MONITORING OF ACUTE TRAUMATIC CEREBRAL INJURY IN PEDIATRIC

Essay

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By

Sherif Mohsen Mohamed Elsayed Abd Elaziz

(M.B.B.Ch,)

Under the supervision of

Prof. Dr. Hanaa Elsayed Abou Elnour

Professor of Anesthesiology

Faculty of Medicine

Cairo University

Prof. Dr. Amina Abou Elela Mousa

Assistant Professor of Anesthesiology

Faculty of Medicine

Cairo University

Dr. Mohamed Ebrahim Emam

Lecturer of Anesthesiology

Faculty of Medicine

Cairo University

Faculty of Medicine

Cairo University

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الطبيب/ شريف محسن محمد السيد عبد العزيز

بكالوريوس الطب والجراحة . جامعة القاهرة

تحت إشراف

الأستاذة الدكتورة/ هناء السيد أبو النور

أستاذ التخدير

كلية الطب – جامعة القاهرة

الأستاذة الدكتورة/ أمينة أبو العلا موسى

أستاذ مساعد التخدير

كلية الطب – جامعة القاهرة

الدكتور/ محمد إبراهيم محمد إمام

مدرس التخدير

كلية الطب – جامعة القاهرة

كليـــــــــة الطب

جامعة القاهرة

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ABBREVIATIONS

ABG	Arterial Blood Gases
$AjvDO_2$	Difference in Oxygen content between Arterial and Jugular Venous Blood
AMP	Amplitude
ATP	Adenosine Tri Phosphate
AVMs	Arterio Venous Malformations
BSI	Bi Spectral Index
CaO_2	Arterial Oxygen Content
CBC	Complete Blood Picture
CBF	Cerebral Blood Flow
CBFV	Cerebral Blood Flow Velocity
CBV	Cerebral Blood Volume
cEEG	Continuous Electroencephalography
CFM	Cerebral Function Monitor
CFAM	Cerebral Function Analysing Monitor
$CjvO_2$	Oxygen Content of Jugular Venous Blood
$CMRO_2$	Cerebral Metabolic Rate of Oxygen
CNS	Central Nerves System
CPB	Cardio Pulmonary Bypass
CPP	Cerebral Perfusion Pressure
CSF	Cerebro Spinal Fluid
CT	Computed Tomography
CVR	Cerebrovascular Resistance
DAI	Diffuse Axonal Injury
DO_2	Cerebral Oxygen Delivery
DRS	Disability Rating Scale
DVT	Deep Vein Thrombosis
EBIC	European Brain Injury Consortiums
ECF	Extra Cellular Fluid
ECG	Electrocardiogram

EEG	*Electroencephalogram.*
ETCO2	*End Expiratory CO2*
EVD	*External Ventricular Device*
FIM	*Functional Independence Measure*
FVmean	*Mean Flow Velocity*
GABA	*Gamma Amino Butyric Acid*
GCS	*Glasgow Coma Score.*
GI	*Gastro Intestinal*
GOS	*Glasgow Outcome Scale*
GU	*Genito Urinary*
HB	*Hemoglobin*
HbO2	*Oxygenated Haemoglobin*
Hct	*Hematocrit Value*
HPLC	*High Performance Liquid Chromatography*
HR	*Heart Rate*
ICP	*Intracranial Pressure.*
NICU	*Neuro Intensive Care Unite.*
JVP	*Jugular Venous Pressure*
LED	*light Emitting Diode*
LOC	*loss of Consciousness*
MABP	*Mean Arterial Blood Pressure.*
MAP	*Mean Arterial Pressure.*
MCA	*Middle Cerebral Artery*
MD	*Microdialysis*
MEPs	*Motor Evoked Potential*
MRI	*Magnetic Resonance Image.*
MV	*Motor Vehicle*
NIRS	*Near-Infrared Spectroscopy*
PaO_2	*Arterial Partial pressure of Oxygen.*
$PaCO_2$	*Arterial Partial Pressure of Carbon dioxide.*
$PbtO_2$	*Brain Tissue Partial Pressure Oxygen*
PE	*Pulmonary Embolism*
PET	*Positron-Emission Tomography*
PRX	*Pressure-Reactivity Index*

PTA	*Post-Traumatic Amnesia*
PTS	*Posttraumatic Seizures*
PT	*Prothrombin Time*
PTT	*Partial Thromboplasten Time*
P1,2,3	*Peak 1,2,3*
RAP	*Index of Compensatory Reserve*
ROS	*Reactive Oxygen Species*
rSO2	*Regional Oxygen Saturation*
SAH	*Sub-Arachnoid Haemorrhage*
SBP	*Systolic Blood Pressure*
SEPs	*Sensory Evoked Potential*
SHI	*Severe Head Injury*
$SjvO_2$	*Jugular Venous Oxygenation Saturation*
SPECT	*Single-Photon Emission CT*
SSEPs	*Somatosensory Evoked Potential*
TBI	*Traumatic Brain Injury*
TCD	*Transcranial Doppler*
TCU	*Transcranial Doppler Ultrasonography*
VMCA	*Velocity of Middle Cerebral Artery*

INTRODUCTION

INTRODUCTION

Traumatic injuries remain the leading cause of death in children and in adults aged 45 years or younger. Head trauma is more likely in young children than in adults given the same deceleration of the body due to their large and heavy heads and weak cervical ligaments and muscles. Resulting brain injury is more severe due to their thin, pliable skulls and the yet unfused sutures. Accordingly, children below the age of 4 years have lower chances of a full recovery after severe TBI, although in general, neurologic recovery after severe brain injury in children is better than in adults. **[1]**

The pediatric brain has higher water content, 88% versus 77% in adult, which makes the brain softer and more prone to acceleration-deceleration injury. The water content is inversely related to the myelinization process. The unmyelinated brain is more susceptible to shear injuries. Infants and young children tolerate intracranial pressure increases better because of open sutures. **[2]**

The time course of brain injury can be divided into two steps: primary and secondary injury. Primary brain injury exclusively results from the initial impact. **[1]**

Adverse physiologic conditions during recovery after head trauma may account for additional brain damage, which is then referred to as secondary brain injury which may occur hours or even days after the inciting traumatic event. Injury may result from impairment or local declines in cerebral blood flow after a traumatic brain injury. Decreases in

cerebral blood flow are the result of local edema, hemorrhage, or increased intracranial pressure. As a result of inadequate perfusion, cellular ion pumps may fail, causing a cascade. As the cascade continues, cells die, causing free radical formation proteolysis, and lipid peroxidation.These factors can ultimately cause neuronal death. **[3]**

Three evidence based measures are of critical importance to prevent or minimize secondary brain injury: (a) avoid hypoxemia, (b) avoid post-traumatic arterial hypotension, and (c) refer the traumatized child to an experienced trauma team. **[1]**

The goal of monitoring in the injured brain is to enable the detection of harmful physiological events before they cause irreversible damage to the brain, thereby allowing diagnosis and effective treatment and providing 'on-line' feedback to guide therapy. Aims to minimize secondary injury in an attempt to optimize patient management and outcome. **[4]**

Continuous monitoring of intracranial pressure (ICP) and cerebral perfusion pressure (CPP) has become a standard in neurointensive care of severe head injured patients. In addition, head injured patients should have systemic parameters closely monitored, including ECG, heart rate, blood pressure, temperature, fluid intake and output. Routine monitoring of oxygen saturation and capnography is paramount in severely head injured patients so as to avoid unrecognized hypoxemia or changes in ventilation. New devices including: jugular venous oxygen saturation monitoring, Near-Infrared Spectroscopy , Cerebral Microdialysis, Cerebral Imaging Monitoring, Transcranial Doppler Ultrasonography, Continous electroencephalography. **[4]**

ANATOMY OF THE PEDIATRIC NEUROLOGY

Anatomy of pediatric head differs from that of adult so knowledge of the basic anatomy of the pediatric head, brain and its coverings is essential to understand the mechanism and types of traumatic brain injury in pediatric **[5]**.

The scalp is the outer most covering and is highly vascular, tending to bleed profusely when lacerated. Under the scalp is a tendentious sheath extending from frontal to occipital regions called **the galea**. The potential space beneath the galea is the **subgaleal compartment** which an occasional site of bleeding after head injury. **[6]**

Anatomy Of The Newborn Skull:

The skull is the next part after the scalp which is composed of three layers; the bony outer layer and inner tables layer separated by diploic space which is more vascular. Although the skull appears to be one large bone, there are actually several major bones that are connected together. These include: one *occipital* bone, two *parietal* bones and two *frontal* bones. These bony plates cover the brain and are held together by fibrous material called sutures which do not fuse in the child's skull until as late as the tenth year (fig.1-1). **[7]**