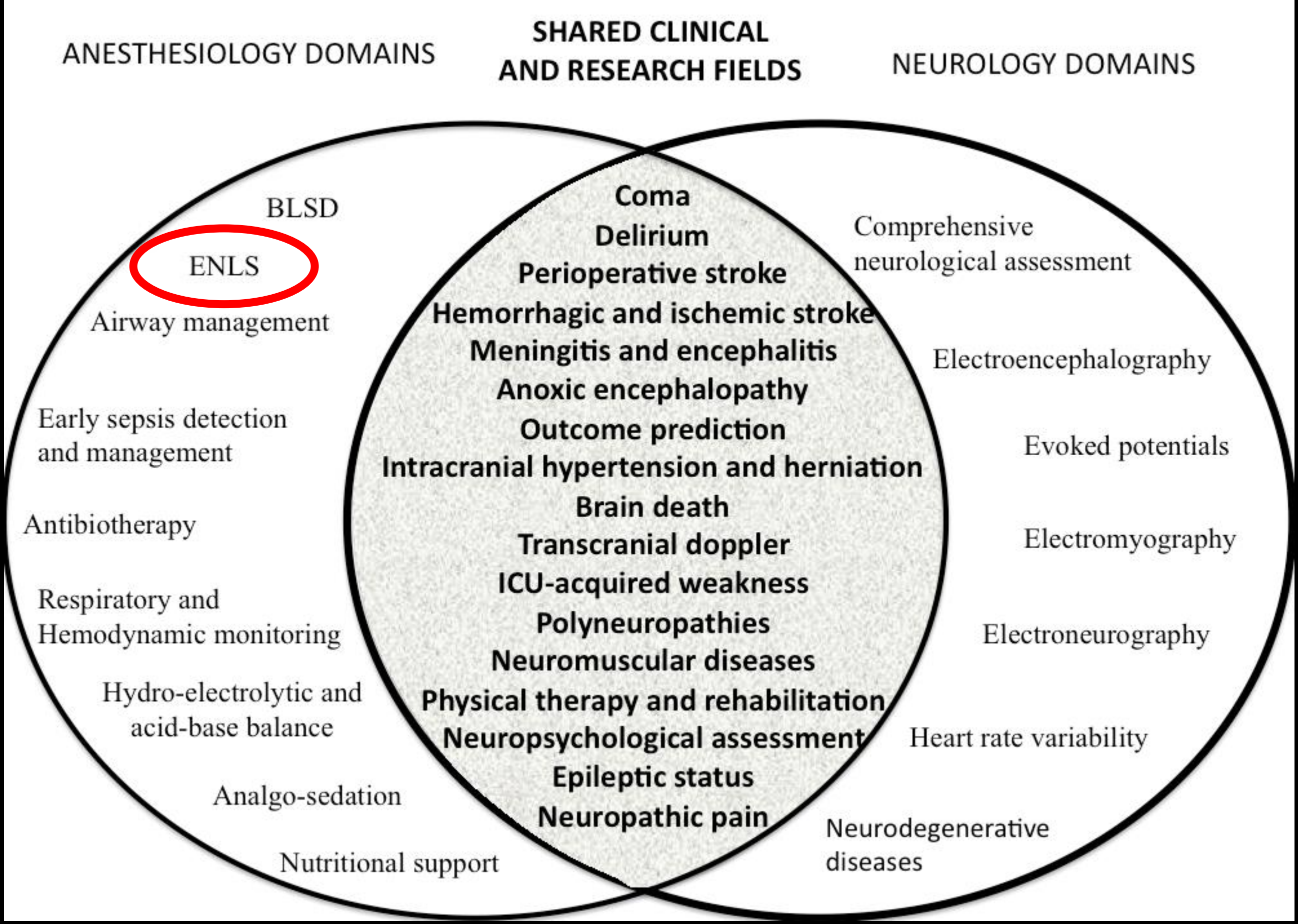


It is important for the anesthesiologist to know the primary type of lesion, its location, the proximity of vital structures, and which approach is to be used

OUTCOME IMPROVEMENT

The link between anesthesiology and neurology: a mindful cooperation to improve brain protection

Anna T. MAZZEO [1*], Iacopo BATTAGLINI [2], Luca BRAZZI [1], Luciana MASCIA [3]



Minerva Anestesiol. 2017;83:69-78

Classification of interventional neuroradiological procedures

Intracranial lesions

- Diagnostic angiography
- Glue embolization of cerebral arteriovenous malformation
- Coil embolization of cerebral aneurysms (elective and emergency)
- Embolization of carotid-cavernous fistula
- Intracerebral chemotherapy for head and neck tumours
- Sclerotherapy of venous angiomas
- Balloon angioplasty and carotid artery stenting
- Venous stenting
- Therapeutic carotid occlusions for giant aneurysms and skull base tumours
- Embolization of intracranial tumours
- Carotid artery test and therapeutic occlusions for aneurysms and tumours
- Stenting of aneurysms
- Thrombolysis and thrombectomy after stroke
- Treatment of cerebral vasospasm and carotid stenosis with transluminal balloon angioplasty

Extracranial lesions

- Embolization of dural arteriovenous malformations, fistulae, and spinal arteriovenous malformation
- Vertebral artery stenting
- Vertebroplasty and kyphoplasty

CT-guided interventions

- Biopsies of tumours and masses

Interventional magnetic resonance imaging

- Stereotactic-guided neurosurgery—deep brain stimulation for movement disorders
- Implantation of intracranial electrodes for telemetry
- Temporal lobe resections for epilepsy

Patel BJA 2016;147:147-152

Complications in NRD

Table 2 Complications of interventional neuroradiological procedures

- CNS complications
  - *Haemorrhagic*
    - Aneurysm perforation
    - Intracranial vessel injury, dissection
  - *Occlusive*
    - Thromboembolic complications
    - Displacement of coil into parent vessel, coil fracture
    - Vasospasm
- Non-CNS complications
  - Contrast reactions
  - Contrast nephropathy
  - Haemorrhage at the puncture site, groin haematoma, retroperitoneal haematoma

Varma et al BJA 2007;99:75-85

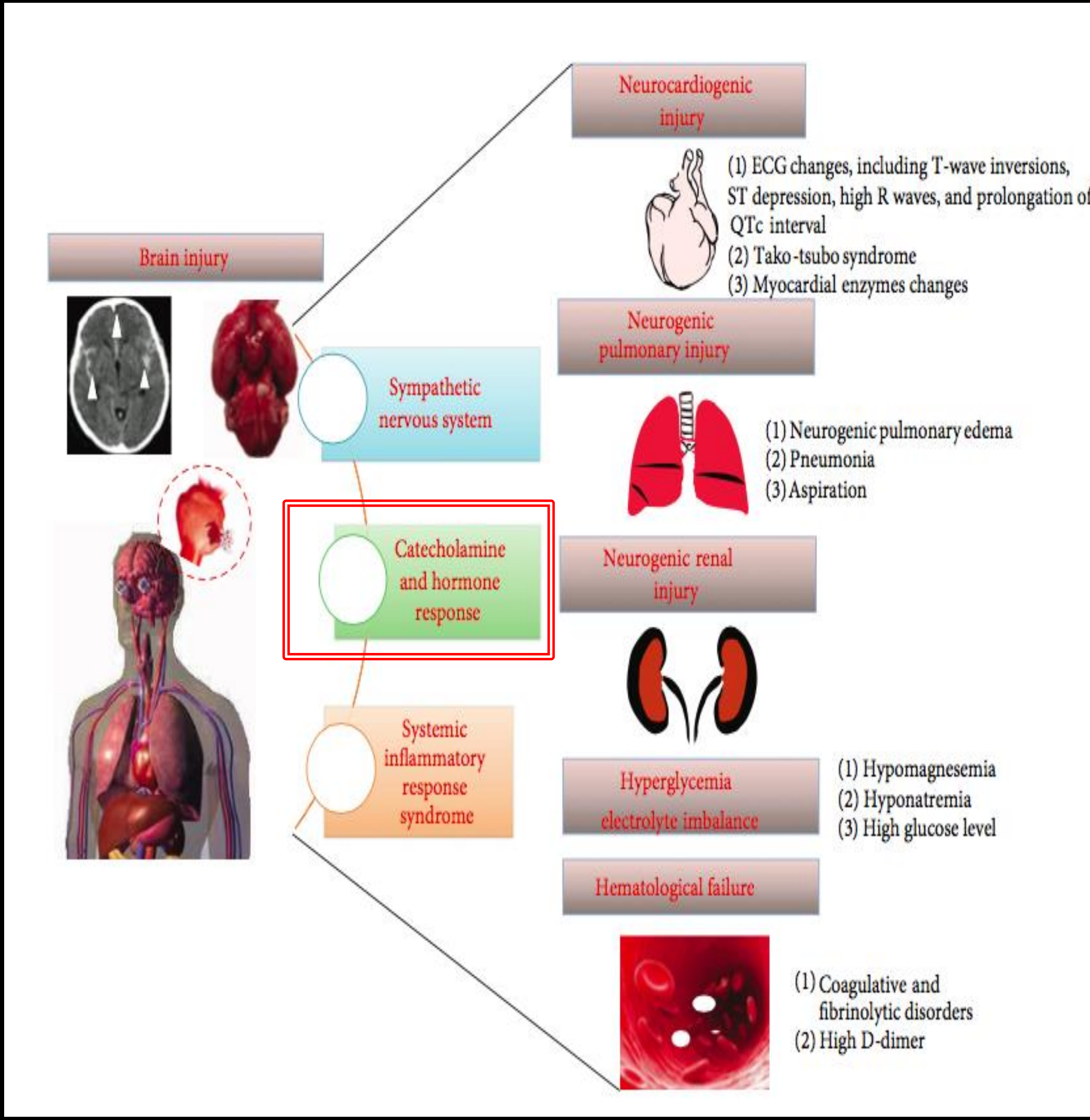
Time is brain

Estimated Pace of Neural Circuitry Loss in Typical Large Vessel, Supratentorial Acute Ischemic Stroke

	Neurons Lost	Synapses Lost	Myelinated Fibers Lost	Accelerated Aging
Per Stroke	1.2 billion	8.3 trillion	7140 km/4470 miles	36 y
Per Hour	120 million	830 billion	714 km/447 miles	3.6 y
Per Minute	1.9 million	14 billion	12 km/7.5 miles	3.1 wk
Per Second	32 000	230 million	200 meters/218 yards	8.7 h

Saver JL et al: *Time is brain-Quantified.* Stroke 2006; 37

NON-NEUROLOGIC COMPLICATIONS OF SAH



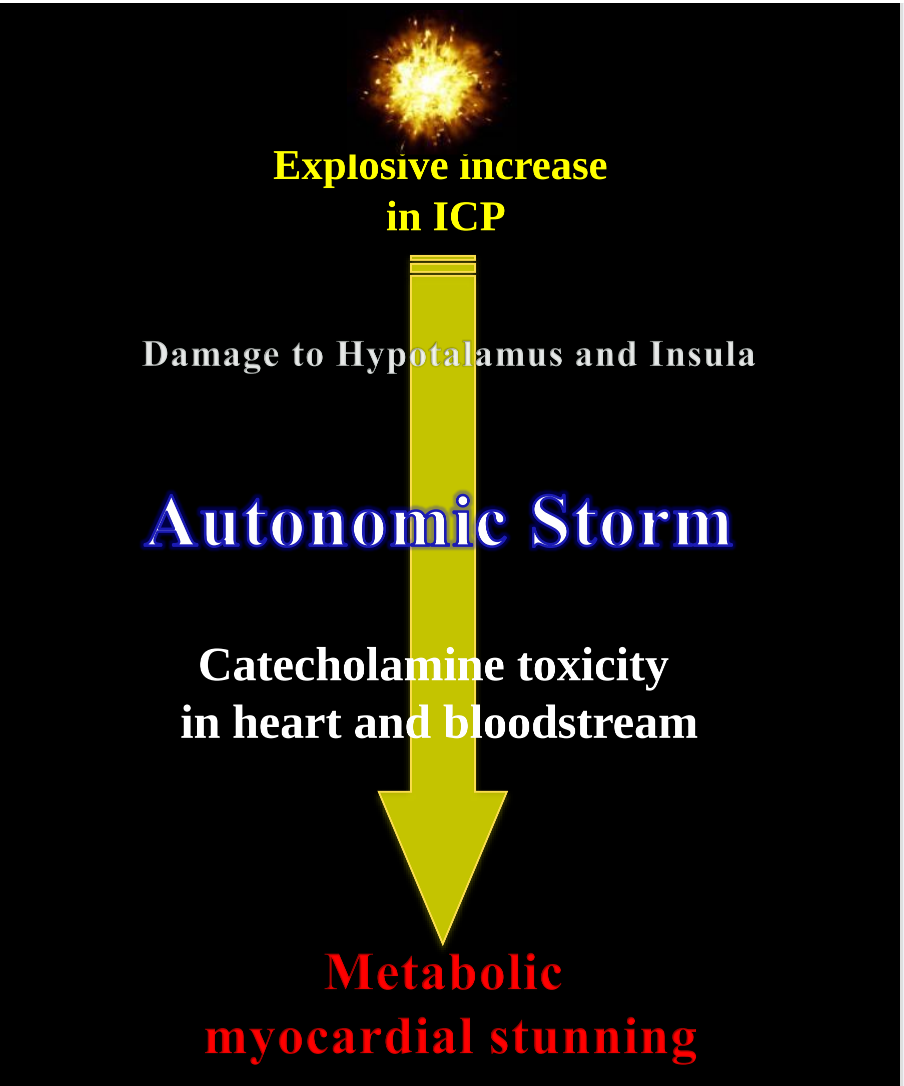
British Journal of Anaesthesia **112** (5): 803–15 (2014)
Advance Access publication 17 March 2014 · doi:10.1093/bja/aeu046

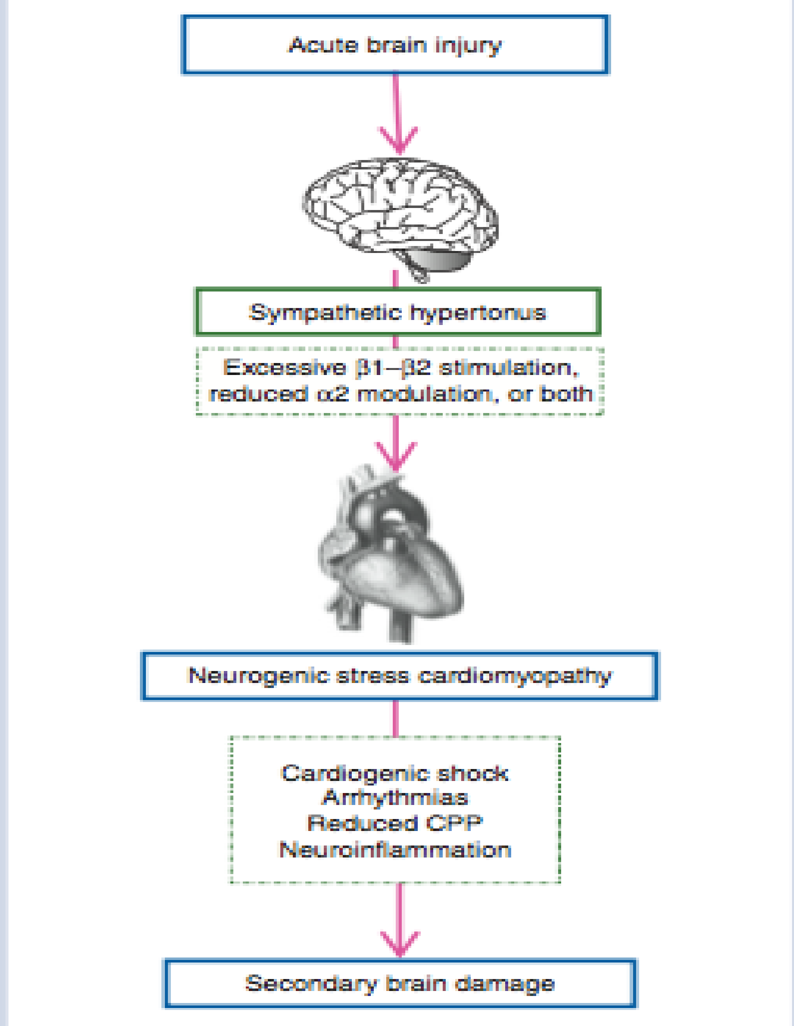
BJA

CME

Brain–heart crosstalk: the many faces of stress-related cardiomyopathy syndromes in anaesthesia and intensive care

A. T. Mazzeo[1*], A. Micalizzi[2], L. Mascia[1], A. Scicolone[3] and L. Siracusano[2]





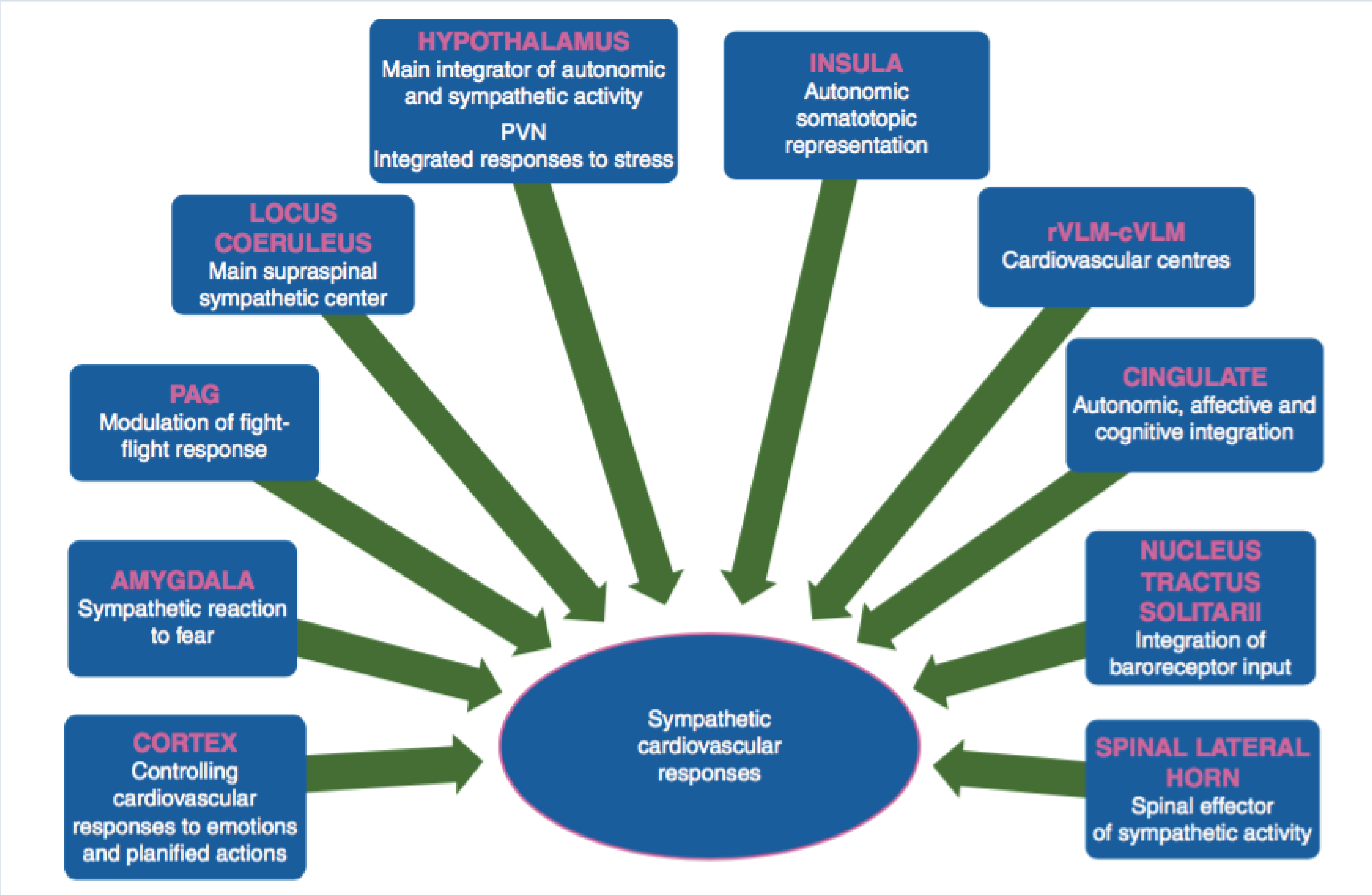
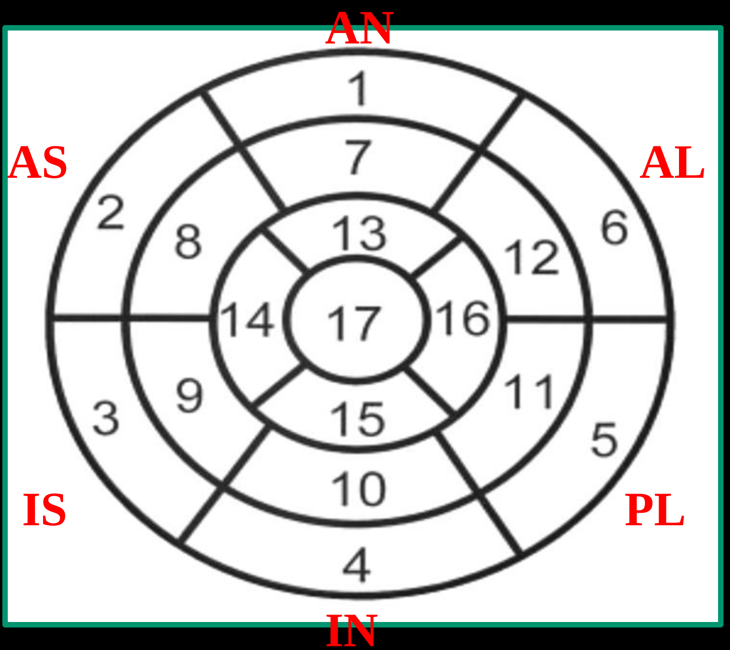


Fig 2 Cardio-regulatory sympathetic pathways. The figure illustrates the main centres involved in the neural regulation of the cardiovascular system. rVLM, rostral ventral lateral medulla; cVLM, caudal ventrolateral medulla; PVN, paraventricular nucleus; PAG, periaqueductal grey.

Mazzeo AT- BJA 2014

Echocardiography in stress cardiomyopathy



1. Basal anterior	7. Mid anterior	13. Apical anterior
2. Basal anteroseptal	8. Mid anteroseptal	14. Apical septal
3. Basal inferoseptal	9. Mid inferoseptal	15. Apical inferior
4. Basal inferior	10. Mid inferior	16. Apical lateral
5. Basal inferolateral	11. Mid inferolateral	17. apex
6. Basal anterolateral	12. Mid anterolateral	

Regional wall motion score RWMS

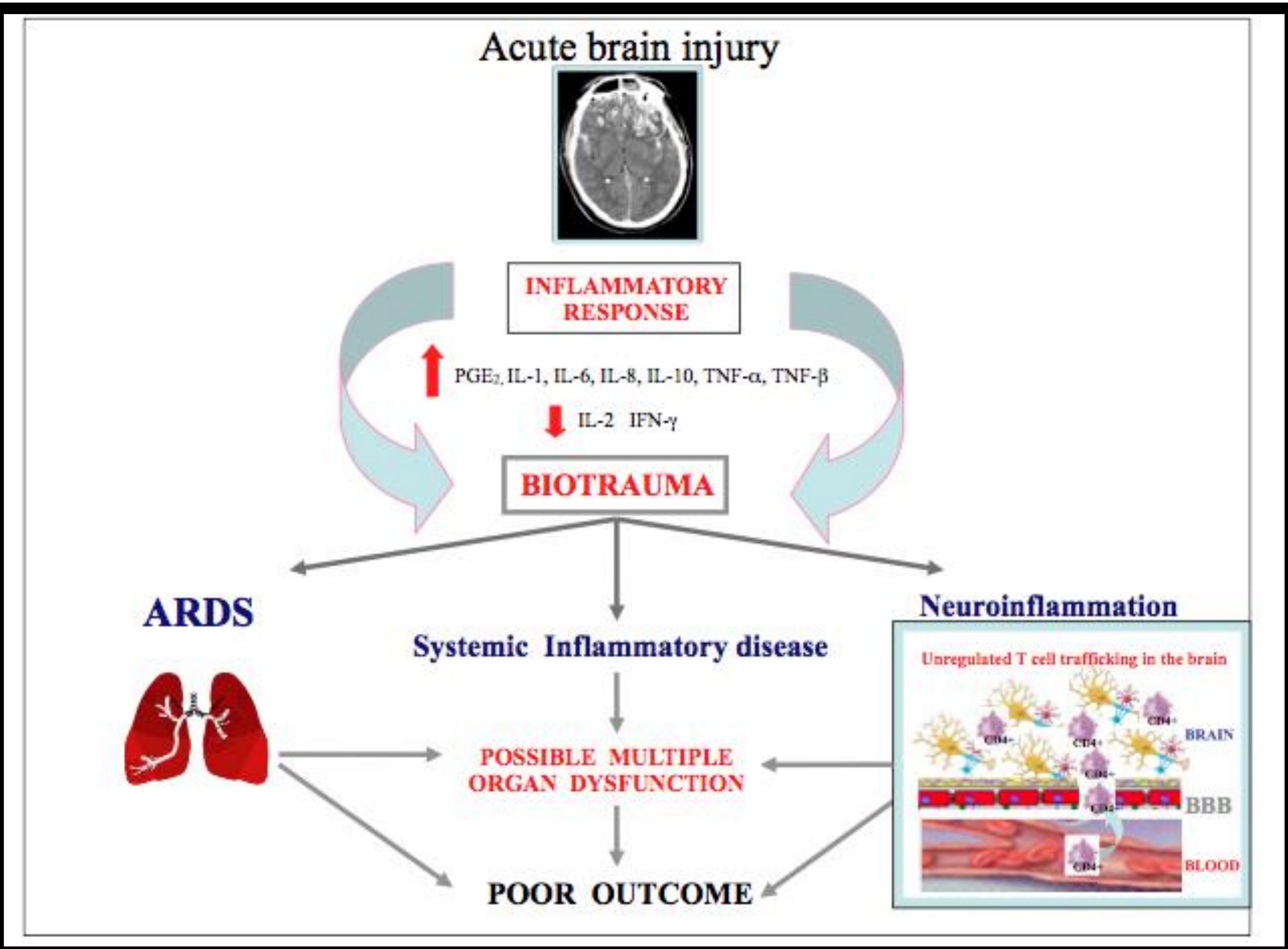
I= normal
II = hypokinetic
III= akinetic/dyskinetic

$$\text{WMSI} = \frac{\sum \text{wall motion scores}}{\text{No. Segments visualized}}$$

Vn= 1 (normale contrazione)
>2.5 = (estese anomalie regionali)

Brain-lung crosstalk in critical care: how protective mechanical ventilation can affect the brain homeostasis

A. T. MAZZEO, V. FANELLI, L. MASCIA



Minerva Anestesiol 2013;79:299-309)

RCoA
Royal College of Anaesthetists

Chapter 14

Guidelines for the Provision of Anaesthesia Services (GPAS)

Guidance on the Provision of Services for Neuroanaesthesia and Neurocritical Care 2016

Introduction: the importance of neuroanaesthesia and neurocritical care services

- Anaesthesia for neurosurgery (neuroanaesthesia) is based in recognised neuroscience centres, which allow grouping together of the interrelated specialties required to support neurosurgery. These centres, whether they are in specialist, teaching or district general hospitals, should provide neurosurgical, neurological, neuroradiological and neurocritical care and other supporting specialist and general services necessary for the management of patients with neurological disease.
- The provision of adequate numbers of neurocritical care beds is a prerequisite for the delivery of such specialist services.[3]
- The centralisation of neuroscience practice is essential to ensure critical mass for delivery of efficient and high-quality clinical care. The pace of development, and the scope of procedures being undertaken in neurosurgery and interventional neuroradiology, continues to increase the specialist nature of neuroanaesthesia and neurocritical care.
- The clinical service should provide:
  - anaesthesia for neurosurgery – intracranial, complex spinal and associated surgery
  - anaesthesia for neuroradiology – diagnostic and interventional procedures including MRI.
- In units where there is a co-located neurocritical care unit, the department may be also be responsible for providing clinical service cover to:
  - neurocritical care – pre- and post-operative management of complex elective cases and the management of critically ill patients, such as those with severe head injury, intracranial haemorrhage or severe neurological disease and those who develop systemic complications secondary to their neurological condition.

The role of neuroanesthesiologist in NRD

- Haemodynamic stability
- Maintenance of adequate CPP
- Avoidance of secondary insults
- Patient immobility
- Rapid management of complications
- Smooth, rapid emergence

Anaesthesia for neuroradiology: thrombectomy: 'one small step for man, one giant leap for anaesthesia'

Dhuleep S. Wijayatilake[a,b], Gamunu Ratnayake[b], and Dassen Ragavan[a,b]

The authors speculate in the future, acute ischaemic stoke patients will be managed similarly to trauma patients. On arrival they would be met by a team who will rapidly assess, resuscitate, and prepare the patient for the intervention within 1 h of arrival. This is similar to the 'Trauma Call' concept in major trauma.

Curr Op Anesthesiol 2016;29:568-575

- **Location**
- **Imaging devices rotating freely**
- **Extension of tubing**
- **Monitors also outside the suite**
- **Radiation safety**
- **Emergency charts**

American Society of Anesthesiologists

STATEMENT ON NONOPERATING ROOM ANESTHETIZING LOCATIONS

Committee of Origin: Standards and Practice Parameters

(Approved by the ASA House of Delegates on October 19, 1994, and last amended on October 16, 2013)

THE AMERICAN SOCIETY OF ANESTHESIOLOGISTS, INC. VIGILANCE FOUNDED 1905 INCORPORATED NEW YORK 1936

The standards of anesthesia care and patient monitoring are the same regardless of location

ICONA

Italian COnsensus in Neuroradiological Anaesthesia (ICONA): managing anaesthesia during endovascular procedures

Castioni Carlo Alberto[1]*, Amadori Andrea[2], Bilotta Federico[3], Bolzon Moreno[4], Barboni Edoardo[5], Caricato Anselmo[6], Dall'Acqua Guido[7], Di Paola Francesco[7], Forastieri Molinari Andrea[8], Gritti Paolo[9], La Rosa Italia[3], Longo Marcello[10], Maglione Carla[11], Martorano Pietro[12], Munari Marina[13], Perotti Valerio[14], Rasulo Frank[15], Ruggiero Maria[16], Santoro Antonio[3], Scudeller Luigia[17], Tumolo Miriam[18], Mazzeo Anna Teresa[19]; on behalf of the SIAARTI Study Group on Neuroanesthesia and Neuroresuscitation, AINR, SARNePI°, SINCh°

METHODOLOGY

Multidisciplinary panel: 21 experts from 21 institutions, including neuro and paediatric anaesthesiologists, interventional neuroradiologists, neurosurgeons, and a clinical methodologist.

Key areas were identified and clinical questions were formulated in PICO format (Population, Intervention, Control, Outcomes)

- **P = pazienti** = pazienti da sottoporre a procedure di neuroradiologia interventistica
- **I = intervento** = monitoraggio aggiuntivo
- **C = confronto** = monitoraggio standard
- **O = outcome** = sicurezza? efficacia?

Nine working groups were established

AIM

To identify and address open questions concerning perioperative issues during elective and urgent endovascular neuroradiological procedures for aneurysms and cerebrovascular malformations.

Table 1. Levels of Certainty Regarding Net Benefit according to US Preventive Services Task Force criteria.[6]

Level of Certainty*	Descript ion
High	The available evidence usually includes consistent results from well-designed, well-conducted studies in representative primary care populations. These studies assess the effects of the preventive service on health outcomes. This conclusion is therefore unlikely to be strongly affected by the results of future studies.
Moderate	The available evidence is sufficient to determine the effects of the preventive service on health outcomes, but confidence in the estimate is constrained by such factors as: • The number, size, or quality of individual studies. • Inconsistency of findings across individual studies. • Limited generalizability of findings to routine primary care practice. • Lack of coherence in the chain of evidence. As more information becomes available, the magnitude or direction of the observed effect could change, and this change may be large enough to alter the conclusion.
Low	The available evidence is insufficient to assess effects on health outcomes. Evidence is insufficient because of: • The limited number or size of studies. • Important flaws in study design or methods. • Inconsistency of findings across individual studies. • Gaps in the chain of evidence. • Findings not generalizable to routine primary care practice. • Lack of information on important health outcomes. More information may allow estimation of effects on health outcomes.

Table 2. Grading of consensus statements and suggestions for clinical practice according Preventive Services Task Force criteria.[6]

Grade	Definition	Suggestions for Practice
A	The USPSTF recommends the service. There is high certainty that the net benefit is substantial.	Offer or provide this service.
B	The USPSTF recommends the service. There is high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial.	Offer or provide this service.
C	The USPSTF recommends selectively offering or providing this service to individual patients based on professional judgment and patient preferences. There is at least moderate certainty that the net benefit is small.	Offer or provide this service for selected patients depending on individual circumstances.
D	The USPSTF recommends against the service. There is moderate or high certainty that the service has no net benefit or that the harms outweigh the benefits.	Discourage the use of this service.
I Statement	The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of the service. Evidence is lacking, of poor quality, or conflicting, and the balance of benefits and harms cannot be determined.	Read the clinical considerations section of USPSTF Recommendation Statement. If the service is offered, patients should understand the uncertainty about the balance of benefits and harms.

Question 1

In addition to standard monitoring provided for general surgery, what additional monitoring should be conducted during interventional neuroradiological procedures?

Statement 1

Neurophysiological monitoring may be used for early detection of intra-operative neural changes.

Level of certainty: Moderate **Strength of consensus statement: B**

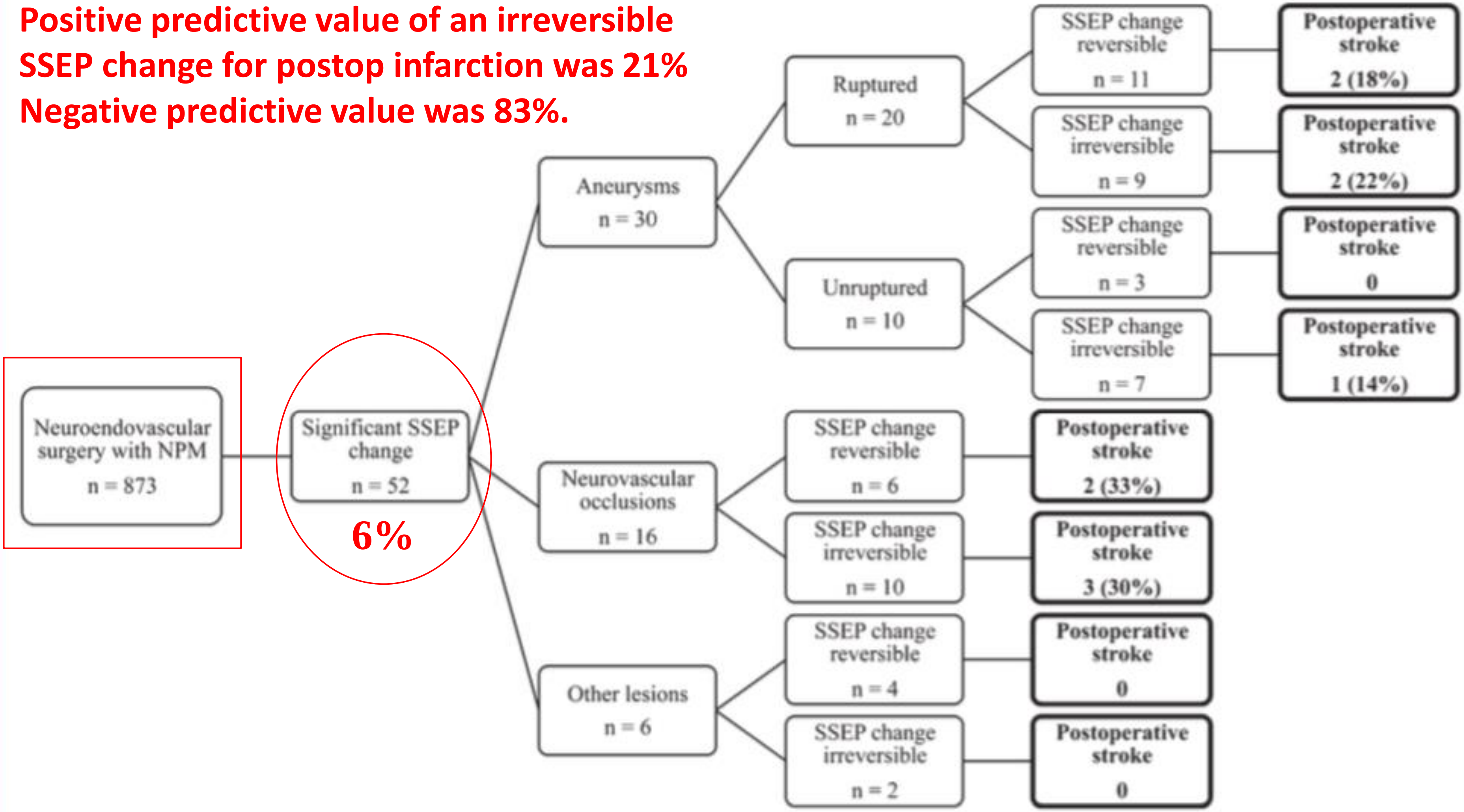
Statement 2

Near-infrared spectroscopy (NIRS) might be used to detect changes in cerebral oxygenation.

Level of certainty: Low **Strength of consensus statement: I**

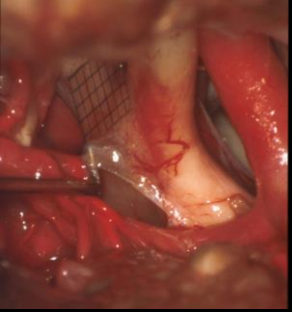
Somatosensory Evoked Potential Changes in Neuroendovascular Procedures: Incidence and Association With Clinical Outcome in 873 Patients

Positive predictive value of an irreversible SSEP change for postop infarction was 21%
Negative predictive value was 83%.



10 (19%) with SSEP changes suffered postoperative infarcts. **<u>Reduced duration and reversibility of SSEP changes were associated with lower incidence of postop infarction</u>**

Phillips et al:Neurosurgery 75:560–567, 2014



Intraoperative Monitoring for Intracranial Aneurysms: The Michigan Experience

Kinshuk Sahaya, Aditya S. Pandey,† Byron G. Thompson,† Brian R. Bush,‡ and Daniela N. Minecan‡*

Retrospective - 470 intracranial aneurysms (endovascular or microsurgical)
SSEP, BAEP, EEG

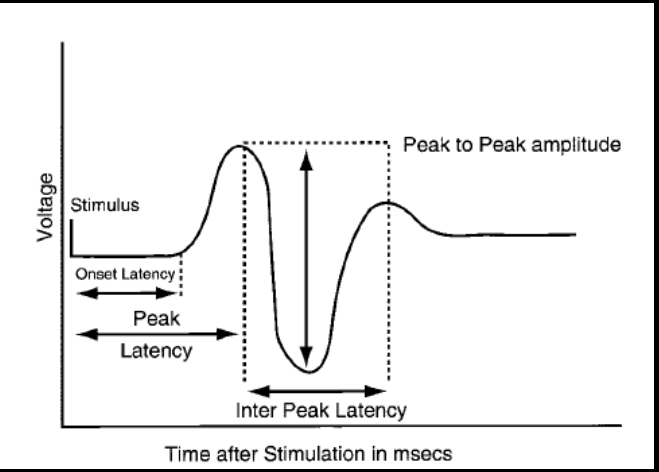
IONM changes 3.8%

Reversible in 44%, partly reversible in 22%, irreversible in 33%

Sensitivity 90%   Specificity 98.04%
Negative predictive value 99.78%
Positive predictive value 50%

Sahaya, Journal of Clinical Neurophysiology 2014

What constitutes an important SSEP Change?



decrease in amplitude of $\geq$ 50%

increase in latency of $\geq$ 10%

Loss of integrity of a neural pathway

Banoub, Anesthesiology 2003

Question 2

During neuroradiological interventions for the treatment of cerebral aneurysms and/or the correction of CVMs, should GA be preferred for all patients or are there cases in which conscious sedation may be used?

Statement

In selected cooperative patients with good neurological grade, conscious sedation may represent an alternative to GA.

Level of certainty: Low **Strength of consensus statement: C**

…Sailing quietly in the darkness or sailing fast under a dayligth storm…

Molina Stroke 2010;41:2718-19

Table 1 General anaesthesia or local anaesthesia for endovascular therapy after acute ischaemic stroke

General anaesthesia	Local anaesthesia
Pros	Pros
Immobility	Smoother haemodynamics
Pain control	Intra-procedural neurological evaluation
Airway protection	
Cons	Cons
Haemodynamic changes	Lack of airway protection
Additional workforce	Patient movement possible
Potential of time delay before start of procedure	Uncontrolled pain and agitation
	Prolonged procedure time

Anastasian BJA 2014;113:9-16

Question 3

During neuroradiological interventions for the treatment of cerebral aneurysms and/or correction of CVMs, is intravenous or inhaled anaesthesia preferred, when considering (1) haemodynamic stability, (2) cerebral blood flow, (3) intracranial pressure, (4) the use of neurophysiological monitoring, (5) neurological recovery?

Statement

There is insufficient evidence to favour intravenous anaesthesia or inhaled anaesthesia during neuroradiological procedures for cerebral aneurisms or CVMs.

Level of certainty: Moderate **Strength of consensus statement: C**

When neurophysiological monitoring is used, intravenous anaesthesia should be preferred.

Level of certainty: High **Strength of consensus statement: B**

Intravenous anaesthesia may be appropriate when high intracranial pressure is suspected.

Level of certainty: Moderate **Strength of consensus statement: C**

All volatile anesthetics produce a dose-dependent increase in SSEP latency, an increase in central conduction time and a decrease in amplitude

Table 1. Effect of Inhaled Anesthetics on Somatosensory Evoked Potentials

Anesthetic Drug/Concentration	Early Cortical Waveform‖ Latency	Early Cortical Waveform‖ Amplitude	Subcortical Waveform
Halothane[24,26,34]			
0.5 MAC + 60% N_2O	< 10% ↑	≈60% ↓	Negligible
1.0 MAC + 60% N_2O	< 10% ↑	≈70% ↓	Negligible
1.5 MAC + 60% N_2O	10–15% ↑	≈80% ↓	Negligible
1.5 MAC (alone)	10–15% ↑	≈70% ↓	Negligible
Isoflurane[23–28,31,35,36]			
0.5 MAC + 60% N_2O	< 10% ↑‡	50–70% ↓	Negligible
0.5 MAC (alone)	< 15% ↑	< 30% ↑	Negligible
1.0 MAC + 60% N_2O	10–15% ↑	50–75% ↓	Negligible
1.0 MAC (alone)	15% ↑	≈50% ↓	Negligible
1.5 MAC + 60% N_2O*	> 15% ↑	> 75% ↓	5% ↑ in latency
1.6 MAC (alone)*	15–20% ↑	60–70% ↓	5% ↑ in latency 20% ↓ in amplitude
Enflurane[24–26]			
0.5 MAC + 60% N_2O	< 10% ↑	≈50% ↓	Negligible
0.2–0.6 MAC (alone)	< 10% ↑	< 20% ↓	NA
1.0 MAC + 60% N_2O*	20% ↑	≈85% ↓	Negligible
1.5 MAC + 60% N_2O	Not recordable	Not recordable	Negligible
1.5 MAC (alone)*	> 25% ↑	≈85% ↓	Negligible
Sevoflurane[32,33]			
0.5 MAC + 66% N_2O	< 5% ↑	38% ↓	Negligible
1.0 MAC + 66% N_2O	< 10% ↑	≈45% ↓	Negligible
1.5 MAC + 66% N_2O	< 10% ↑	≈50% ↓	Negligible
1.7–2.5 MAC	10–15% ↑	≈100% ↑§	NA
Desflurane[38,39]			
0.5 MAC	<5% ↑	<20% ↓	Negligible
1.0 MAC	3–8% ↑	30–40% ↓	Negligible
1.5 MAC	≤ 10% ↑	< 50% ↓	Negligible
Any with 65% N_2O†	≥ 15% ↑	> 60% ↓	Negligible
Nitrous oxide[39,41,47]			
60–65 %	No effect	50–55% ↓	Negligible

Banoub, Anesthesiology 2003;99:716-37

Intravenous anesthetics generally affect SSEPs less than inhaled anesthetics

Table 3. Effect of Intravenous Anesthetics on Somatosensory Evoked Potentials

Drug/Dose	Early Cortical Waveform§		Subcortical Waveform
	Latency	Amplitude	
Thiopental[43,50,51,53]			
2.5–5.0 mg/kg	<10% ↑	5–30% ↓	Negligible
75 mg/kg	15% ↑	60% ↓	Negligible
Pentobarbital[54,55]			
Up to 20 mg/kg	≈10% ↑	45% ↓	None (latency) 20% ↓ (amplitude)
Ketamine[44,63,236,237]			
0.5 mg/kg	No effect	No effect	No effect
2–3 mg/kg + 2 mg · kg^{-1} · h^{-1}	No effect	0–30% ↑	Negligible
Etomidate[43,50,56]			
0.3–0.4 mg/kg + 2 mg · kg^{-1} · h^{-1}	<10% ↑	40–180% ↑	None (latency) 50% ↓ (amplitude)
1 mg/kg	10% ↑	150% ↑	Negligible
Propofol[62]			
2.5 mg/kg	< 10% ↑	No change	Negligible
Propofol			
2.5 mg/kg, then 10 mg · kg^{-1} · h^{-1} + sufentanil[48] 0.5 μg/kg, then 0.25 μg · kg^{-1} · h^{-1}	10–15% ↑	50%	NA
Midazolam[43,63,65,238]			
0.1–0.3 mg/kg*	< 5% ↑	25–40% ↓	Negligible
Diazepam[66,69]			
0.1–0.25 mg/kg	Minimal	↓	NA
Morphine[72]			
0.25 mg/kg	< 10% ↑	≈20% ↓	NA
Lidocaine[74, 239, 240]			
1.5 mg/kg, then 3 mg · kg^{-1} · h^{-1}	5% ↑	25–30% ↓†	Negligible
Fentanyl[28,50,71,72]			
2.5 μg/kg + N_2O	5–10% ↑	Variable‡	No change
25–100 μg/kg	<10% ↑	10–30% ↓	Negligible
Sufentanil[66,73,74]			
Sufentanil + N_2O + 0.5%isoflurane/1 μg/kg + infusion	5–10% ↑	≈50% ↓	No change
5 μg/kg Sufentanil (alone)	≈5% ↑	≈40% ↓	No change (latency) Amplitude: 40% ↓
1 μg/kg + Sufentanil propofol	5–10% ↑	No change	NA
Remifentanil[76] (with 0.4 MAC isoflurane)			
1 μg/kg + 0.2 μg · kg^{-1} · min^{-1}	NA	15–30% ↓	NA
2.5 μg/kg + 0.5 μg · kg^{-1} · min^{-1}		30–40% ↓	
5.0 μg/kg + 1.0 μg · kg^{-1} · min^{-1}		≈40% ↓	
Clonidine[84–86]			
2–10 μg/kg	No effect	No effect	10% Amplitude ↓ No effect (latency)
Alfentanil[75,241]			
10 μg/kg alone	NA	50% ↓	NA
100 μg/kg + 2 with N_2O	No effect	40% ↓	NA
Dexmedetomidine[87]			
Low sedative dose	NA	≈10% ↓	≈20% Amplitude ↓
High sedative dose	NA	≈30% ↓	≈10% Amplitude ↓

Banoub, Anesthesiology 2003;99:716-37

Question 4

What is optimal haemodynamic management for patients receiving anaesthesia during neuroradiological interventions for the treatment of cerebral aneurysms and/or correction of CVMs?

Statement

There is no evidence for an optimal blood pressure target. It is suggested that pressure be kept in the low-normal range of the baseline values, during the neuroradiological procedure.

Appropriate blood pressure may vary depending on whether there are intraprocedural haemodynamic complications, and on the phase of the procedure.

Level of certainty: Low

Strength of consensus statement: C

Question 5.

During interventional neuroradiological procedures, what is optimal management of neuromuscular blockade?

Statement

There is a lack of evidence on the management of neuromuscular blockade during interventional neuroradiological procedures. When neuromuscular blockade is deemed appropriate, guidelines and recommendations for GA should be followed.

Level of certainty: Low **Strength of consensus statement: C**

Question 6

During interventional neuroradiological procedures, what is the optimal way to monitor and manage antiaggregant/anticoagulant therapy?

Statements

In patients undergoing neuroradiological procedures in which the use of anticoagulant therapy is indicated, it may be appropriate to monitor the efficacy of such therapies.

Level of certainty: Moderate **Strength of consensus statement: B**

In patients undergoing neuroradiological procedures in which the use of antiaggregant therapy is indicated, the appropriateness of monitoring the efficacy of such therapies is uncertain.

Level of certainty: Low **Strength of consensus statement: C**

Question 7

For interventional neuroradiological procedures in patients at risk for intracranial hypertension due to hydrocephalus, when is it appropriate to place an external ventricular/lumbar catheter and monitor intracranial pressure?

Statement

In deteriorating patients with acute hydrocephalus, a ventricular or lumbar catheter should be placed for intracranial pressure monitoring and/or cerebrospinal fluid drainage. When placed before the procedure, it is suggested that ICP should not fall below 15 mm Hg. When there is no longer a risk of intracranial hypertension or hydrocephalus, effort should be made to remove the drain as soon as possible, to avoid catheter-related meningitis/ventriculitis.

Level of certainty: High **Strength of consensus statement: A**

Question 8

After an uncomplicated interventional neuroradiological procedure for an unruptured intracranial aneurysm or CVM, what intensity of postoperative care is appropriate?

Statement

After uncomplicated elective procedures, there is no evidence to recommend routine admission to an intensive care environment. Continuous monitoring should be ensured for the first 1-4 hours post procedure.

Level of certainty: Low

Strength of consensus statement: C

PEDIATRICS

I am not a small Adult

CONSIDERATIONS FOR PAEDIATRIC PATIENTS

Following the "2004 Guidelines for Sedation in Pediatric Neuroradiology" published by the SIAARTI - SARNePI Neuroanesthesia and Neurointensive Care Working Group,[94] issues related to the management of anaesthesia for neuroradiological endovascular procedures in children are considered in this section. Whereas the paucity of evidence in this setting precludes the formulation of strong recommendations, some guidance can be provided.

The following considerations must be made:

1. Diagnostic cerebral angiography

- As for adult patients, clear liquids can be given up to two hours before the procedure, so that the patient is euvolemic and haemodynamically stable at induction.
- Preoperative blood pressure should be recorded at baseline.
- Peripheral venous access is generally sufficient, serving only to maintain adequate hydration and blood volume.
- Procedures are generally conducted under GA. Only more mature patients can undergo this procedure with conscious sedation.
- Normocapnia is recommended in the great majority of cases; the merits of hypocapnia should be discussed case by case within the medical team
- Fluid management should aim for normal blood pressure and provide euvolemia or slight hypervolemia to reduce the risk of kidney damage from contrast medium.
- Once the arterial access is established, the procedure is not painful; therefore, there is generally no need for long-acting opioids.
- As for adults, neuromuscular blockade is not mandatory.

After the procedure:

Paediatric patients should have 2-6 hours of bed rest after sheath removal. The presence of family members and use of behavioural approaches are encouraged, but younger or less cooperative patients may require narcotics or alpha-2 agonists. Deep extubation may be indicated to avoid coughing.

2. Therapeutic cerebral angiography or embolization

• Given the long procedure durations, care should be taken in positioning the patient and using protective supports. Careful temperature monitoring and thermal care throughout the procedure is advised.

• GA with neuromuscular blockade is appropriate in the majority of cases.

• Venous accesses suitable for the infusion of liquids and administration of drugs are appropriate.

• Euvolemia or mild hypervolemia are suggested.

• The volume of heparinised saline infused through the guide catheter to reduce the risk of emboli should be recorded, as it can become significant.

•In selected cases, heparin may be administered to an activated coagulation time of 250-300 seconds.[95]

• Tight blood pressure control is generally appropriate. Target blood pressure should be agreed on beforehand by the neuroradiologist and anaesthesiologist, and maintained through intra-arterial monitoring.

• Haemodynamic changes during and after these procedures may be large and associated with increased risk of periprocedural bleeding, especially in cases of partial embolization before surgical resection. Thus, tight blood pressure control should continue through the first night after the procedure. In some centres, this is achieved either with sedation and delayed extubation or with continuous infusion of dexmedetomidine after extubation.

• Close blood pressure control, monitoring of vital signs and modulation of sedation generally require postoperative observation in an intensive care environment. In a study of 127 paediatric endovascular interventions for AVMs all patients were admitted to ICU for 48 h postprocedure.[96]

• Careful airway and haemodynamic management are needed during transport. In particular, the depth of anaesthesia should be maintained to prevent hypertension.

3. Safety

• Anaesthesia equipment should be comparable to that used in main operating rooms, and be suitable for ventilation and monitoring of critical paediatric patients.[97]

Take home messages

- Understanding goals & methods of endovascular intervention, anticipating potential problems, is crucial to optimize perioperative outcome.

- Open communication between anesthesia and interventional teams regarding blood pressure goals, anticoagulants, case urgency, procedural variables, and complications is essential

Future…

Istituzione di database nazionale per tutte le procedure NRD?

Registro dell'OUTCOME (nel perioperatorio ed a 6 mesi)?

Incidenza di complicanze periprocedurali

N. Procedure annue/patologie trattate/tecniche impiegate/tipo di anestesia