Rehabilitation Nursing Study Group

Neuroanatomy
Part I – Anatomy of the brain

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Nurse Educator

Learning objectives

• Outline normal and abnormal function of the brain structures and cranial nerves
• Explain the normal cerebrovascular circulation
Neuroanatomy

- **Knowledge of neuroanatomy**:  
  - Provides rehabilitation nurses with the foundation for providing optimal rehabilitation nursing interventions
  
  - Provides rehabilitation nurses with a rationale for setting appropriate goals with clients and families
  
  - Assist nurses in helping patients and families to adapt to changes in function
  
  - Assist nurses/interdisciplinary team members in setting realistic, outcome-based goals
    » *Core Curriculum Rehabilitation Nursing, 2000*

Outline

- Brain structures
- Cranial nerves
- Cerebral circulation
- Questions
Meninges

• Covers both the brain and spinal cord

• The layers from the outermost layer inward are called:
  – dura mater
    • lies against the skull and vertebrae
  – arachnoid mater
    • thin delicate, cobweb-like layer
  – pia mater
    • adheres to the brain and spinal cord
    • highly vascularized layer
Spaces

- **Subarachnoid space**
  - Space between pia and arachnoid mater filled with CSF
  - Bleeding in this space - SAH (subarachnoid hemorrhage)
- **Subdural space**
  - Space between arachnoid and dura mater
  - Subdural hematoma
- **Epidural space**
  - Space between dura mater and the bone
  - Epidural hematoma

CSF and Ventricles

- **Cerebral Spinal Fluid (CSF)**
  - Function
    - Cushions and protects the CNS
    - Carries nutrients to the CNS and removes wastes
  - Formed within the ventricles
  - CSF flows through the various channels
  - Exits from within the brain then circulates in the subarachnoid space
  - Re-absorbed into the venous system
CSF and ventricles

- **Ventricles**
  - Cavities within the brain filled with CSF
  - Two lateral ventricles located in each of the hemisphere
  - Third ventricle lies between the thalamus on either side
  - Fourth ventricle located in brain stem
  - Channel continues within the CNS and becomes the central canal of the spinal cord
Neurons

- Neuron ⇒ basic functional unit in the CNS. These cells are specialized to:
  - receive
  - conduct
  - and transmit electrochemical signals
- Neuron consists of:
  - Cell body
  - Dendrites
  - Axon

Types of neurons

- **Unipolar or pseudopolar neuron**
  - found in the sensory ganglia of peripheral nerves
- **Bipolar neuron**
  - Found primarily in visual, auditory and olfactory systems
- **Multipolar neuron**
  - Found throughout CNS and peripheral nervous system
Brain structures

- Cerebral hemispheres
  - Frontal
  - Parietal
  - Temporal
  - Occipital
- Limbic system
- Basal Ganglia
- Diencephalon
  - thalamus
  - hypothalamus
- Brainstem
  - Midbrain
  - Pons
  - Medulla
- Cerebellum

Cerebral hemispheres

- Divided into two halves
- Connected by nerve fibers called **corpus callosum**
- Covered with bumps (gyri) and grooves (small groove- sulci, large grooves – fissures)
- Composed of **white matter** (deep inside the brain) and **gray matter** (cell bodies located on the outer portion of the brain)
Hemisphere dominance

- Usually one hemisphere is dominant
- Dominant hemisphere responsible for speech
- 90% of population have highly developed left hemisphere (right handed individuals)
Cerebral cortex
Frontal lobe

- Prefrontal region
  - Concentration, abstract thought, memory, judgment, ethics, insight, emotion, tact and inhibition
  - sequences thoughts appropriately, evaluate consequences of actions and solves complicated intellectual function
  - guides behavior
- Motor cortex
  - Control voluntary motor function (contralateral)
- Broca’s area
  - Expression of speech: word formation, memory of motor patterns
  - Articulation, pronunciation, voice and speech production

Motor representation – motor homunculus
Injury to the frontal lobe can result in...

- Difficulty with executive functions
- Personality changes
- Difficulty initiating voluntary movements
- Broca’s aphasia
- Impaired judgment

Cerebral cortex
Parietal lobe

- Integration of different sensory input (i.e. two point discrimination, pressure, weight, texture, pain)
- Ability to sense the position, location, orientation and movement of the body and its parts (proprioception)
- Manipulation of objects
- Visual attention
- **Sensory cortex** – arranged in the same type of topographical scheme as the motor strip (contralateral)
Injury to the parietal lobe can result in:

- Difficulty with left/right discrimination
- Spatial perceptual deficits
- Denial of deficits
- Loss of sensation
- Apraxia
Cerebral cortex
Temporal lobe

- Receives, discriminates and interprets sounds
- Integration of visual, auditory, somatic information
- **Wernicke’s area** – receptive language
- Memory (storage, retrieval of words, experiences)
- Emotions

**Injury to the temporal lobe can result in...**

- Loss of smell/taste
- Hearing deficits
- Memory deficits
- Wernicke’s aphasia
- Hallucinations
Cerebral cortex
Occipital lobe

- receives impulses from the retina, transmits them to cranial nerve II and then sends them to the brainstem for further interpretation

- provides complex visual interpretation and perception of form and meaning

Injury to the occipital lobe can result in...

- Visual disturbances
- Visual deficits
- Visual agnosia
Limbic system

- Major structures of the limbic system:
  - Amygdala
  - Hippocampus
  - Cingulate cortex
  - Fornix
  - Septum
  - Mammillary bodies
- Appears to be involved in basic drives such as hunger, thirst, sex and temperature regulation
- Appears to affect motivation, attention and biological rhythm

Basal ganglia

- Includes:
  - Amygdala
  - Caudate
  - Putamen
  - Globus pallidus
- Function:
  - helps to adjust posture,
  - allow steady voluntary movements
  - and suppress meaningless and unintentional movements
Diencephalon

- Divided into four regions:
  - Thalamus
  - Hypothalamus
  - Subthalamus
  - Epithalamus

Diencephalon

Thalamus

- Plays a role in:
  - the conscious awareness of pain
  - the focusing of attention
  - the reticular activating system
  - the limbic system
**Diencephalon**  
**Hypothalamus**

- Located below thalamus
- Master controller of parasympathetic and sympathetic activities
- Responsible for the control of homeostatic mechanisms, including water balance, temperature regulation and food intake
- Plays a role in producing two hormones:  
  1) antidiuretic hormone (ADH) 2) oxytocin

**Brain Stem**
Brain stem
Midbrain

- Composed of two structures:
  1) Substantia nigra – motor nuclei concerned with muscle tone (area impaired with patients with Parkinson’s disease)
  2) Red nucleus – large motor nuclei associated with flexor rigidity

Brain stem
Pons

- Located between midbrain and the medulla
- Two areas that control breathing
  - Apneustic center
  - Pneumotaxic center
- Injury to the pons usually involves abnormal breathing patterns
- Two reflexes tested in comatose patients
  - Oculocephalic reflex (doll’s eyes)
  - Oculovestibular reflex (calorics)
- Pontine lesions produce a locked-in syndrome
Brain stem
Medulla

- Consists mainly of white matter
- Respiratory center – inspiratory dominant
- Produces rhythmic breathing
- Involves chemoreceptors sensitive to CO₂ levels
- Controls temperature, regulates hunger, thirst and sleep-wake patterns
- Houses the vasodilatation and vasopressor centers
- Originates the swallowing and vomiting centers

Reticular formation

- Located in brain stem
- A complex network of nuclei and short interconnecting tracts
- Receives sensory input from all sensory organs and acts as a relay station
- Plays a role in controlling many vital body functions and in the promotion of *arousal*, *attention* and *sleep*
Cerebellum

• Functions:
  – Coordination of the action of muscle groups
  – Control of fine movement
  – Control of coordination of movement
  – Control of balance
  – Maintenance of feedback loops to correct movement

Injury to the cerebellum can result in…

  – Hypotonia
  – Ataxia
  – Nystagmus
**Question 1**
Clients may understand the speech of others, but not be able to speak effectively, with injury to which of the following areas?

A) Broca’s area  
B) Brainstem  
C) Cerebellum  
D) All of the above

**Cranial Nerves (CN)**

- 12 pairs, numbered in roman numerals  
- Number based on the descending order in which the CN and their nuclei attach to the CNS  
- Three sensory CNs (I, II, VIII)  
- Five motor CNs (III, IV, VI, XI, XII)  
- Four CNs with mix function (V, VII, IX and X)
<table>
<thead>
<tr>
<th>Cranial nerve</th>
<th>Function</th>
<th>Sensory/motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN I: Olfactory</td>
<td>smell</td>
<td>sensory</td>
</tr>
<tr>
<td>CN II: Optic</td>
<td>vision</td>
<td>sensory</td>
</tr>
<tr>
<td>CN III: Oculomotor</td>
<td>eye movement (e.g. elevating eyelids, moving eyes in and out, constricting pupil, accommodating for light)</td>
<td>motor, parasympathetic</td>
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<tr>
<td>CN IV: Trochlear</td>
<td>eye movement down and outward</td>
<td>motor</td>
</tr>
<tr>
<td>CN V: Trigeminal</td>
<td>chewing, sensations of face, scalp, and teeth</td>
<td>sensory, motor</td>
</tr>
<tr>
<td>CN VI: Abducens</td>
<td>outward eye movement</td>
<td>motor</td>
</tr>
<tr>
<td>CN VII: Facial</td>
<td>facial expression, taste anterior 2/3 of tongue, salivation, crying</td>
<td>Sensory, motor, parasympathetic</td>
</tr>
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<td>CN VIII: Accoustic</td>
<td>hearing and sense of balance</td>
<td>sensory</td>
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<tr>
<td>CN IX: Glossopharyngeal</td>
<td>secretes saliva, swallowing, controls gag reflex, sensation in the throat and taste</td>
<td>Sensory, motor, parasympathetic</td>
</tr>
<tr>
<td>CN X: Vagus</td>
<td>swallowing, voice production, heart rate, rate of peristalsis, sensation of throat, thoracic, and abdominal viscera</td>
<td>Sensory, motor, parasympathetic</td>
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<td>CN XI: Spinal accessory</td>
<td>shoulder and head movement</td>
<td>Motor</td>
</tr>
<tr>
<td>CN XII: Hypoglossal</td>
<td>tongue movement</td>
<td>Motor</td>
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</table>
Cranial nerves

• Mnemonic tip for remembering the cranial nerves: On Old Olympus’ Towering Top, A Finn And German Viewed Some Hops

Question 2
Which of the following statement is false regarding cranial nerve dysfunction:

a) individual with dysfunction of CN XI will be unable to shrug shoulders or turn head to one side
b) individual with dysfunction of CN V will have decreased facial mouth, and teeth sensation, impaired ability to chew, facial dysesthesias, decreased or absent corneal reflex
c) damage to CN XII will result in dysarthria, dysphagia, cardiac instability and respiratory difficulty
d) damage to CN II will affect sense of vision and peripheral vision
Question 3

Which of the following is false regarding the cranial nerves:

a) the Oculomotor (III), Trochlear (IV) and Abducens (VI) CN function together to control eye movements

b) the Glossopharyngeal (IX) and Vagus (X) CNs control swallowing, the gag reflex, articulation and phonation

c) the Facial (VII) CN can be assessed by asking client to wrinkle her forehead, smile showing her teeth, and wink her eyes

d) the Trigeminal (V) CN controls the trapezius and sternocleidomastoid muscles

Cerebrovascular circulation

• Originating from internal carotid arteries:
  – Anterior cerebral artery
  – Middle cerebral artery

• Originating from vertebral/basilar arteries:
  – Posterior cerebral artery

• Communication arteries:
  – Posterior – connects posterior cerebral and middle cerebral arteries
  – Anterior – connects the two anterior cerebral arteries
Cerebrovascular Circulation

Blood Supply to the Brain
Many arteries and their branches carry blood to the brain. Each artery supplies specific areas of the brain, but some brain areas are supplied by more than one artery.

Cerebrovascular circulation

- Anterior Cerebral Artery
- Middle Cerebral Artery
- Posterior Cerebral Artery
Cerebral Circulation – Circle of Willis

• Formed by the two internal carotid arteries and the two vertebral arteries

• Composed of:
  – Anterior cerebral
  – Posterior cerebral
  – Anterior communicating
  – Posterior communication
  – Internal carotid
Circle of Willis

- Located at the base of the skull in the subarachnoid space
  - Site of many congenital aneurysms
  - If an aneurysm bursts or vessels are sheared or torn, a SAH occurs

MIDDLE CEREBRAL ARTERY STROKE
Case study
Mr. T.

• Male, 62 years
• Suffered Lt MCA infarct (witnessed)
• Risk factor – hyperlipidemia
• Received t-PA
• Functional level: global aphasia, flaccid right arm, dependent with all ADL activities, right neglect, dysphagia

Question 4
True or false

• A patient with a middle cerebral artery occlusion could present with the following clinical symptoms:
  a) contralateral motor or sensory loss
  b) contralateral motor loss in lower face
  c) arm involved more than leg
  d) homonymous hemianopia
  e) possible communication deficit (left hemisphere)
  f) Possible spatial perceptual deficit (right hemisphere)
Question 5
Ms X. has experienced a thrombotic stroke involving the left posterior cerebral artery. Which symptoms would you expect Ms. X to exhibit as a result of an occipital lobe infarct?

a) Broca’s aphasia
b) disorders of abstract thought
c) visual association deficits
d) disorders of memory and judgment

Web site

Neuroscience for kids:
http://faculty.washington.edu/chudler/neurok.html
Answers

• Question 1 ➔ d. all of the above
• Question 2 ➔ c.
• Question 3 ➔ d.
• Question 4 ➔ true
• Question 5 ➔ c.

References

• Crimlisk, J., Grande, M., Neurologic Assessment Skills for the Acute Medical Surgical Nurse, Orthopaedic Nursing, January/February 2004, Vol 23, Number 1, p. 3-9
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Resources