

Recent advances in cerebral monitoring

An essay submitted for fulfillment of master degree in
anesthesiology

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Introduction

While there is increasing body of knowledge in regard to central nervous system function and/or the mode of action of centrally active agents on neuronal function, little done to develop new techniques on how to measure such changes.

In the past monitoring of central nervous system is only done in rare cases where operative procedures impend nervous function integrity. Since in the past decade the aging population undergoing operation, patients with severe head injury and critically ill neurologic patients has risen considerably, the risk of cerebral malperfusion or minute signs of degradation of the central nervous system (CNS) to anesthetics and agents being used in the operating room (OR) or the intensive care unit (ICU), needs continuous monitoring of an organ which presents the highest vulnerability and likely to deteriorate faster than the cardiovascular system.

Cerebral monitoring is important for management of severe head injury and critically ill neurologic patient. It is also useful in subarachnoid hemorrhage, stroke, intracerebral hematoma, meningitis, encephalitis, hepatic failure, after neurosurgery and in patients undergoing carotid artery surgery.

In spite of rapid improvement in technology regarding electroencephalogram (EEG) and evoked potential monitoring, physicians are reluctant to use a technology on a routine base which will give them insight to the brain function and activity.

Such "windows to the brain" now not just reserved to specialists of neurology and/or psychiatry, more so, cerebral monitoring is getting an integrated part in the overall therapy in patients undergoing operation or who need ventilatory support in the ICU as it affects well-being and outcome.

Aim of the essay

The aim of this essay is to highlight the methods of cerebral monitoring which will help us to detect changes in cerebral hemodynamics, cerebral oxygenation, intracranial pressure, cerebral metabolism and neuronal function.

CONTENTS

<u>Chapter 1</u>	1
Intracranial pressure monitoring.....	2
Normal anatomy and physiology.....	2
Pathophysiology.....	3
Normal and pathologic ICP.....	6
Methods of ICP monitoring.....	7
Placement.....	8
Indications of ICP monitoring.....	11
Complications of ICP monitoring.....	12
 <u>Chapter 2</u>	 14
Anatomy.....	15
Cerebral hemodynamic monitoring.....	20
Cerebral perfusion pressure.....	20
The basic physiology.....	20
Physiological factors affecting CPP.....	21
Autoregulation.....	21
Cerebral blood flow monitoring.....	23
Modalities of DBF and CPP monitoring.....	24
Transcranial Doppler ultrasonography.....	24
Positron emission tomography.....	26
SPECT/CT perfusion.....	28
Advanced ultrasonography.....	30
The Xe-CT Modality.....	31
Continuous quantitative CBF monitoring.....	33
Dynamic perfusion CT modality.....	34
Perfusion- and diffusion- weighted MRI modalities.....	36
 <u>Chapter 3</u>	 41
Monitors of cerebral functions.....	41
Electroencephalography.....	41
Bispectral index.....	44
Evoked potentials.....	46
Electrophysiological monitoring.....	50

Glasgow coma score and other scales.....	52
Continuous neurological monitoring: Wake-up test.....	54
Electromyography: Monitoring of facial nerves.....	55

Chapter 4

Monitoring of brain metabolism.....	57
Principles of microdialysis.....	57
Catheter placement.....	60
Biochemical markers.....	60
Safety of cerebral microdialysis.....	65
Limitations of CMD monitoring.....	65

Chapter 5

Monitoring of cerebral oxygenation.....	68
Jugular venous oxygen saturation.....	68
Cerebral near-infrared spectroscopy.....	71
Brain tissue oximetry.....	74

Chapter 6

Interpretation of cerebral monitoring.....	80
Interpretation of ICP monitoring.....	81
Benefits of ICP monitoring.....	81
Critical CPP threshold in TBI.....	81
Usefulness of EEG.....	82
Advantages of evoked potentials.....	83
Benefits of bispectral index in anesthesia.....	83
Uses of electrophysiological monitoring.....	84
Clinical applications of CMD monitoring.....	84
Advantages of cerebral microdialysis.....	85
Interpretation of cerebral oxygenation monitoring.....	85

Summary

References

Arabic summary

ABBREVIATION

(ABI).....	Acute brain injury
(AMP).....	The amplitude of ICP wave form
(ARDS).....	Adult respiratory distress syndrome
(AvDO ₂).....	Arterio-venous oxygen difference
(BBB).....	Blood brain barrier
(BTF).....	Brain Trauma FOUNDATION
(CA).....	Cerebral autoregulation
(CaO ₂).....	Arterial oxygen
(CFM).....	Cerebral function monitoring
(CBF).....	Cerebral blood flow
(CBV).....	Cerebral blood volume
(CMD).....	Cerebral microdialysis
(CMR).....	Cerebral metabolic rate
(CMRO ₂).....	Cerebral metabolic
(CPB).....	Cardio-pulmonary bypass
(CPP).....	Cerebral perfusion pressure
(CSF).....	Cerebro spinal fluid
(CT).....	Computed tomography
(CVP).....	Central venous pressure
(CVR).....	Cerebral vascular resistance
(DCH).....	Decompressive hemicraniotomy
(EEG).....	Electroencephalography
(EP).....	Evoked potential
(EVD).....	External ventricular drain (Intraventricular)
(GCS).....	Glasgow coma scale
(ICP).....	Intracranial pressure
(ICA).....	Internal carotid artery
(ICU).....	Intensive care unit
(JvDO ₂).....	Jugular venous
(LDF).....	Laser Doppler flowmetry
(LPR).....	Lactate: Pyruvate ratio
(MAP).....	Mean arterial pressure
(MD).....	Microdialysis
(MRI).....	Magnetic resonance imaging
(NICU).....	Neurointensive care unit
(PaCO ₂).....	Arterial partial pressure of carbon dioxide
(PaO ₂).....	Arterial partial pressure of oxygen
(PbO ₂).....	Brain tissue oxygen
(PET).....	Positron emission tomography

(PRx).....	Pressure reactivity index
(PtiO ₂).....	Brain tissue oxygen saturation
(QEEG).....	Quantitative EEG parameter
(RAP).....	Index of compensatory reserve
(RCTs).....	Randomized controlled trials
(rCBV).....	relative cerebral blood volume
(rCBF).....	regional cerebral blood flow
(rCMRGLu).....	relative metabolic glucose requirement
(rCMRO ₂).....	relative metabolic O ₂ requirement
(rSO ₂).....	regional oxygen saturation
(SAH).....	Subarachnoid hemorrhage
(SaO ₂).....	Arterial oxygen saturation
(SPECT).....	Single-photon emission computed tomography
(SjvO ₂).....	Jugular venous saturation of
(SSEPs).....	Somatosensory evoked potentials
(TBI).....	Traumatic Brain Injury
(TCD).....	Transcranial Dopple

SUMMARY

Cerebral monitoring of patients with acute intracranial disorders generally focuses on intracranial pressure and cerebral perfusion pressure monitoring. Recently, several new techniques have become available for more detailed routine monitoring of cerebral function, oxygenation and metabolism.

Elevated intracranial pressure has been recognized as one of the most important factors affecting morbidity and mortality rates in patients who have had traumatic brain injury (TBI); therefore, intracranial pressure (ICP) monitoring has become routine in the management of severe head injuries. Normal ICP is 7-15 mm Hg adult. It is considered abnormal if exceeds 15 mm Hg.

Hemodynamic monitoring in the care of the critically ill neuroscience patient provides information that assists the clinician in minimizing secondary neuronal injury.

Cerebral perfusion pressure (CPP) is the pressure gradient across the cerebral vessel, the difference between arterial inflow and venous outflow. CPP is measured clinically as the mean arterial pressure minus the intracranial pressure.

Reduced CPP, due to intracranial hypertension or inadequate blood pressure, contributes to a fall in cerebral blood flow (CBF) in patients with severe TBI.

EEG investigates the spontaneous electrical activity of the cerebral cortex. EEG is the summation and recording of postsynaptic potentials from the pyramidal cells of the cerebral cortex. The electrical signal is

amplified, filtered, and displayed to give an accurate representation of electrical activity throughout the cortex. Changes in neuronal perfusion and oxygen supply lead to changes in the EEG recording.

Bispectral index is a continuous EEG reading. The calculations obtained from the EEG indicate the sedation level in the patient. It was designed for use during general anesthesia to measure sedation but has since crossed over the ICU.

Evoked potentials are the electrical responses generated in the nervous system in response to a stimulus. Evoked potentials are event-related. They are pathway-specific. They have much lower amplitude than the normal EEG activity.

The severity of altered consciousness is evaluated with the Glasgow Coma Scale. The scale consists of eye opening, verbal communication, and motor response to verbal or noxious stimulation. The Glasgow Coma Scale is the sum of the three components, and has arranged from 7 to 15.

Cerebral microdialysis is a relatively new technique for measuring the levels of brain extracellular chemicals, which to date has predominantly been used as a research tool. Brain glucose and lactate levels can be monitored with the help of imaging modalities such as magnetic resonance and positron emission tomography scanning. Recently, however, the ability to measure the concentration of metabolites in the extracellular space directly and continuously, has only become feasible with the application of cerebral microdialysis.

Jugular venous oxygen saturation and brain tissue PO_2 have been used as measures of cerebral oxygenation in place of quantitative CBF

measurement. Because they have been found to be very good indicator of the adequacy of CBF in relation to cerebral metabolic requirements. If the brain is hypoperfused, oxygen extraction will be increased, and $SjvO_2$ will be reduced. On the other hand, If CBF is adequate for the brain metabolic need, and then $SjvO_2$ will remain normal. This information is more often useful clinically than the absolute CBF values.

Cerebral near-infrared spectroscopy is a noninvasive technique to monitor brain oxygenation by measuring regional cerebral venous oxygen saturation.

Brain tissue oxygen pressure measurement is increasingly being used for evaluation of cerebral oxygenation. It is used in patients with multiple extracranial injuries and TBI, aneurismal subarachnoid hemorrhage, during aneurysm surgery, during surgery of cerebral arterio-venous malformations, during cerebral angiography and during cardiopulmonary resuscitation. Two monitoring devices are currently available, "Licox" and "Neurotrend" technology. The Neurotrend probe uses optical sensors while The Licox probe uses a polarographic cell.

الملخص العربى

حدث تقدم شديد فى المراقبة المخيه فى العقدين الأخيرين ويرجع جزء كبير من هذا التقدم الى الطفرة الشديده التى حدثت فى علم تخدير المخة الأعصاب وعلم العناية المركزه.

وبالرغم من التطورات الجديده فيما يتعلق بالرصد الدماغى لا يزال الأطباء مترددين فى استخدام هذه التكنولوجيا على أساس روتينى مما سيعطيهم تبصره بوظائف المخ و نشاطه.

وهذه التقنيات الحديثه للرصد الدماغى ليست حكرا على أطباء الأمراض العصبية والطب النفسى بل أصبحت جزءا أساسيا فى علاج المرضى الذين سيخضعون لعمليات جراحية أو الذين سيوضعون تحت أجهزة التنفس الصناعى فى وحدات الرعاية المركزه.

وتهدف هذه الدراسه الى بيان مختصر للتطورات التى حدثت فى أجهزة المراقبة والرصد للحالات الخطره من مرضى المخ والأعصاب وأهميتها الشديده فى انقاذ وعلاج الحالات الحرجه.

وتبدأ بمراجعته مبسطه تبين من خلالها أسباب ارتفاع الضغط داخل الدماغ ومضاعفاته والطرق الحديثه لقياسه ومراقبته.

ثم تبين الدراسه العوامل المؤثره على ضغط الارواء المخى وتدفق الدم للمخ والأجهزة الحديثه لرصدهما وحسابهما.

كما تبين الدراسه مراقبة الوظائف المخيه وكيفية تقدير النشاط الكهربائى التلقائى لقشرة الدماغ وحساب درجة الوعى للمريض والردود الكهربائيه التى تنتج فى النظام العصبى ردا على محفز خارجى.

ثم تشرح تلك الدراسه أهمية مراقبة أيض الدماغ والعلامات الكيمياويه الحيويه وكيفية مراقبتها والتطبيقات الحديثه لها.

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Chapter 1

ICP Monitoring