NMNEC Concept: **Intracranial Regulation**

Mega Concept: Health and Illness

Category: Homeostasis and Regulation

Concept Name: Intracranial Regulation

Concept Definition:
Factors that impact intracranial function and conditions leading to impairment

Scope and Categories:

- **Scope:** When functioning optimally, intracranial regulation (ICR) allows individuals to function normally. If there is any disruption in regulation, dysfunction can range from minimal to severe.
- **Categories:** The causes of ICR dysfunction can be categorized into problems with:
  - To receive adequate oxygen and nutrients, the brain must have consistent perfusion. Impaired perfusion may be caused by blockage (cerebrovascular accident [CVA]), hypotension, damage (trauma) or increased intracranial pressure.
  - Normal neurotransmission is dependent on fully functioning neurons, nerves and neurotransmitters.
  - Pathological processes such as brain tumors, degenerative disease (dementia, Parkinson's) and inflammatory conditions (meningitis) can also cause intracranial dysfunction. (Smith, 2017)

Risk Factors: Because ICR problems encompass so many conditions, all individuals are potentially at risk.

Populations at Risk:

- Older adults related to degenerative pathology
- Young adults and adolescents related to injury

Individual risk factors: Anything that potentially affects cerebral function such as head trauma, infection, perfusion, hypoglycemia, etc. puts an individual at risk. Some individuals are at higher risk:

- The elderly and very young are at higher risk for falls which could result in a brain injury.

- There are also individual risk factors related to the specific type of ICR dysfunction, such as:
    - CVA
    - Age
    - Hypertension (HTN)
    - Diabetes
    - Tobacco usage

Physiological Processes to protect and preserve ICR:

- Cranial skull acts as a rigid, noncompliant protective covering.
- Blood-brain barrier is a tight layer of endothelial cells between the arterial and venous network of the brain which make it difficult for neurotoxic substances to pass into the brain.
- Meninges are three layers of protective membranes that surround the brain and spinal cord (dura mater, arachnoid layer, pia mater).
- Since the brain cannot store glucose, a constant supply is required. The cerebral cortex, hippocampus and cerebellum are particularly sensitive to hypoglycemia.
- Autoregulation adjusts regional cerebral flow in response to the brain's metabolic demands by changing the diameter of cerebral blood vessels.
- The Monro-Kelly Hypothesis is that the skull creates a closed system that contains brain, cerebral spinal fluid, and blood. If any one of these components increase in volume, there must be a decrease in volume of the other components or the intracerebral pressure will increase.
- Cerebral spinal fluid circulates within the subarachnoid space, acting as a cushion and support, in addition to providing nutrients.
- Carbon dioxide is a potent vasodilator. Hyperventilation is a compensatory mechanism that causes vasoconstriction, which reduces cerebral blood volume and intracranial pressure.
- Brain tumors can occur in any part of the brain and are commonly a result of metastasis from another primary site outside the brain.

(Lewis, Heitkemper, Harding, Kwong, and Roberts, 2017)

Physiologic Consequences of impaired ICR:

- Cerebral edema is a symptom common to many ICR conditions. The resulting increased brain size negatively affects perfusion and oxygenation. It may be caused by lesions, injury, surgery, infection, vascular insult, or toxic/metabolic conditions.

- Increased intracranial pressure can also affect perfusion, resulting in dysfunction. Pathologic consequences may occur at sustained pressures >20 mm Hg.

Assessment:

Subjective:

A thorough history should be collected from the patient, or family member. Particularly with ICR dysfunction, the patient presentation is crucial to developing an appropriate plan of care. Depending on the injury or disorder, include:

- Baseline and alterations in functioning
- Symptom analysis

Depending on the presentation information should be solicited related to level of consciousness, neuromuscular function, motor and sensory deficits, recent and remote memory, speech (expressive, receptive), signs and symptoms of increased intracranial pressure

Objective:

Physical assessment may reveal abnormalities in some or all of the body systems. Listed are some of the common areas affected and tools used during the examination:

- Mental status: general description, emotional state, experiences, thinking, sensorium and cognition. If it is not necessary to do a complete mental status exam, the Mini-Mental Status Exam (MMSE) is an option.
- Motor and cognitive function
- Glasgow Coma Scale
- Cranial nerves may be assessed “grossly” or thoroughly depending on the dysfunction and the educational level and training of the nurse.
- Intracranial pressure (ICP) may be assessed directly if an ICP monitoring device is available, or indirectly through the signs and symptoms
- Cerebral Perfusion Pressure (CPP) is a calculation used in the intensive care unit (ICU) environment to give specific information about cerebral perfusion
- Cushing’s Triad: may indicate impending brain herniation
    - Widening pulse pressure
    - Hypertension
    - Irregular respiratory pattern
    - Bradycardia

- The National Institutes of Health Stroke Scale (National Institutes of Health, 2019) is commonly completed by nurses.

Diagnostic Tests:

- Neuroimaging studies can detect the origin and extent of neurologic injury [computed tomography (CT), magnetic resonance imaging [MRI], magnetic resonance angiography (MRA), positron emission tomography (PET)].
- Skull radiograph detects fractures, bone erosion, calcification, and/or abnormal vasculature.
- Electroencephalogram (EEG) measures and records the brain's electrical activity through multiple electrodes placed on the scalp. Video EEG monitoring includes the ability to simultaneously record a patient's movement and activity. A "normal" EEG can help to identify psychogenic nonepileptic seizures (emotional or stress related in origin).
- Brain biopsy will determine the type and stage of tumors.
- Lumbar puncture allows the analysis of the cerebrospinal fluid (CSF), which may be indicated when there is a suspected infection.
- Doppler studies may be done to assess blood flow.

(Lewis, Heitkemper, Harding, Kwong, and Roberts, 2017)

Clinical Management:

Primary Prevention: Strategies are intended to maintain optimal health and prevent injury or disease. Leading a healthy lifestyle can decrease the risk of vascular disease. Injury prevention programs can reduce the risk of traumatic brain injury. Examples may include:

- Tobacco use cessation
- Diet
- Exercise
- Blood pressure control
- Seat belt and helmet use
- Violence prevention programs
- Decreasing alcohol consumption to decrease injury potential, especially in the elderly

Secondary Prevention:

- No true screening tests are available specifically related to ICR dysfunction

Tertiary Prevention/Collaborative Care: Treatment

- Pharmacotherapy
  - Osmotic diuretics draw water across the blood brain barrier, leading to a decreased interstitial volume and a decrease in ICP.
  - Sedatives can decrease ICP by reducing metabolic demand.
  - Analgesics relieve pain, which in turn will decrease oxygen demand.
  - Anti-epileptics manage seizures which can increase metabolic demand.
  - Glucocorticoids may be indicated in some conditions (cerebral edema related to tumors), but contraindicated in others (moderate to severe head injury).
  - Antipyretics decrease metabolic demand.
  - Anti-hypertensives may be detrimental (acute ischemic stroke) or beneficial (hemorrhagic stroke) depending on the condition.
  - Antiparkinsonian medications attempt to restore the balance of dopamine.
  - Cholinesterase inhibitors improve cortical function in patients with mild to moderate dementia.
- Surgery: Craniotomy, craniectomy, shunt, stereotactic procedures
- Rehabilitation to return the individual to optimal functioning requires a multi-disciplinary effort that may include physical, occupational and/or speech therapy working closely with medical and nursing professionals.
- Nutrition management may require the expertise of Dieticians and Nurses.

Nursing Management:

The primary focus of nursing management in caring for an individual with an ICR disorder is to prevent secondary injury and restore optimal intracranial functioning. Some general principles of care include:

- Ongoing assessment is essential to notice changes in condition and initiate early interventions.
- Interventions to lower ICP: positioning, activity management, airway management, hyperventilation and bowel management
- Patient education should focus on health promotion.

Interrelated Concepts:

- Cognition: Cognitive functioning may be impaired temporarily or permanently. The degree of impairment is dependent on the number of neuronal cells affected.

- Perfusion: Intracranial functioning is dependent on consistent, adequate perfusion to deliver essential oxygen and nutrients to the brain.
- Gas exchange: Essential to provide optimal oxygenation.
- Mobility: Impairment accompanies many ICR disorders such as CVA, Parkinson's, brain tumors, and head injuries.
- Other concepts that may be related, depending on the ICR disorder include:
  - Clotting: Issues may lead to a CVA.
  - Behavio**r:** Interpersonal violence and risk taking behavior may cause a brain injury.

Model Case:

Norma James* is a 65 year old widow who lives alone. She has a long history of Type 2 Diabetes and Hypertension. She has smoked ½ pack cigarettes a day since she was in her 20's. She was recently diagnosed with atrial fibrillation and prescribed warfarin. One morning she woke up "not feeling quite right". Her right arm felt tingly and somewhat numb. She went back to bed, thinking she was just tired. Two hours later her right arm and leg "felt heavy" and she had difficulty walking and speaking. She finally went to the hospital 2 hours later. A CT scan confirmed an ischemic stroke.

Norma is a good example of someone with ICR dysfunction. A clot from her atria lodged in a cerebral artery depriving the brain of oxygen and nutrients (perfusion and clotting). Though the injury was in the brain she has systemic manifestations (cognition, mobility). She had both modifiable (tobacco use, diabetes, hypertension) and non-modifiable (age) risk factors. Primary prevention could have potentially changed her outcome. She will require many of the Collaborative Care interventions during her recovery.

* Neighborhood (NBH) character © University of New Mexico College of Nursing

Exemplars:

New Mexico Nursing Education Consortium (NMNEC) Required Exemplars:

Traumatic Brain Injury (TBI)

- TBI is the leading cause of death and disability in children and adults ages 1 to 44. Populations that are most affected are youth and elderly who have falls. Each year about 2 million individuals have TBIs of which approximately 50,000 result in death, and over 80,000 suffer permanent disability (Brain Trauma Foundation, 2019).
  - TBI illustrates the ICR Category of Perfusion.

Seizures

- Epilepsy affects about 2 million people in the United States and accounts for $15.5 billion in direct costs (medical) and indirect costs (lost or reduced earnings and productivity) each year. More than one-third of people with epilepsy continue to have seizures despite treatment. Children younger than age 2 and adults older than age 65 are particularly vulnerable because the risk factors for epilepsy are more common in these age groups. About 10% of Americans will experience a seizure sometime during their lives. About 3% will receive a diagnosis of epilepsy by age 80 (Epilepsy Foundation, 2019).
    - Epilepsy illustrates the ICR category of Neurotransmission

Cerebrovascular Accident (CVA)

- Stroke is the third leading cause of death in the United States. More than 140,000 people die each year from stroke in the United States. Stroke is the leading cause of serious, long-term disability in the United States. Each year, approximately 795,000 people suffer a stroke. Nearly ¾ of all strokes occur in people over the age of 65. The risk of having a stroke more than doubles each decade after the age of 55. Stroke death rates are higher for African-Americans than for whites, even at younger ages (American Heart Association, 2019).
    - CVA illustrates the ICR category of the concept of Perfusion.

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