

Guide to the Care of the Patient with Craniotomy Post–Brain Tumor Resection

AANN Reference Series for Clinical Practice



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Preface

To meet its members' needs for educational tools, the American Association of Neuroscience Nurses (AANN) has created a series of guides to patient care called the AANN Reference Series for Clinical Practice. Each guide has been developed based on current literature and built upon evidence-based practice. The purpose of this guide is to assist registered nurses, patient care units, and institutions with providing safe and effective care to patients with craniotomy after brain tumor resection.

Neuroscience nursing care of the patient with craniotomy post-brain tumor resection is inherently complex. This complexity arises from the meticulous monitoring and multidimensional clinical decision making required to provide optimal care. Currently there are limited nursing references dedicated solely to the care of a patient with a brain tumor after craniotomy. This reference material was derived from a combination of evidence-based research studies, review articles, nursing textbooks, and medical textbooks. The information has been combined for the nurse at the bedside or in the office as a guide or reference to provide optimal patient care and improve patient outcomes. This guide is not intended to replace formal learning, but rather to augment the knowledge base of clinicians and provide a readily available reference tool.

Neuroscience nursing and AANN are indebted to the volunteers who have devoted their time and expertise to this valuable resource, created for those who are committed to neuroscience patient care.

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Statement of the Problem

Primary brain tumors compose a heterogeneous group of neoplasms that vary widely by site of origin, morphologic features, growth potential, extent of potential invasiveness and tendency for progression, and recurrence and treatment response. In some cases, craniotomy with maximal surgical excision of a brain tumor provides the best treatment for prolonging survival and improving neurological status of patients with brain tumors (Sawaya, 1998). In the case of some benign brain tumors, surgery may be curative. Although craniotomy for surgical resection of a brain tumor may not be curative in other cases, it does offer more accurate diagnosis than needle biopsy, improvement in symptoms with decreased intracranial pressure (ICP), and theoretically an increased response to other treatments such as chemotherapy and radiation.

Caring for a patient with a craniotomy post brain tumor resection requires a multidisciplinary approach with the bedside nurse playing a vital role. Postoperative complications can often lead to permanent neurologic injury if gone unrecognized. Prompt recognition of postoperative neurologic decline by the bedside nurse and timely diagnosis and intervention by the multidisciplinary team improves patient outcome and subsequent quality of life.

I. Characteristics of Primary Brain Tumors

A. Benign brain tumor

1. Slow-growing cells
2. Distinct borders
3. Rarely spreads to other parts of brain or spine
4. May be considered life threatening secondary to vital location in the brain
5. Often requires only craniotomy for tumor resection

B. Malignant brain tumor

1. Rapidly growing cells
2. Invasive of surrounding tissues
3. Tends to spread to other locations of brain and spinal cord but rarely outside the central nervous system (CNS)
4. Life threatening
5. Often requires multiple modality treatments with craniotomy for tumor resection as well as chemotherapy, radiation, and other treatments

II. Etiology of primary brain tumors

A. Definite cause unknown (at this time)

B. Current research to identify causal factors

1. Genetic factors
2. Hereditary factors
3. Environmental factors
 - a. Physical agents such as low-frequency electromagnetic fields and ionizing radiation

- b. Chemical agents such as regular exposure to acrylonitrile, vinyl chloride, formaldehyde, and pesticides
- c. Biological agents such as exposure to viruses

III. Incidence of primary brain tumors

A. Incidence rate of all primary benign and malignant brain tumors, 14.0 cases per 100,000 person-years

- 1. Benign tumors, 5.7 per 100,000 person-years
- 2. Malignant tumors, 7.7 per 100,000 person-years

B. Incidence rate by sex

- 1. Men, 14.2 per 100,000 person-years
- 2. Women, 13.9 per 100,000 person-years

C. Median age at diagnosis, 57 years

IV. Prevalence of primary brain tumors

- A. All primary brain tumors, 130.8 per 100,000 persons
- B. Primary benign brain tumors, 97.5 per 100,000 persons
- C. Primary malignant tumors, 29.5 per 100,000 persons

V. Survival

A. Five-year relative survival rate following diagnosis of a primary malignant brain tumor excluding lymphoma

- 1. Men, 32.7%
- 2. Women, 31.6%

B. Five-year relative survival rate following diagnosis of a primary malignant brain tumor by age of diagnosis

- 1. 0–19 years, 63.1%
- 2. 20–44 years, 50.4%
- 3. 45–64 years, 14.2%
- 4. 65 years or older, 4.9%

VI. Anatomical Location

A. Supratentorial

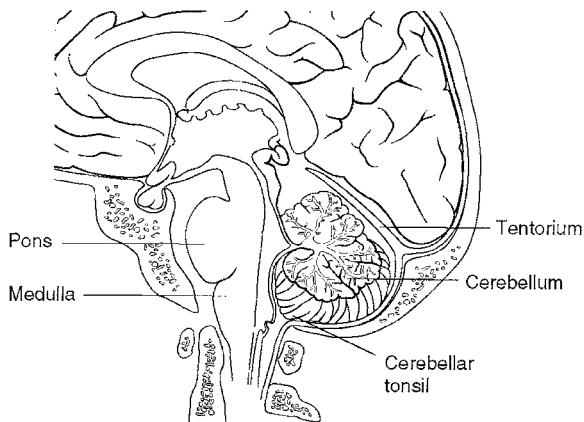
- 1. Tumor above the tentorium—a double fold of dura matter that forms a partition between the cerebral hemispheres and the brain stem and cerebellum (**Figure 1**)
- 2. Signs and symptoms
 - a. Secondary to the following conditions
 - (1) Increased ICP from mass effect of tumor, edema, or both
 - (2) Blockage of cerebrospinal fluid (CSF) drainage
 - b. Focal deficits including weakness, dysphasia
 - c. Headache
 - d. Seizures
 - e. Mental status changes

- f. Symptoms suggestive of transient ischemic attack (TIA)
- g. Special cases of pituitary tumors
 - (1) Endocrine hyper- or hypofunction
 - (2) Visual field loss due to compression of optic chiasm
 - (3) CSF leak
 - (4) Rarely, pituitary apoplexy (hemorrhage)

B. Infratentorial

- 1. Tumor below the tentorium cerebelli—includes the brain stem and cerebellum
- 2. Signs and symptoms
 - a. Increased ICP due to hydrocephalus
 - (1) Headache
 - (2) Nausea and vomiting
 - (3) Papilledema
 - (4) Gait disturbances
 - (5) Vertigo
 - (6) Diplopia
 - b. Mass effect
 - (1) Ataxia
 - (2) Dysmetria
 - (3) Intention tremor
 - (4) Cranial nerve abnormalities

Figure 1. The tentorium is a double fold of dura mater that forms a partition between the cerebral hemispheres and the brain stem and cerebellum. Surgery may be classified by anatomical location. The supratentorial approach is used to gain access to lesions of the frontal, parietal, temporal, and occipital lobes. The infratentorial approach is used to gain access to lesions of the brain stem or cerebellum.



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VII. Distribution of All Primary Brain and CNS Tumors

- A. Brain, cranial nerves, and spinal cord (excluding ventricle and cerebellum), 63.3%
- B. Meninges, 22.3%
- C. Ventricle, 1.4%
- D. Cerebellum, 4.1%
- E. Pituitary, 7.6%
- F. Pineal, 0.5%
- G. Nasal cavity, 0.2%
- H. Other CNS, 0.6%

VIII. Classification of Primary Brain Tumors

- A. Tumors of neuroepithelial tissue (i.e., astrocytic tumors, oligodendroglial tumors, ependymal tumors, glioblastoma multiforme tumor)
- B. Tumors of the meninges (i.e., meningioma)
- C. Tumors of cranial and spinal nerves (i.e., schwannoma, neurofibroma)
- D. Hematopoietic neoplasms (i.e., malignant lymphoma)
- E. Germ cell tumors (i.e., teratoma)
- F. Cysts and tumors such as lesions (i.e., Rathke cleft cyst, epidermoid cyst)
- H. Tumors of the sellar region (i.e., pituitary adenoma)
- I. Local extensions from regional tumors (i.e., paraganglioma, chordoma)
- J. Metastatic tumors

Treatment for Primary Brain Tumors

Craniotomy with maximal surgical excision of a brain tumor provides the best treatment for prolonging survival and improving neurological status of patients with brain tumors (Sawaya, 1998). The primary goal of craniotomy in the case of malignant brain tumors is diagnosis, reduction of mass effect, and theoretically improved response to adjuvant therapy. Total removal of the tumor via craniotomy, however, may significantly affect the patient's morbidity and mortality based on the location of the tumor and the patient's medical condition. Therefore, patients may require alternative treatments for brain tumors. The advantages and disadvantages of alternative treatment options are discussed below. Not all treatment options are available at all institutions.

I. Biopsy

Biopsy of the tumor tissue is performed to provide a definitive diagnosis. Tissue is obtained by stereotactic biopsy or open craniotomy. Tumor histology guides the treatment plan for the patient.

II. Stereotactic Biopsy

This is a closed procedure that allows the neurosurgeon to navigate a biopsy needle to the precise location of the lesion with minimal disruption to normal brain tissue (**Figure 2**).

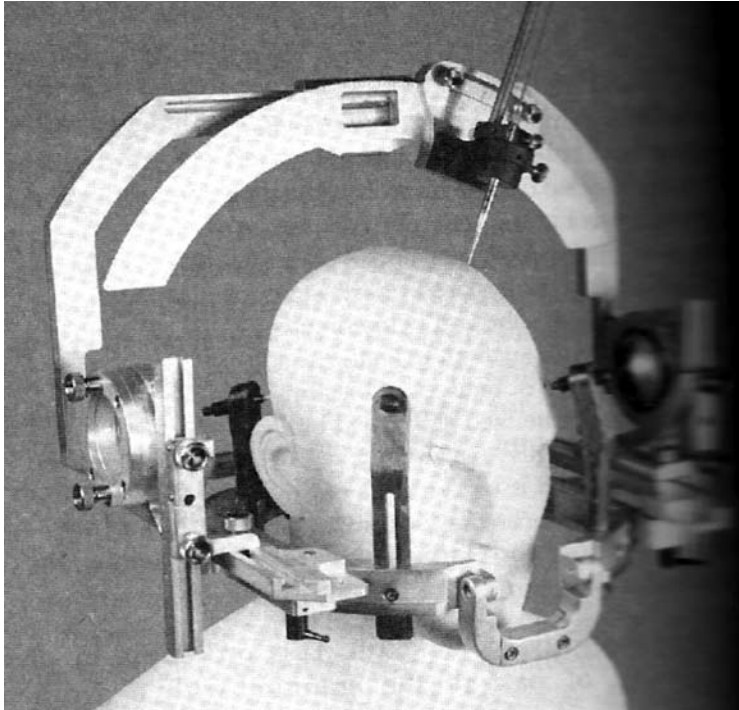
A. Advantages

1. Provides access to deep-seated tumors and tumors in eloquent areas that are surgically inaccessible with significant neurologic risk
2. Creates smaller incision
3. Can be performed under local anesthesia and conscious sedation, which provides a safer option for patients who have a contraindication to general anesthesia
4. Involves decreased operative time
5. Requires shorter hospital stay
6. Allows precise placement of burr hole
7. Yields accurate diagnosis in $\geq 95\%$ of cases
8. Serves as a more cost-effective option compared with open craniotomy

B. Disadvantages

1. Does not provide the direct visualization of an open procedure
2. Can not address lesions causing mass effect, which must be addressed with craniotomy
3. May cause bleeding from vascular tumors (i.e., metastatic renal cell carcinoma, choriocarcinoma, and metastatic melanoma), which can be catastrophic
4. Only provides tumor pathology of small samples, which may not be representative of large tumor

Figure 2. CRWTM stereotactic system used in the biopsy of tumors



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III. Craniotomy

A. Surgical procedure—opening of the bones of the skull in order to access a tumor for resection

B. Shape of incision (determined by lesion size, lesion site, or both)

1. Straight
2. Curved
3. Coronal—ear to ear
4. Pterional—slightly curved in front of the ear
5. Question mark
6. Horseshoe shaped

C. Advantages

1. Provides direct visualization of brain tissue and tumor borders
2. Enables total tumor removal, if possible
3. Creates opportunity to obtain tumor tissue for pathology and definitive diagnosis
4. Decompresses intracranial contents, reduces ICP

5. Requires only local anesthesia and permits monitoring of conscious sedation for tumors involving the eloquent cortex
6. Allows placement of local therapies (i.e., gliadel wafers, other chemotherapy, brachytherapy)
7. Relieves symptoms
8. Improves neurological status and quality of life

D. Disadvantages

1. Involves inherent risks due to the invasive nature of the procedure
2. May result in increased swelling due to trauma from surgery
3. Usually requires intensive care unit (ICU) stay
4. Results in higher total hospitalization costs compared with stereotactic surgery

IV. Other Surgical Options

A. Awake craniotomies with brain mapping

1. Procedure is useful when the tumor involves the eloquent cortex (motor strip, sensory areas, and speech).
2. Medical team can interact with the patient during surgery and monitor for complications.

B. Functional magnetic resonance imaging (fMRI)

1. This allows for noninvasive brain mapping by using an fMRI scanner.
2. Patient is asked to perform repetitive tasks such as reading a list of words, finger tapping, or thinking of certain types of objects.
3. The areas that control these functions within the brain show increased activity, which can be translated into an image that shows the anatomical area of interest.
4. The fMRI scan is then combined with a conventional MRI scan in which a contrast medium is given that outlines the tumor.
5. The combination of these scans is transferred to a surgical computer that guides the neurosurgeon on the appropriate navigational path to preserve these areas.

C. Neuroendoscopy

1. Surgery is performed by making one or more incisions (or small burr holes) and using an endoscope to visualize the tumor.
2. This is applicable only to tumors within the ventricular system.
3. It is a minimally invasive surgery due to small burr holes and potentially less traumatic to normal tissue.
4. Surgeon has increased ability to perform microsurgical procedures.
5. MRI is performed after surgery to assess the extent of tumor removal and to assist with the planning of further treatments.

D. Stereotactic surgery

1. Similar to stereotactic biopsy; however, instead of obtaining a sample of the tumor, the goal is to remove as much of the tumor as possible.

2. Surgery utilizes computer equipment and MRI scan to coordinate the location of the tumor and navigational path to remove it.

V. Chemotherapy

- A. Chemotherapy is an important treatment option for many types of brain tumors.
- B. It is used in conjunction with other modalities such as surgery and radiation.
- C. Due to its toxic nature, chemotherapy precautions should be followed at all times.
- D. Its use has been limited in some tumors due to the body's natural defense mechanism called the blood-brain barrier.
 1. Commonly used chemotherapy agents
 - a. Carmustine (BCNU)
 - b. Lomustine (CCNU)
 - c. Procarbazine (PCV)
 - d. Vincristine
 - e. Thiotepa
 - f. Methotrexate
 - g. Temozolomide (Temodar)
 2. Chemotherapy drugs that can cross the blood-brain barrier
 - a. BCNU
 - b. CCNU
 - c. Procarbazine
 - d. Thiotepa
 - e. High dose Methotrexate
 - f. Temozolomide (Temodar)
 3. Common side effects
 - a. Nausea, vomiting, or both
 - b. Hair loss
 - c. Neutropenia
 - d. Fatigue
 - e. Diarrhea
 - f. Weight loss
 - g. Mucositis
 - h. Sterility
 4. Combination therapy (where 2 or more chemotherapy agents are utilized together) also common

VI. Radiation Therapy

- A. Damages cellular DNA
 1. Tumor cells—rapidly dividing nature susceptible to radiation
 2. Normal cells—also affected
- B. Allows for maximum recovery of normal cells (in divided doses)

C. Varies according to tumor location and pathology, which affects type and efficacy

D. Types

1. External beam radiation therapy
 - a. Involves directing a beam of radiation to a tumor
 - b. Affects the tumor, operative cavity, and a 2-cm margin
2. Three-dimensional conformal radiation therapy
 - a. Serves as a focal method of radiation
 - b. Involves shaping multiple beams of radiation to the exact contour of the treatment area
 - c. Sparing most surrounding area from exposure to radiation
3. Intensity modulated radiation therapy (IMRT)
 - a. Allows variations of shape and intensity of radiation to be delivered to different parts of treatment area
 - b. Enables precise treatment of tumor according to thickness
4. Hyperfractionated radiation therapy
 - a. Provided in two fractions per day
 - b. Delivers a higher total dose of radiation per day
 - c. Used in brain stem tumors only generally
 - d. Under investigation in tumors of other locations
5. Gamma-knife therapy and stereotactic radiosurgery therapy
 - a. Do not affect all of the surrounding tissue, unlike conventional radiation therapy that does
 - b. Involve immobilizing a patient's head in a frame
 - c. Provide concentrated radiation to tumors by focusing many ultra low-dose beams from multiple angles onto the tumor bed
 - d. Vary from single dose to fractionated doses based on the tumor and its location
 - e. Vary according to tumor location and pathology, which affects therapy type and efficacy
 - f. Treat small areas of residual tumor or recurring tumors
6. Brachytherapy
 - a. Places radioactive isotopes in close contact with the tumor or directly in the tumor bed after tumor resection
 - b. Provides precise doses of radiation to the treatment area

F. Possible side effects

1. Hair loss
2. Fatigue
3. Redness of the skin (similar to sun burn)
4. Headache
5. Swelling
6. Visual and neurological disturbances
7. Hearing loss
8. Facial numbness

VII. Investigational Treatment

A. Monoclonal antibody therapy

B. Gene therapy

C. Immunotherapy

D. Vaccines

E. Radiation sensitizers

F. Combination therapies

Introduce radiation, intracavitary local chemotherapy, or both in combination with systemic chemotherapy.

Craniotomy for Resection of a Brain Tumor

I. Assessment and Monitoring

A. Preoperative

1. Admission
 - a. Admission history and physical provide database for planning care and a baseline examination against which postoperative examinations may be compared.
 - b. Full neurological examination with mental status examination and cranial nerve, motor, sensory, and cerebellar examinations should be performed.
2. Psychosocial aspects to be addressed with the patient and family
 - a. Fears and anxieties of patient and family
 - b. Concerns about disability, loss of independence, changes in personality characteristics, and fear of alterations in physical appearance
3. Obtaining informed consent—institution specific
 - a. Generally it is the physician's responsibility to disclose to the patient and family the purpose of surgery, possibility of alternative treatment, risks, benefits, complications, and expected outcomes.
 - b. Nurse's presence during the informed consent discussion is helpful in clarifying and reinforcing the information provided to the patient and family.
4. Preoperative orders—institution specific
 - a. Isotonic intravenous fluids
 - b. Blood pressure control
 - c. Corticosteroids to decrease risk of peritumoral edema
 - d. Anticonvulsant medications to decrease risk of intraoperative and postoperative seizures
 - e. Prophylactic antibiotics to reduce risk of postoperative infection
 - f. Deep vein thrombosis prophylaxis with sequential compression device (SCDs), pneumatic compression boots (PCBs), or thromboembolic stockings (TEDs)
 - g. Preoperative imaging if necessary (i.e., stereotactic MRI)

B. Intraoperative

1. Neuroanesthesia
 - a. Important consideration is made regarding the effect of anesthetic drugs on cerebral metabolism, cerebral blood flow, ICP, vasomotor tone, hemostasis, and blood pressure.
 - b. Osmotic diuretics may be given for swelling prevention.
2. Hypotension—important in some surgical procedures with increased vascularity
3. Hypothermia
 - a. Hypothermia sometimes is induced to decrease cellular metabolism and the need for oxygen.

- b. For every degree lowered below 37.9 °–25 °C (98.6 °–77.0 °F), there is a 6% reduction in oxygen consumption by the brain.
- 4. Hyperventilation
 - a. Control hyperventilation via a ventilator and maintain during surgery.
 - b. Use to assist in management of cerebral edema.
- 5. Venous air embolus—potential intraoperative complication associated with the sitting operative position
 - a. Negative pressure is produced in the dural venous sinuses and veins draining the brain.
 - b. Air is quickly carried to the right side of the heart.
 - c. Signs and symptoms include the following:
 - (1) hypotension
 - (2) circulatory shock
 - (3) respiratory distress
 - (4) tachycardia
 - (5) cyanosis.
 - d. Treatment possibilities include the following:
 - (1) Identifying possible site of air introduction and occlude that site
 - (2) Placing the patient in the left lateral decubitus position, terminating the surgery, and observing patient for transient neurological deficits, if the entry site cannot be located (Figure 3).

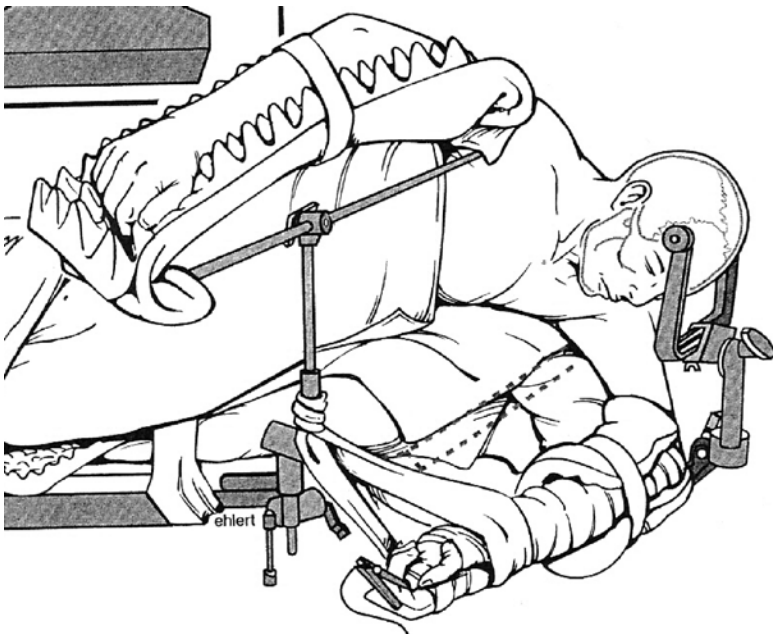
C. Postoperative

- 1. Provide the following care after admission to critical care unit or acute care unit.
 - a. Close observation and monitoring
 - (1) Most complications requiring surgery will occur in the first 6 hours following a craniotomy.
 - (2) Continue for 12–24 hr after procedure.
 - b. Neurological deficit possibilities after surgery
 - (1) Some deficits may be expected due to the region of surgical intervention (i.e., craniotomy for resection of an occipital glioma could result in an expected visual field cut).
 - (2) Ask the neurosurgeon what deficits are expected, identify those deficits and symptoms, and closely monitor the patient.
 - c. Admission assessment—complete vital signs and neurological examination including mental status, cranial nerves, motor, sensory, and cerebellar function.
 - d. Postoperative vital sign and neuro check orders—institution specific
 - (1) Serial assessments (from which nurses can identify changes and complications that may be subtle or rapid)
 - (a) Comparing current findings with baseline findings to determine trends
 - (b) Conducting emergency evaluation and providing treatment if the postoperative neurologic status is worse than the

preoperative neurological status, especially in a patient who deteriorates after initially doing well

- (2) Blood pressure control
 - (3) Corticosteroids to decrease risk of significant peritumoral edema
 - (4) Anticonvulsant medication to reduce risk of seizure activity
 - (5) Laboratory testing
 - (6) DVT prophylaxis
 - (7) GI prophylaxis
2. Include the following overview of the surgery in the RN report from anesthesia regarding intraoperative course.
 - a. Cite the type of craniotomy performed and anatomical approach.
 - b. Document the reason for surgery.
 - c. Record the length of surgery.
 - d. Note complications during surgery.
 - e. List anesthetic agents and any reversal agents.
 - (1) History of preoperative neurological deficits
 - (2) Preexisting medical problems
 - (3) Current baseline neurological signs
 - (4) Information provided to the family
 - (5) Review of the postoperative orders

Figure 3. Example of patient positioning in the operating room for brain tumor resection



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II. Postoperative Complications

A. General postoperative complications

1. Reversal agents for anesthetic complications—as needed if a preoperative level of consciousness is not obtained
 - a. Narcan (for narcotics)
 - b. Flumazenil (for benzodiazepines)
 - c. anticholinesterase agents
 - d. anticholinergic agents
2. Respiratory complications
 - a. Reasons for respiratory difficulty
 - (1) Decreased level of consciousness and inability to protect airway following surgery
 - (2) Development of edema in and around the brain stem, particularly following infratentorial surgery
 - b. Preventative measures
 - (1) Keeping neck in neutral position
 - (2) Maintaining SpO₂ > 94%.
 - (3) Incentive spirometry
 - (4) Obtaining arterial blood gases as needed
 - (5) Withholding oral intake until the presence of the gag and swallowing reflexes are verified, and patient can protect airway
3. Cardiovascular complications
 - a. Hypovolemic shock results from general fluid loss (blood, plasma, or water), especially if osmotic diuretics have been used, and the result is a decreased amount of circulating volume.
 - (1) Common signs and symptoms are tachycardia, decreasing blood pressure, shallow and rapid respirations, cool, pale skin, decreased urinary output (10–25 ml/hr), and restlessness to coma.
 - (2) Treatment is directed toward fluid replacement.
 - (a) Fluid resuscitation is directed toward maintaining normovolemia, adequate cardiac output, and tissue perfusion.
 - (b) Isotonic and hypertonic saline are generally used. Hypotonic saline has been shown in data to increase total brain water and intracranial pressure.
 - b. Blood pressure—usually normotensive state is maintained.
 - (1) Avoid hypertension to reduce the risk of hemorrhage in the surgical bed.
 - (2) Avoid hypotension to reduce the risk of hypoperfusion and ischemia to surrounding edematous brain.
 - c. Cardiac arrhythmias—usually present postoperatively if patient has a history of arrhythmia or may be due to increased sympathetic discharge after surgery.
 - (1) Obtain cardiac enzymes if arrhythmia sustained to rule out myocardial infarction.

- (2) Check electrolytes such as potassium and magnesium.
- (3) Aggressively treat myocardial infarction if present to preserve cardiac function and adequate tissue perfusion.
- 4. Gastrointestinal complications—gastric stress ulceration and hemorrhage
 - a. Some drugs used in neurological treatment contribute to gastric irritation (e.g., Decadron, Phenytoin, and certain antibiotics). Those patients most at risk include brain tumor patients taking a prolonged course of steroids such as Decadron.
 - b. The following are agents used in the prevention of gastric ulceration.
 - (1) Antacids
 - (2) H₂ blockers
 - (3) Sucralfate
 - (4) Proton pump inhibitors
 - c. Patient's hemoglobin, hematocrit, and stools should be monitored for signs and symptoms of GI hemorrhage.
- 5. Endocrine complications (**Table 1**)
 - a. Diabetes insipidus
 - (1) Characteristics
 - (a) Seen almost exclusively with surgery of the pituitary gland area
 - (b) Caused by disturbance of the posterior lobe of the pituitary gland
 - (c) Due to the secretion of an insufficient amount of antidiuretic hormone (ADH)
 - (d) Most cases self-limiting, lasting only 12–36 hours following a neurosurgical procedure
 - (2). Diagnosis
 - (a) Patient complaint of polydipsia
 - (b) Urine output >200 ml/hr x 2 consecutive hr
 - (c) Urine specific gravity <1.005
 - (d) Sodium level >145 mEq/L
 - (e) Serum osmolality >300 mOsm/L
 - (3) Treatment
 - (a) Replace excess urine output with intravenous fluid or encourage oral fluids if not contraindicated to avoid dehydration.
 - (b) Medication
 - i. Desmopressin acetate (DDAVP)
 - ii. Aqueous vasopressin (Pitressin)
 - b. Syndrome of inappropriate antidiuretic hormone (SIADH)
 - (1) Characteristics
 - (a) Abnormally high level or continuous secretion of ADH
 - (b) Water intoxication—caused by continually reabsorbed water from the kidney tubules

- (2) Diagnosis
 - (a) Hallmark symptom—serum sodium <135 mEq/L, usually considered a dilutional hyponatremia
 - (b) Low serum osmolality (usually <275 mOsm/L)
 - (c) High urine sodium (25 mEq/L)
 - (d) High urine osmolality (higher than sodium osmolality)
 - (e) Normal plasma volume
 - (f) Decreased urinary output
 - (g) Generalized weight gain
- (3) Treatment
 - (a) Fluid restriction <1000 ml/24 hr
 - (b) Severe hyponatremia—replace sodium with hypertonic saline
 - i. Frequent monitoring of sodium level
 - ii. Rate of sodium correction, <1.3 mEq/L/hr, secondary to the risk of developing central pontine myelinolysis (CPM)
- c. Cerebral salt wasting
 - (1) Characteristics
 - (a) Renal loss of sodium
 - (b) Caused by renal loss of sodium—hypovolemia, decreased body weight, hyponatremia,
 - (2) Diagnosis
 - (a) Confusion and lethargy and signs of dehydration and seizures
 - (b) Serum sodium <135 mEq/L
 - (c) Serum hyperosmolality may be present >290 mOsm/L
 - (d) Increased BUN >25 mg/dL
 - (e) Increased hematocrit
 - (f) Increased urine sodium
 - (g) Weight loss
 - (3) Treatment
 - (a) Calculating volume replacement therapy with 0.9% sodium chloride to match urine losses
 - (b) Vigorously replacing oral sodium
 - (c) Maintaining a positive sodium balance
 - (d) Supplying infusion of hypertonic saline—must monitor infusion rates to avoid too rapid of a correction of hyponatremia because this may result in CPM
 - (e) Administering fludrocortisone acetate, 0.2 mg/day—intravenous (IV) or by mouth (PO)
 - (f) Increasing sodium reabsorption at the renal tubule—may cause hypertension and hypokalemia
- 6. Infectious complications
 - a. Meningitis
 - (1) Characteristic—inflammation of the protective barrier over the brain and spinal cord, the meninges
 - (2) Three primary causes of meningitis

Table 1. Comparison of signs and treatment of diabetes insipidus, cerebral salt wasting, and syndrome of inappropriate diuretic hormone

	Diabetes Insipidus (DI)	Cerebral Salt Wasting (CSW)	Syndrome of Inappropriate Diuretic Hormone (SIADH)
Signs	Serum NA level >145 mEq/L Serum Osmolality >300m Osmo/L Urine output > 200 cc/hr x 2 consecutive hours Urine specific gravity <1.005	Serum NA <135 mEq/L Serum osmolality WNL or increased >290 mOsm/L High urine sodium Decreased plasma volume Decreased extracellular volume	Serum NA level <135 mEq/L Serum osmolality <280 mOsm/L High urine sodium Increased plasma volume Increased extracellular volume
Treatment	Replace excess urine output Vasopressin or DDAVP	Volume replacement Administration of exogenous sodium (i.e., hypertonic saline)	Fluid restriction Administration of exogenous sodium (i.e., hypertonic saline infusion)

- (a) Bacterial
- (b) Viral
- (c) Fungal organisms
- (d) Other causes—include parasites and cancer
- (3) Signs and symptoms (depending on pathogen)
 - (a) Fever, headache, nuchal rigidity, malaise, and photophobia
 - (b) Cranial nerve palsies (II–VIII), hemiparesis, altered mental status, and seizures
 - (c) A petechial rash that appears on the trunk and lower extremities, mucous membranes, and conjunctiva (indicative of a poor outcome)
- (4) Diagnosis
 - (a) Assessment of medical history that includes recent illness, surgery, insect bites, travel, or close contact with infected persons
 - (b) Laboratory studies
 - i. Comprehensive hematological, chemistry, and coagulation profiles
 - ii. Cultures—blood, sputum, CSF, and rash aspirate
 - (c) Computed tomography (CT) of the head (must *always* precede lumbar puncture [LP])

- (d) LP and CSF studies
 - i. Normal cell counts of <5 cells/ml in CSF versus elevated count in all types of meningitis
 - ii. Elevated protein levels
 - iii. Glucose levels—elevated, viral meningitis; decreased, fungal and bacterial meningitis
 - iv. Gram stain and cultures—determine the causative organism
- (5) Treatment
 - (a) Pathogen-specific broad spectrum of antibiotic therapy, which is based on patient's age and suspected causative organism
 - (b) Corticosteroid therapy
 - (c) Surgical intervention—treats complications, such as drainage of abscesses or insertion of ventricular-peritoneal shunt for communicating hydrocephalus management
- b. Brain abscess
 - (1) Characteristics
 - (a) Pus that may be encapsulated in the brain tissue usually related to an infection in another part of the body
 - (b) Causes
 - (i) Penetrating trauma and neurosurgical procedures, 10%
 - (ii) Other causes—infections of inner ear, mastoid, sinuses, lungs, and acute bacterial endocarditis
 - (iii) Site of origin—main factor in predicting the causative organism
 - (2) Signs and symptoms—usually develop rapidly and may mimic those of a tumor or other lesion within the brain
 - (a) Headache
 - (b) Nausea, vomiting, or both
 - (c) Altered level of consciousness
 - (d) Focal neurological deficits
 - (e) Seizures
 - (3) Diagnosis
 - (a) Assessment of primary infection and causative organism
 - (b) Laboratory studies
 - i. Increased white blood cell count (may be mild)
 - ii. Elevated sedimentation rate
 - (c) LP—performed with caution due to cerebral mass
 - (d) X rays of the chest, sinuses, and skull to assess for other sites of infection
 - (e) CT and or MRI scan (Bader & Littlejohns, 2004)
 - i. Provide early diagnosis and staging of abscess
 - ii. Able to differentiate between liquid necrosis and edema

- (4) Treatment
 - (a) Medical
 - i. Empiric antibiotic therapy is initiated even before receiving culture results.
 - ii. Once culture sensitivities are determined, antibiotic therapy is adjusted to treat the specific organism.
 - iii. Antibiotic therapy is adjusted based on the size of the abscess and organism involved, and usually is continued for 6 weeks.
 - iv. Antibiotics alone may be effective but should not be used as a single therapy for abscesses >2 cm.
 - (b) Surgical
 - i. Surgical intervention is based on the age and neurological status of the patient, along with the size, location, and number of lesions involved.
 - ii. Craniotomy and craniectomy facilitate drainage and removal of abscess.
 - iii. Burr hole aspiration to safely remove fluid from one or multiple abscesses. It is useful for providing a specimen for culture along with decompressing the affected area.
- c. Intracranial epidural abscesses
 - (1) Develop between the skull and dura mater and occur at a rate of 1.8% after craniotomy
 - (2) Often associated in the immunocompromised and in patients with history of bacteremia and drug use
 - (3) Other contributing factors—trauma, sinusitis, mastoiditis, and surgery
 - (4) Signs and symptoms
 - (a) Frontal headache
 - (b) Low grade fever
 - (c) Purulent discharge from the sinuses or ear
 - (d) Nuchal rigidity
 - (5) Diagnosis
 - (a) CT or MRI scan —findings similar between the two, and they allow for visualization of the abscess.
 - (b) Lumbar puncture
 - i. May not be performed due to the risk of intracranial mass and increased intracranial pressure
 - ii. Would see increased opening pressure and may show increased white blood cell count and increased protein level in CSF
 - (6) Treatment
 - (a) Medical—Antibiotic therapy (see antibiotic therapy treatment for brain abscesses)

- (b) Surgical
 - i. Burr hole aspiration
 - ii. Insertion of subdural drains
 - iii. Craniotomy or craniectomy
- 7. Hematological complications
 - a. Deep vein thrombosis (DVT)
 - (1) Incidence of clinically overt venous thromboembolism after craniotomy for brain tumor has been reported to be 1.6%–4.0%.
 - (2) Patients diagnosed with DVT have increased risk of forming pulmonary embolism.
 - (3) Malignancy is a risk factor for DVT and pulmonary embolism.
 - (4) Signs and symptoms
 - (a) Redness
 - (b) Tenderness
 - (c) Warmth
 - (d) Swelling
 - (e) Positive Homan’s sign
 - (5) Prophylaxis
 - (a) General measures
 - i. Passive range of motion
 - ii. Ambulate as early as possible after surgery
 - (b) Mechanical techniques
 - i. Use sequential compression device (SCD) or pneumatic compression boots (PCB)
 - ii. Reduce incidence of DVT and probably pulmonary emboli (PE)
 - iii. Do not use if DVT already present
 - iv. Continue use until patient is able to walk 3–4 hr/day
 - (c) Thromboembolic stockings (TEDs)
 - i. Applies graduated pressure distally
 - ii. No evidence that benefit is additive
 - iii. Take care to avoid a tourniquet effect at the proximal end.
 - (d) Low dose anticoagulation
 - i. Initiation of low dose anticoagulation is institution specific and physician specific.
 - ii. Agents used may include subcutaneous heparin or low molecular weight heparin (i.e., Lovenox).
 - (e) Combination of SCD and PCB and low dose anticoagulation
 - (6) Diagnosis
 - (a) Lower extremity dopplers
 - (b) Contrast venography
 - (7) Treatment
 - (a) Bed rest with elevation of involved leg(s)
 - (b) Anticoagulation
 - i. Heparin drip to keep PTT 1.5–2 x control

- ii. Low molecular weight heparin
- iii. Convert patient to Warfarin when appropriate
- iv. Full anticoagulation may begin <3–14 days postoperatively depending on patient diagnosis and neurosurgeon preference. As the incidence of heparin-induced thrombocytopenia (HIT) is on the rise, some patients may require a heparin alternative, such as bivalirudin.
- (c) Vena cava filter
 - i. Placed if full anticoagulation is contraindicated
 - ii. Cautiously begin to ambulate after 7–10 days.
 - iii. Wear TED stocking on affected lower extremity indefinitely.
- (8) Pain
 - (a) Difficult to balance comfort of patient versus the need for a reliable and accurate neurological examination
 - (b) Administered based on patient need and comfort level, while avoiding overdosing of narcotic medication
 - (c) Nonsteroidal antiinflammatory medications (NSAIDs) usually avoided immediately postoperatively due to the risk of developing platelet dysfunction and hemorrhage.
 - (d) Short acting agents, such as Fentanyl and Versed, are preferred especially because reversal agents are available.
 - i. Medications should be administered in a bolus form as needed, making certain that a neurologic exam is possible.
 - ii. Avoid sedation infusions.

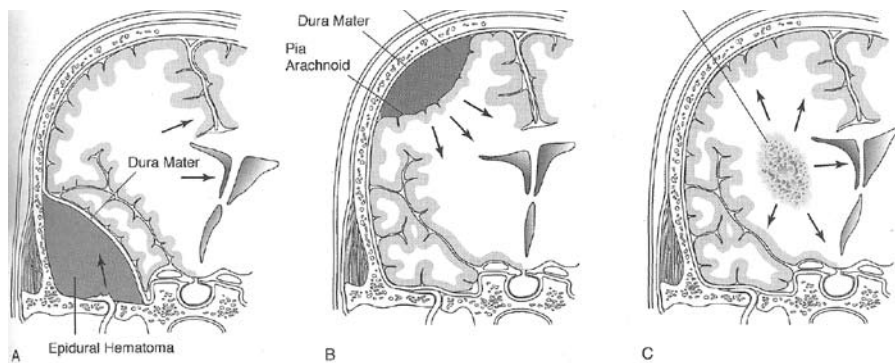
B. Specific neurologic complications

A noncontrasted CT of the brain should be obtained with any change or potential change in neurological status in order to assess potential devastating complications.

1. Hemorrhage (Figure 4)

- a. May result from bleeding into the subdural, epidural, intraparenchymal, or intraventricular space
- b. Overall risk of postoperative hemorrhage, 0.8%–1.1%
 - (1) Intraparenchymal, 43%–60%
 - (2) Epidural, 28%–33%
 - (3) Subdural, 5%–7%
- c. Signs and symptoms
 - (1) Sudden onset of hemiplegia
 - (2) Depressed LOC
 - (3) Signs and symptoms of increased ICP
- d. Send coagulopathy labs immediately and correct abnormalities as necessary.
- e. Immediately intervene to prevent irreversible cerebral damage and death.
- f. Overall mortality, 32%

Figure 4. Hemorrhagic complications of craniotomy for tumor resection include epidural hematoma, subdural hematoma, and intracerebral/intraparenchymal hemorrhage



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2. Increased intracranial pressure

a. Causes

- (1) Hemorrhage
- (2) Diffuse cerebral edema
- (3) Surgical trauma
- (4) Hydrocephalus
- (5) Retraction on brain during resection
- (6) Interference with venous drainage
- (7) Cerebral infarct

b. Signs and symptoms

- (1) Decreased LOC
- (2) Headache
- (3) Pupillary abnormalities
- (4) Visual disturbances
- (5) Sixth nerve palsy
- (6) Hemiparesis
- (7) Cushing response—hypertension, respiratory irregularity, bradycardia

c. Treatment

- (1) Management of the underlying cause
- (2) Placement of external ventricular drainage catheter with ventricular drainage
- (3) Maintain cerebral perfusion pressure >60 mm Hg
- (4) Elevate head of bed to 30°–45°
- (5) Osmotic diuretics with Mannitol
- (6) Hypertonic saline

- (7) Hypothermia
 - (8) Hyperventilation
 - (a) Causes vasoconstriction
 - (b) Only recommended for a short periods of time, such as <24 hours
 - (c) Remains controversial
 - (9) For increased ICP unresponsive to previous treatment
 - (a) Sedation with Propofol to decrease cerebral metabolism
 - (b) Paralytics for decreased cerebral metabolism
 - (c) Barbiturate coma
3. Peritumoral edema
- a. Vasogenic edema
 - (1) Extracellular edema due to an increase in capillary permeability of the arterial walls to large molecules due to a breakdown of the blood brain barrier
 - (2) Commonly seen with brain tumors
 - (3) Results in an increased effective diameter of the brain tumor
 - c. Signs and symptoms
 - (1) May result in new focal neurological deficits
 - (2) May exaggerate preexisting focal deficits
 - d. Treatment—Dexamethasone
 - (1) Lowest dose administered to maintain the patient free from headache, drowsiness, and other focal neurological deficits
 - (2) Usually dosed 4–10 mg IV/PO every 6 hours
 - (3) Tapered slowly over 7–10 days in order to avoid symptomatic hypoadrenalism
4. Cerebral infarction
- a. Characteristics
 - (1) May occur intraoperatively or postoperatively following a period of hypotension associated with a decrease in cerebral blood flow
 - (2) May be arterial or venous
 - b. Signs and symptoms—depend on location of infarct in brain
 - c. Treatment—directed toward preventing and treating cerebral edema and maintaining perfusion to the infarcted area
5. Pneumocephalus
- a. Characteristics
 - (1) Presence of air into the subdural, epidural, subarachnoid, intraparenchymal, or intraventricular compartments
 - (2) Could develop as early as 24 hours or as late as 1 week postoperatively
 - b. Tension pneumocephalus
 - (1) Characteristic—sufficient volume of air could act as a space occupying lesion causing rapid neurological deterioration
 - (2) Treatment—emergent craniotomy for evacuation of air

- c. Signs and symptoms
 - (1) Drowsiness
 - (2) Lethargy
 - (3) Decreased LOC
 - (4) Headache
 - (5) Focal deficits
- d. Treatment
 - (1) After 1–3 days, air will usually reabsorb without treatment with symptom improvement.
 - (2) 100% O₂ is often administered to facilitate the absorption of air.
- 6. Hydrocephalus
 - a. May develop early or late in postoperative course
 - b. Signs and symptoms
 - (1) Mental status changes with lethargy and confusion
 - (2) Generalized weakness
 - c. Treatment
 - (1) Placement of ventriculostomy to drain CSF temporarily
 - (2) May require surgical shunting procedure if hydrocephalus does not resolve
- 7. Seizures
 - a. May be generalized convulsions or focal seizure activity
 - b. Best predicted by location of tumor
 - (1) Approximately 40% of seizures occur with tumors in the frontal, temporal, and parietal lobes.
 - (2) Approximately 14% of seizures occur with tumors in the occipital lobe.
 - (3) Not generally associated with infratentorial surgery
 - c. History of seizures preoperatively increases the risk of postoperative seizure activity especially in first 24 hours after surgery.
 - d. Obtain head noncontrast CT and basic laboratory profile after seizure activity to rule out structural cause versus metabolic cause of seizure.
 - e. Consider obtaining EEG to identify seizure focus and monitor effectiveness of treatment.
 - f. Monitor anticonvulsant level frequently and maintain within therapeutic range.
- 8. Cerebrospinal fluid leak
 - a. Population most at risk
 - (1) Patients who have undergone a transsphenoidal operation
 - (2) Patients who have undergone a posterior fossa craniotomy with dural opening
 - b. Caused by an opening in the subarachnoid space
 - c. Increased risk for meningitis and cerebral abscess
 - d. Signs and symptoms
 - (1) Rhinorrhea or otorrhea with clear fluid
 - (2) CSF leak may be seen at operative site

- (3) Salty-sweet taste in mouth
- e. Treatment
 - (1) Bed rest—but if gotten out of bed with LD, clamp and relevel for chair height and drainage parameters.
 - (2) Height of bed elevated. With a posterior fossa CSF leak (as may occur post acoustic neuroma resection), the head of the bed should be flat to help seal the dura when patient has a lumbar drain. Head elevation may place more pressure on the surgical site.
 - (3) Avoid straining
 - (4) Acetazolamide (Diamox) to reduce CSF production
 - (5) Approximately 90% of patients will seal the leak spontaneously.
 - (6) Persistent CSF leak, LD will be placed to drain CSF at a rate of 5–15 cc/hr. The lumbar drain provides a lower-resistance path for CSF allowing for sealing of the leak.
 - (7) Continued leak despite lumbar drainage of CSF may require the patient to undergo surgical exploration and repair of the dural defect.
- 9. Cranial nerve deficits
 - a. Possible causes
 - (1) Direct result of surgical procedure
 - (2) Temporary complication as a result of peritumoral edema
 - b. Most common with infratentorial surgery
- 10. Wound infection
 - a. Most frequent causative agent—staphylococcal organisms
 - b. Signs and symptoms
 - (1) Redness and drainage from wound
 - (2) Foul odor from wound
 - (3) Elevated white blood cell count
 - c. Treatment
 - (1) Antibiotics
 - (2) May require craniotomy for surgical irrigation and debridement
 - (3) Prophylactic antibiotics often prescribed for short duration immediately postoperatively

Postoperative Nursing Interventions

I. Neurological

A. Head dressing

1. Generally a snug turban-style dressing
2. Important to monitor the dressing for drainage—nurse should outline drainage directly on dressing and continue to monitor for increase in drainage beyond outline.
3. Precise removal time is institution specific.
4. In general, head dressings are removed after 24 hours.
5. After removal, a smaller dressing may be applied or the incision can be left open to air.

B. Incision care

1. Monitor the incision for redness or drainage or signs of wound infection.
2. Keep the incision with staples or stitches dry.

C. Jackson Pratt (JP) drain

1. Occasionally placed in the surgical bed
2. Requires monitoring and measurement of the drainage
3. Maintain patency of the drain
4. Not placed in the surgical bed if the physician has placed biodegradable wafers, which release chemotherapy

D. Drains

1. Be certain you know the location of each drain and label them clearly.
2. *Never* place a drain to wall suction.
3. Subgaleal drains can be placed to full bulb suction.
4. Drains in the subdural space are either drained to gravity or to partial bulb suction.
5. Aggressive suction on the brain surface can tear vessels and cause hemorrhage.

E. Subgaleal drain

1. Drains the pocket of CSF, which may have collected under the skin near the craniotomy flap
2. Collects fluid under the scalp, should be soft to palpate and nontender; skin should not be red.
3. The fluid will be reabsorbed over time.

F. Postoperative imaging

1. It is important to differentiate expected postoperative changes from new tumor, residual tumor, or radiation effects.
2. Imaging studies will vary among physicians, histologic diagnosis of the tumor, and clinical findings of the patient.
3. Types of postoperative imaging

- a. CT scan of head with or without contrast—Noncontrasted scan determines postoperative blood or edema. Contrast scan can determine areas of enhancement of tumor.
 - b. MRI with or without contrast (gadolinium)—Serves as baseline scan before treatment with radiation, chemotherapy, or both—frequency determined by physician preference, patient condition, and clinical research protocols
4. Patients will require scans at various intervals postoperatively to determine if further treatment is necessary or if treatment is effective. It is important that imaging studies be shared with the multiple disciplines involved in care to avoid duplication.

II. Cardiovascular

- A. Monitor cardiac rate and rhythm.
- B. Monitor blood pressure and maintain ordered parameters.

III. Respiratory

A. Essential to prevent atelectasis and pneumonia

B. Maintain SaO₂ = 94%.

C. Incentive spirometry

1. Allows patient and nurse to measure and set goals for deep breathing
2. Encourage every 2 hours
3. Contraindicated for use after transsphenoidal surgery

IV. Nutrition

A. Essential for the healing process

Generally begin with clear liquid diet and advance to regular diet as tolerated.

B. Swallow evaluation

1. Assess patient alertness, ability to follow commands, dysarthria, and facial or tongue asymmetry.
2. May be done first by nurse at bedside and if findings found, refer for speech consult and formal speech and swallow evaluation.
 - a. The swallowing team will give recommendations to the medical and nursing staff regarding food and liquid textures that are safe for the patient and that will prevent aspiration pneumonia.
 - b. If a patient fails the oral swallowing test, consider tube feedings, total parental nutrition, or peripheral parental nutrition.

V. Blood Glucose

- A. Hyperglycemia potentially disrupts the blood-brain barrier and increases cerebral edema.
- B. Elevated blood glucose is often a result of steroid therapy in both diabetic and nondiabetic patients.

- C. Blood sugars are obtained before meals, at bedtime, and more frequently if necessary.
- D. Target range of blood glucose as recommended by the American Association of Clinical Endocrinologists in order to prevent adverse neurological outcome
 - 1. Intensive care unit, 100–140 mg/Dl
 - 2. Acute care unit, 140–180 mg/Dl (Griesdale, 2009)

VI. Intravenous Fluids

- A. IV fluid with dextrose should be avoided due to risk of increasing blood glucose and potential worsening of cerebral edema.
- B. Hypertonic solutions are used more frequently with patients who are fluid-restricted and those with cerebral edemas.
- C. Important to titrate IV fluids down once the patient is taking liquids and eating. This avoids fluid overload and decreases potential intracerebral edema.

VII. Activity and Ambulation

Early ambulation is essential to prevent negative effects of immobility, such as pneumonia, atelectasis, DVT, and deconditioning. Obtain physical therapy and occupational therapy. Consult if necessary for patient mobility.

VIII. Pain Control

- A. Assess pain via hospital protocol (i.e., face scale, scale 1–10)
- B. Administer pain medication as needed.
- C. Offer other techniques for pain management (i.e., deep breathing, music).

Patient and Family Education

I. Craniotomy Experience

- A. Vital for patients undergoing craniotomy for brain tumor and their families
- B. Education may be conducted in different settings and through different members of the healthcare team.
- C. Education begins at diagnosis and continues throughout prehospitalization, hospitalization, discharge, and long-term follow-up.
- D. Nurse holds a major role in preadmission assessment and education
 - 1. Clarify and reinforce the information provided by the physician related to surgery.
 - 2. Describe preparatory events for the surgery, including chest x-ray, hair shaving, (SCDS), etc.
 - 3. Discuss possible events that may occur after surgery
 - a. Possible pain after surgery and how to control and communicate pain level
 - b. Length of stay
 - c. Daily hospital expectations
 - d. Roles of various healthcare team members who will be involved in the patient's care
 - e. Potential rehabilitation needs and plans for discharge.
 - 4. Teach deep breathing and leg exercises.

II. Follow-Up Appointments

Determined by physician's practice and standards, follow-up appointments generally include an appointment for suture or staple removal in approximately 10–14 days postsurgery and on appointment 6–8 weeks postsurgery to discuss progress, medications, further treatment and imaging plans (as indicated), driving, work issues, etc.

III. Neuro-Oncology and Radiation Oncology

- A. Neuro-oncology and radiation oncology referrals are made for malignant brain tumors during inpatient stay.
- B. The neuro-oncologist and radiation oncologist discuss with the patient tumor histology, recommended treatments, and clinical trials available for treatment.
- C. Multimodality treatment is important for survival in malignant tumor patients.

IV. Discharge Planning

- A. The patient's support systems and potential discharge needs are important to assess early on in treatment.
- B. Predictions regarding course of care can be difficult, and therapies are initiated as needed.
 - 1. Physical therapy—work with patients on muscle strengthening, gait, balance, mobility
 - 2. Occupational therapy—work with patients on activities of daily living and safety recommendations
 - 3. Speech therapy—important for language, articulation of speech, and swallowing
- C. Social services consulting
 - Serves a major role in connecting patients and families to resources in the community and evaluating and planning discharge needs.

V. Support Groups and Resources

- A. Support groups are important as a way to connect patient with others who have gone through similar experiences.
- B. Members may share their experiences and coping strategies with people who understand what they are going through.
- C. A study published in the *New England Journal of Medicine*, December 13, 2001, found that patients survived about the same length of time whether they took part in a support group or not. However, participants did improve their mood and perceptions of pain.

Patient and Family Resources

The American Brain Tumor Association
The Brain Tumor Society
The National Brain Tumor Foundation
Online groups

Internet Addresses

www.abta.org
www.tbts.org
www.brainumor.org
www.yahoo.com
www.braintalk.org

Expected Outcomes

I. Craniotomy

A. Review of 1771 supratentorial tumors treated 1984–1990

1. Perioperative mortality rate, 2.1%
2. Morbidity rate, 10%

B. Study of 400 supratentorial and infratentorial craniotomies

1. Major complication rate, 13%
2. Operative mortality rate, 1.7%
3. Overall morbidity, 32%
4. Major neurologic morbidity, 8.5%

Postoperative Documentation

Postoperative documentation depends upon neurosurgical procedure performed and institution requirements. Such postoperative documentation includes but is not limited to the following.

I. Neurological Assessment

Make special note of postoperative deficits and compare with preoperative assessment.

II. Pain Level

Pain scale used depends on hospital protocol.

III. Pain Medications

If neurological status changes, it is important to determine last time of pain medicine and what was given in order to make accurate assessment.

IV. External Ventriculostomy Drain

A. Record CSF drainage.

B. Record ICP.

V. Drains

A. Record drainage amount.

B. Record color of drainage and consistency.

C. Differentiate CSF from blood.

VI. Dressing

Record drainage amount and characteristics.

VII. Incision

After dressing has been removed, record whether the incision has staples or stitches, and record whether there is drainage from incision or redness of incision.

VIII. Record Height of Bed

IX. Record Drainage from Ear or Nose

X. Record Activity and Ambulation

XI. Record Diet Status

XII. Record Glucose Check Results

XIII. Record Use of DVT Prophylaxis and Compliance

Controversial Issues

I. Benign Brain Tumor

- A. Postoperative treatment regimens for benign tumor remain controversial, for example, whether radiation treatment is needed
- B. Timing of postoperative imaging

II. Malignant Brain Tumor

- A. Low-grade tumor
 - Controversy exists over whether surgery for low grade astrocytomas improves survival, although insufficient research has been conducted to prove its benefits or lack of benefits.
- B. High-grade tumor
 - 1. Controversy exists over whether the act of obtaining a biopsy may allow the spread of cancerous cells to other brain areas.
 - 2. Controversy exists among physicians regarding the aggressiveness of the treatment regimen for patients with high grade brain tumors.
 - 3. Controversy exists regarding repeated operations for malignant brain tumors. Some neurosurgeons believe that repeated operations could improve the quality of patients' lives and prolong survival.

III. Anticonvulsant Therapy

- A. Necessity of anticonvulsant therapy preoperatively and postoperatively
- B. Length of anticonvulsant therapy

IV. Anticoagulation

Controversy exists regarding timing of prophylactic and therapeutic anticoagulation.

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