Update in management of patients with traumatic brain injury

Essay

Submitted for complete fulfillment of master degree in anesthesia

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Contents

List of abbreviations

ACA Anterior Cerebral Artery

ARDS Acute Respiratory Distress Syndrome

ALI Acute Lung Injury

ATLS Advanced Trauma Life Support

$AVDO_2$ Arteriovenous Difference Of Oxygen

BBB Blood Brain Barrier

CBF Cerebral Blood Flow

CMR Cerebral Metabolic Rate

$CMRO_2$ Cerebral Metabolic Rate of Oxygen

CNS Central Nervous System

CO_2 Carbon Dioxide

COX Cyclooxygenase

CPP Cerebral Perfusion Pressure

CSF Cerebrospinal Fluid

CT Computed Tomography

CVP Central Venous Pressure

CVR Cerebral Vascular Resistance

DBP Diastolic Blood Pressure

DIC disseminated intravascular coagulopathy

DVT deep vein thrombosis

EEG Electroencephalography

ELISA Enzyme Linked Immunosorbent Assay

EMS Emergency Medical Service

EMT Emergency Medical Team

EPO Erythropoietin

$ETCO_2$ End Tidal Carbon Dioxide

FAST Focused Assessment By Sonography In Trauma

FiO_2 fraction of inspired oxygen

GABA Gamma-Aminobutyric Acid

GCS Glasgow Coma Scale

HES Hydroxyethyl Starch

HMGCoA 3hydroxy 3methyl glutaryl coenzyme A

ICA Internal Carotid Artery

ICAM Intercellular Adhesion Molecules

ICP Intracranial Pressure

ICU Intensive Care Unit

IgG/M Immunoglobin G/M

IJV Internal Jagular Vein

IL Interleukin

LMA Laryngeal Mask Airway

LMWH Low Molecular Weight Heparin

MAP Mean Arterial Blood Pressure

MCA Middle Cerebral Artery

$MgSO_4$ magnisium sulphate

$MgCl_2$ magnisium chloride

MILS Manual In Line Stabilization

MRI Magnetic Resonance Imaging

MRS Magnetic Resonance Spectroscopy

MSC Mesenchymal Stromal Cells

MV mechanical ventilation

N_2O Nitrous Dioxide

NGF Nerve Growth Factor

NIRS Near Infrared Spectroscopy

NMDA N-Methyl-D-Aspartate

NO Nitric Oxide

NOS Nitric Oxide Synthase

NTF Neurotrophic Factor

O_2 Oxygen

$PaCO_2$ Arterial Carbon Dioxide Tension

PaO_2 Arterial Oxygen Tension

PCA Posterior Cerebral Artery

PET Positron Emission Tomography

PEEP Positiveend Expiratory Pressure

PGE_2 Prostaglandin E2

pH Potential Of Hydrogen

PT Prothrombin Time

$PTiO_2$ Brain Tissue Oxygen Tension

PTT Partial Thromboplastin Time

RBC Red Blood Cells

RVM Rostral Ventrolateral Medulla

SAH Subarachnoid Hemorrhage

SBP Systolic Blood Pressure

SCI Spinal Cord Injury

SjvO2 Jugular Venous Oxygen Saturation

SPECT Single Photon Emission Computed Tomography

Sao2 Arterial Oxygen Saturation

SpO2 Oxygen Saturation

TBI Traumatic Brain Injury

TCD transcranial doppler

TH Therapeutic Hypothermia

TNF Tumor Necrosis Factor

UH Unfractionated Heparin

VC Vital Capacity

VILI Ventilator Induced Lung Injury

VIP Vasoactive Intestinal Peptide

VT Tidal Volume

List of figures

List of tables

Abstract

(Key Words: traumatic brain injury – secondary injury – intracranial pressure – monitoring – neuroprotection)

Traumatic brain injury (TBI) causes a temporary or permanent impairment of physical and cognitive functions along with changes in mental status. It accounts for nearly half of on-site deaths, and is the major cause of morbidity and mortality of survivals.

Neurological complications from TBI can occur as a result of the primary injury or may be caused by secondary injuries that follow within minutes to days.

The management of TBI is complicated and demands adequate prehospital care, a rapid diagnostic process and a high level of ICU care.

Introduction

Traumatic brain injury (TBI) reflects an insult to the brain from an external mechanical force (high – energy acceleration or deceleration) that might cause a temporary or permanent impairment of physical and cognitive functions along with changes in mental status. TBI resulting from head injury is the leading cause of death in individuals younger than 45 years and accounts for approximately 40 % of all deaths from acute injuries in the United States.

Neurological complications from TBI can occur as a direct result of the primary injury or may be caused by secondary injuries that follow within minutes to days. The primary injury is typically the result of a direct initial insult and secondary injury is caused by subsequent cascade of biochemical changes that are triggered by ischemia and result in disruption of the normal central nervous system balance between oxygen supply and demand. The entire secondary injury process is a vicious cascade of biochemical changes that lead to further spread of the ischemic injury and neurological deficits.

Critical care of head injured patients is complex and based on recognition and treatment of hazardous increase in intracranial pressure, with therapeutic targets for neuroprotection following TBI.

Chapter 1

Anatomy of the brain

Anatomy of the brain

The central nervous system (CNS) can be divided into brain and spinal cord .The brain, is contained within the cranium, and constitutes the upper, greatly expanded part of the central nervous system. The average weight of the brain, in the adult male, is about 1380 gm; that of the female, about 1250 gm.

The Cerebral Hemispheres

The cerebral hemispheres constitute the largest part of the brain. The hemispheres are separated medially by the longitudinal cerebral fissure .They are connected across the middle line by the corpus callosum. Each possesses a central cavity (the lateral ventricle) and presents three surfaces: lateral, medial, and inferior. These three surfaces are separated from each other by the borders: supero-medial, infero-lateral, medial occipital and medial orbital.

The surfaces of the hemispheres are moulded into a number of irregular eminences, named gyri or convolutions, and separated by furrows termed fissures or sulci. By means of these fissures and sulci, assisted by certain arbitrary lines, each hemisphere is divided into the following lobes: the frontal, the parietal, the temporal, and the occipital. (1)

The anterior end of the hemisphere is named the frontal pole; the posterior end, the occipital pole; and the anterior end of the temporal lobe, the temporal pole.

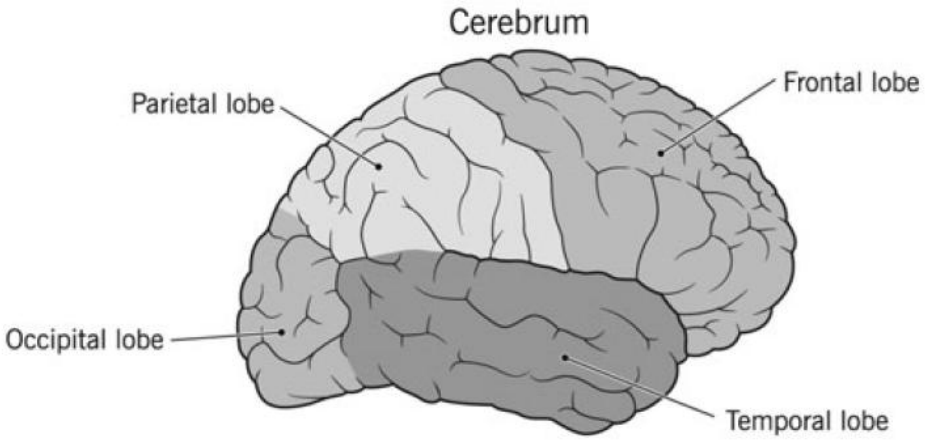

Figure 1 – Principal fissures and lobes of the cerebrum viewed laterally. [2]

Structure of the Cerebral Hemispheres:

The cerebral hemispheres are composed of gray and white substance. The former covers their surface, and is termed the cortex; the latter occupies the interior of the hemispheres.

The white substance consists of medullated fibers, varying in size, and arranged in bundles separated by neuroglia. They may be divided, according to their course and connections, into three distinct systems.

1. Projection fibers connect the hemisphere with the lower parts of the brain and with the spinal cord.
2. Transverse or commissural fibers unite the two hemispheres.
3. Association fibers connect different structures in the same hemisphere.

The gray substance of the hemisphere forms the cerebral cortex, the caudate nucleus, the lentiform nucleus, the claustrum, and the nucleus amygdalae. The cortex is made up of nerve cells of varying size and shape, and of nerve fibers which are either medullated or naked axis-cylinders, imbedded in a matrix of neuroglia. (1)

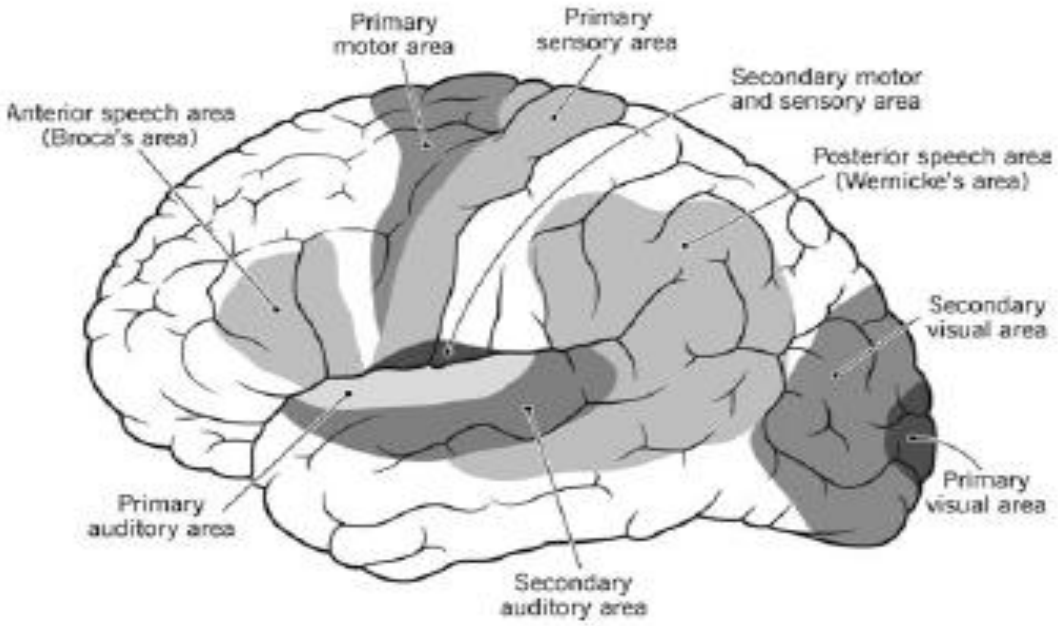

Figure 2 - functional areas of the human brain. (2)

Cerebral Localization:

a- Motor Areas

The motor area occupies the anterior central and frontal gyri and the paracentral lobule. The centers for the lower limb are located on the uppermost part of the anterior central gyrus and its continuation on to the paracentral lobule. Those for the trunk are on the upper portion, and those for the upper limb on the middle portion of the

anterior central gyrus. The facial centers are situated on the lower part of the anterior central gyrus.

b- Sensory Areas

Tactile and temperature senses are located on the posterior central gyrus, while the sense of form and solidity is on the superior parietal lobule and precuneus.

With regard to the special senses, the area for the sense of taste is probably related to the uncus and hippocampal gyrus. The auditory area occupies the middle third of the superior temporal gyrus and the adjacent gyri in the lateral fissure. The visual area occupies the calcarine fissure and cuneus. The olfactory area is present in the rhinencephalon. The center for speech is in the left inferior frontal and anterior central gyri (Broca). [1]

The Brain Stem

The brainstem is a small but extremely important structure, and has primarily three functions. Firstly, it is a conduit for transmitting signals back and forth from the cerebrum and cerebellum to the spinal cord.

Secondly, the 12 cranial nerves and their nuclei are found in the brainstem. These nerves control the motor and sensory functions of the head, face and most of the neck. Since these nerves and nuclei

are so closely located in and around the brainstem, problems in this area rarely affect only one cranial nerve.

Lastly, management of the essential involuntary functions of heart rate, blood pressure and respiratory rate occurs in the reticular networks of the brainstem, with input from the hypothalamus. (3)

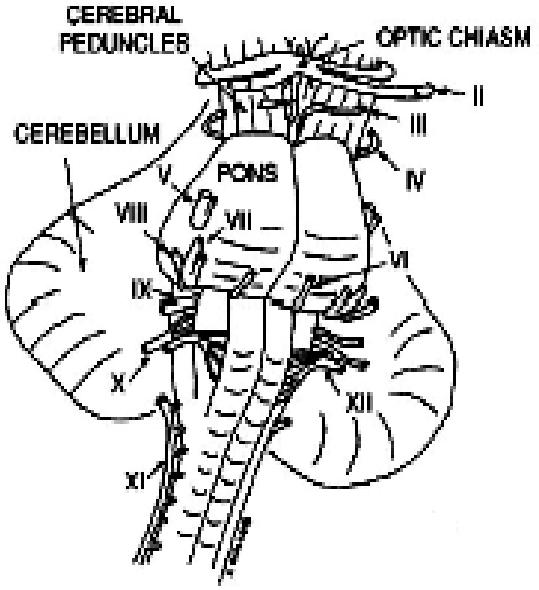

Figure 3 - Anatomy of brain stem. (3)

The brain stem is formed of:

The cerebral peduncles

These are two cylindrical masses situated at the base of the brain, and largely hidden by the temporal lobes of the cerebrum. They emerge from the upper surface of the pons, one on either side of the middle line, and, diverging as they pass upward and forward, disappear into the substance of the cerebral hemispheres.(4)