Preoperative Evaluation

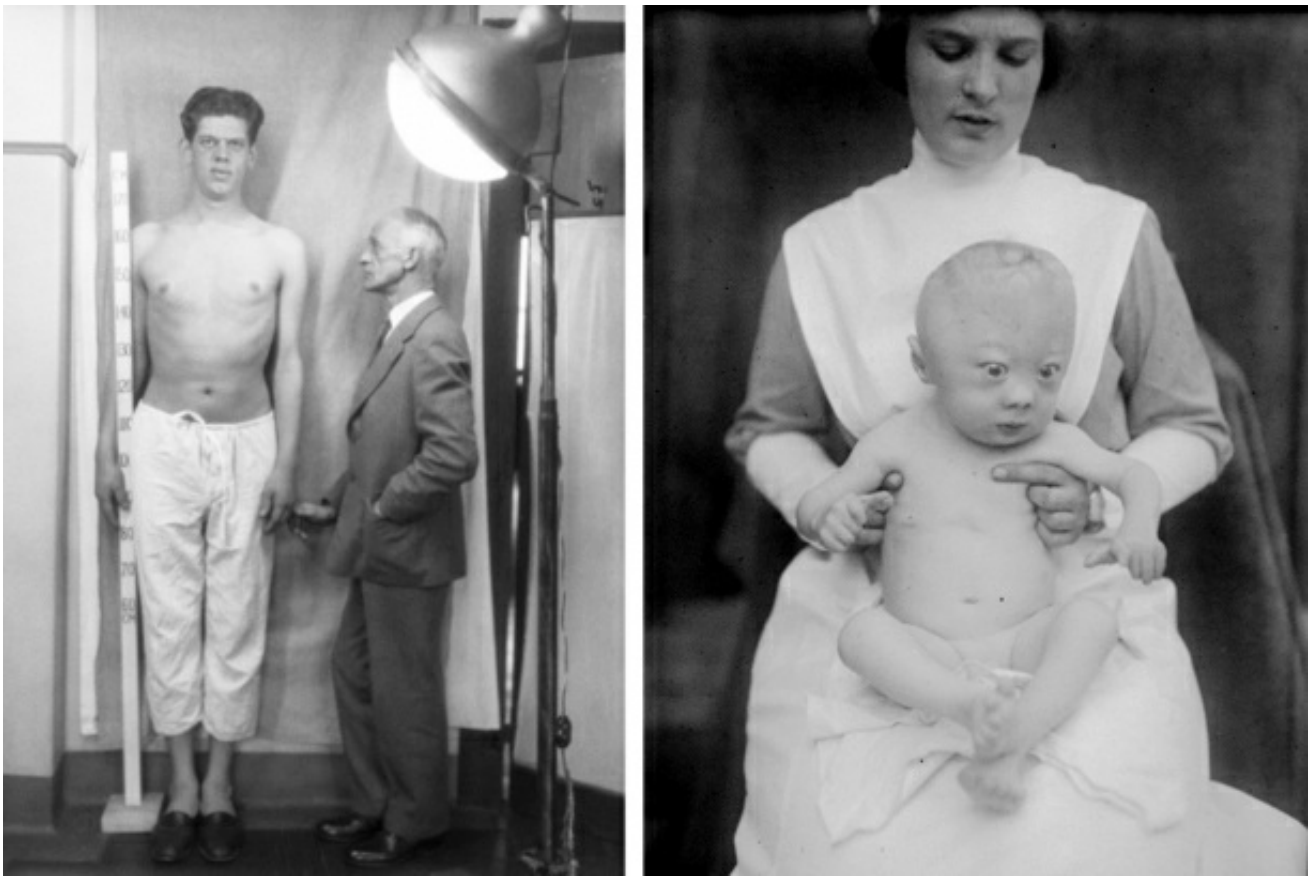

Figure 1: Harvey Cushing had a special interest in pituitary disorders. In the left image, he is standing next to a patient diagnosed with acromegaly during his preoperative evaluation. The right image pictures another patient suffering from craniosynostosis (courtesy of the Cushing Brain Tumor Registry at Yale University).

The preoperative evaluation provides an important opportunity for the surgeon to establish rapport with the patient and family and provide information to them about the procedure and associated risks and benefits. As part of their preoperative evaluation, I refer all my patients who are undergoing elective surgery to our preoperative assessment team for clearance to undergo anesthesia. This team is

comprised of internists and family medicine specialists.

A thorough preoperative evaluation involves:

1. establishing rapport with the patient and family, describing the process of surgery and recovery,
2. a review of past medical, surgical, personal, family, and social history and listing current medications and allergies,
3. a general physical exam and review of relevant laboratory data to arrange for any needed further investigations or consultations,
4. organizing the above data so patients can be appropriately risk-stratified for surgery-related morbidity based on their preoperative condition and
5. appropriate resources and plans are recruited to maximize operative safety and an expeditious recovery.

At the end of the evaluation, the patient's informed consent is documented. The neurosurgeon should also consider the anesthetic concerns and prepare for good communication between the anesthesia and operative teams.

General Evaluation

A patient's preoperative health status can have a important impact on the effects of anesthesia, positioning during surgery, intraoperative events, postoperative pain, and recovery. Pre-existing medical conditions can be a cause of concern and require special attention throughout the preoperative, intraoperative, and postoperative periods.

All patients are given an ASA (American Society of

Anesthesiologists) classification of physical status to stratify their pre-existing health status. Ranging from 1 (a normal healthy patient) to 6 (a patient declared brain-dead), the ASA physical status is an important predictor of postoperative outcome.

Medical History

A thorough medical history should be performed to evaluate pertinent information that may alter preoperative, intraoperative, and postoperative management.

Prior surgeries and previous anesthesia complications or concerns (airway management, IV access, postoperative pain, etc.) are an important part of the past medical history. Any allergies (latex, antibiotics, pain medication, etc.), steroid use (concern for adrenal suppression and hyperglycemia), anticonvulsant therapy (increased resistance to nondepolarizing muscle relaxants), and anticoagulation/antiplatelet therapy should be documented.

Personal history such as smoking and alcohol and drug use may affect anesthesia and postoperative management including recovery. Relevant family history (anesthesia complications, coagulopathy) and social/religious beliefs (such as Jehovah's Witness beliefs) should always be noted as well.

General Physical Examination

Of utmost importance is the general physical state of the patient. The assessment of the patient's airway by an anesthesiologist is an important component of the preoperative evaluation.

Cervical instability or cervical spine lesions can complicate airway management of neurosurgical patients. An incidental finding of myelopathy on the preoperative physical examination warrants spine imaging since nonphysiologic intraoperative body/neck positions

(i.e., the prone position) can lead to neck extension and severe spinal cord injury.

Recognition of potential airway complications allows for proper preparation of accessory equipment and resources to aid and manage the patient's airway. Volume status should be evaluated and corrected before surgery to prevent postinduction hypotension. Lower cranial nerve dysfunction before surgery may lead to cachexia and poor wound healing, therefore pre- or immediately postoperative gastrostomy tube placement may be mandatory to facilitate recovery.

Blood products should be given for pre-existing anemia and be readily available if significant blood loss is expected for surgeries involving an aneurysm, arteriovenous malformation, vascular tumor, and spinal deformity corrections.

System-Based Evaluations

Neurological System

A thorough preoperative evaluation includes a complete assessment of neurologic function. The level of consciousness may alter the need for anesthesia. A depressed preoperative level of consciousness may lead to a delayed emergence from anesthesia and increase the risk for aspiration. In these circumstances, the patient may remain intubated overnight.

Moreover, a depressed level of consciousness exacerbates pre-existing atelectasis, requiring assisted mechanical ventilation postoperatively. Such preparations should be made in advance for transportation and with the intensive care unit team.

There have been reports of life-threatening hyperkalemia after the administration of succinylcholine in patients with preexisting motor deficits.

Cranial nerve IX and X dysfunction places patients at a high risk for aspiration. Surgery of these nerves mandates postoperative swallowing evaluation before feedings are resumed.

Respiratory System

Perioperative respiratory complications rise dramatically among patients suffering from preexisting obstructive or restrictive pulmonary disease. Any patient with suspected pulmonary disease should undergo preoperative pulmonary function testing and arterial blood gas sampling to assess and optimize respiratory function prior to the operation.

An elevated Paco2 or low Po2 based on blood gas sampling is predictive of postoperative respiratory complications and should be compensated for before the procedure. If a patient has significant respiratory disease or impairment, postoperative mechanical ventilation is indicated. Patients who use a continuous positive airway pressure device at home should have the same device available to them throughout their hospital stay. Special arrangements must be made for patients undergoing tranasspenoidal procedures.

Cardiovascular System

Similar to pulmonary disease, preexisting cardiovascular disease should be optimized before proceeding with any neurosurgical procedure. Specifically, in patients with known cardiovascular disease (i.e., ischemic heart disease, heart failure, diabetes mellitus, renal insufficiency, or cerebrovascular disease), perioperative heart-rate control with beta blockade is appropriate. Patients not previously on beta-blocker therapy may have increased rates of stroke and mortality.

In an acute surgical emergency, evaluation should be limited to hematocrit, electrolytes, renal function, and electrocardiography. For planned elective surgery, a thorough cardiac history should be taken, including details of previous cardiac surgery, ischemic heart disease, congestive heart failure, and cerebrovascular disease. It is recommended to wait at least 4 to 6 weeks after an acute myocardial infarction (MI) (<7 days of examination) or recent MI (from 7 days to 1 month of the examination) to perform elective surgery.

In patients with congestive heart failure, cardiac output is greatly reduced. Mannitol should be used sparingly in this patient population as the resultant increase in intravascular volume can exacerbate cardiac and renal failure.

Chronically hypertensive patients typically have increased cerebrovascular resistance resulting in elevated limits of cerebral blood flow (CBF) autoregulation. It is important to be aware of the shift to higher pressures as these patients have a poor tolerance for acute hypotension.

Certain neurosurgical conditions are associated with cardiovascular abnormalities, including association of aneurysms with coarctation of the aorta and hypertension.

Renal System

A thorough review of the patient's medication list is indicated, as some medications may need to be adjusted, particularly those requiring renal elimination. It may be necessary to monitor the blood levels of certain medications or adjust dosage based on the patient's pre- and postoperative renal status.

To prevent renal failure, volume status may need to be carefully monitored by intra-arterial or central venous pressure catheters.

Intravascular volume depletion, contrast dye, nonsteroidal anti-inflammatory drugs (NSAIDs), angiotensin-converting-enzyme (ACE) inhibitors, and aminoglycoside antibiotics all place patients at risk for acute renal failure and should be minimized. Mannitol is avoided in anuric patients.

Patients with preexisting acidosis due to renal failure who require postoperative ventilation need frequent monitoring for acidosis. Inadequate spontaneous ventilation can lead to hypercapnia and respiratory acidosis, which will worsen preexisting acidosis and increase serum potassium to dangerously higher levels, potentially leading to circulatory depression.

Hematologic System

The patient's bleeding tendency and clotting status should be known before surgery. Abnormalities should be corrected, and blood products, clotting factors, and/or platelets be readily available intraoperatively.

General recommendations for discontinuing antithrombolytics before surgery include Coumadin (warfarin) >7-10 days prior to surgery, Plavix (clopidogrel) 5-7 days before surgery, aspirin (acetylsalicylic acid) 7-10 days before surgery, and NSAIDs 5 days before surgery. The risks and benefits of any decision to discontinue anticoagulation for transient ischemic attacks, recent stent placements, or atrial fibrillation should be carefully discussed with the patient's cardiologist. The considerations for resuming these medications after surgery should also be reviewed with the relevant physicians.

Endocrine System

Certain endocrine disorders require special attention during the perioperative timeframe, and hormone assays may be ordered to improve preoperative status. Diabetics are at an increased risk for

infection, poor wound healing, and hyperosmolarity if their blood sugar is not well controlled.

Metformin and sulfonylureas should be stopped 24-48 hours before surgery because their long half-lives place the patients at risk for hypoglycemia. Insulin should be used to maintain strict euglycemia prior to surgery. Furthermore, keep in mind that hyperglycemia adversely affects outcome after temporary focal or global ischemia.

Patients with Cushing's disease typically have hypokalemic metabolic alkalosis as a result of the excess glucocorticoids. Their volume status and electrolytes should be corrected before a transsphenoidal adenomectomy.

Patients who are steroid-dependent due to adrenal insufficiency require supplemental doses perioperatively. Similarly, patients with hyperthyroidism or hypothyroidism should be made euthyroid before any elective procedures, although mild to moderate abnormalities are not an absolute contraindication.

Preoperative Laboratory Assessments

The ASA Task Force on preanesthesia evaluation recommends selective performance of preoperative tests on the basis of patients' clinical characteristics for the purpose of guiding or optimizing perioperative management.

Most neurosurgical patients should have hemoglobin or hematocrit, serum glucose and electrolytes, and coagulation studies. If major blood loss is expected, their blood should be typed and cross-matched, whereas for minor procedures, the blood may be only typed and screened. To minimize the risk of postoperative seizures, anticonvulsant medications should reach the higher end of their therapeutic levels because perioperative events lead to an increase

in their metabolism.

All women of childbearing age with an unknown pregnancy status should be considered for a pregnancy test. Known cardiac disease or risk factors demand a preoperative ECG. Known pulmonary disease, cardiac disease, or recent upper respiratory infection may require a chest radiograph.

The ASA Task Force also suggested that test results and medical history performed within 6 months of the procedure are acceptable if the patient's medical history has not changed substantially, although more recent test results may be necessary in certain situations.

Specific Neurosurgical Considerations

Intracranial Tumors

Peritumoral edema should be controlled with preoperative steroid administration. Long-term (weeks) steroids for management of edema or increased intracranial pressure (ICP) may lead to suppression of the hypothalamic-pituitary axis, requiring supplemental steroids.

Intraoperatively, intracranial pressure may be reduced with the use of diuretics, most commonly mannitol. Volume status must be monitored closely to prevent hypotension and maintain adequate cerebral blood flow. Judicious early cerebrospinal fluid drainage through a lumbar drain, especially in the case of a large posterior fossa mass, can prevent dramatic cerebellar herniation and symptomatic acute brainstem dislocation upon dural opening.

Propofol (Diprivan) has been shown to lower ICP and provide better brain relaxation than isoflurane and sevolfuran. Therefore, neurosurgical patients undergoing intracranial surgery may benefit from the use of propofol over inhaled anesthetics. I do ask our anesthesiologists to use propofol if the patient's brain is tense during

surgery, and have had a good experience with this practice. This tactic has especially worked for posterior fossa operations.

Acromegalic patients present particular difficulties due to their uniquely multiple metabolic disturbances, including diabetes mellitus, hypertension, and cardiomegaly. These patients may be difficult to intubate and their hypertrophied ligaments can complicate their radial artery catheterization. Concerns for patients with Cushing's disease have been discussed above.

Patients should be informed of the risk of general complications related to intracranial procedures, including intra- and postoperative bleeding, seizures, stroke, coma, death, hydrocephalus, meningitis, neurologic deficit related to the area of surgery (paralysis, as well as language, sensory and cerebellar impairments). The patient should express a clear understanding of these risks and be competent to provide consent.

The details of preoperative evaluation and anesthesia for an awake craniotomy and cortical mapping are reviewed in the dedicated chapters titled Language Mapping or Sensorimotor Mapping for Glioma.

Ischemic Cerebrovascular Disease

Patients undergoing carotid endarterectomy typically have other comorbidities, including coronary artery disease, arterial hypertension, peripheral vascular disease, COPD, diabetes, or renal insufficiency. These other comorbidities should be carefully evaluated before surgery.

The North American Symptomatic Carotid Endarterectomy Trial (NASCET) indicated that a history of MI or unstable angina and hypertension are independent risk factors for complications. The

NASCET results also demonstrated that aggressive preoperative blood pressure control is associated with improved outcome, thus advocating for treatment of hypertension prior to the procedure.

Aneurysmal Subarachnoid Hemorrhage

Prognosis for patients with aneurysmal subarachnoid hemorrhage (SAH) has been strongly correlated with their presenting Hunt and Hess grade. Higher grades are associated not only with an increased risk of vasospasm, elevated ICP, and impaired cerebral autoregulation, but also with a higher incidence of arrhythmia and myocardial dysfunction, hypovolemia, and hypernatremia.

All of these risks should be assessed when a patient presents with subarachnoid hemorrhage (SAH). There are many alternative grading scales, including the World Federation of Neurological Surgeons Grade and Fischer Scale. For details of these grading systems, please refer to the chapter on Reference Tables and its Vascular section.

Any patient presenting with SAH should also be evaluated for associated medical conditions, including hypertension and smoking history, coarctation of the aorta, polycystic kidney disease, and fibromuscular dysplasia. Patients should also be monitored for hyponatremia due to cerebral salt wasting from increased release of atrial natriuretic peptide. Hypertonic or isotonic saline should be used to correct hyponatremia.

Electrocardiogram (ECG) changes, including ST-segment changes or T-wave inversion, may be seen after SAH in 40 to 60% of patients, particularly in those with poor-grade SAH. These ST abnormalities may be due to adrenergic or stress-induced MI. However, frequently there is no evidence of cardiac ischemia found on a detailed cardiac work-up. Ventricular dysfunction may also be more prevalent in

patients with high-grade SAH.

Microsurgery or endovascular intervention for ruptured aneurysms should be postponed only if the patient is hemodynamically unstable, has a ventricular ejection fraction below 30%, or is clinically in heart failure.

One final concern for patients presenting with SAH is pulmonary aspiration. Because loss of consciousness is often associated with the ictus of hemorrhage, the risk of aspiration increases the risk for impaired gas exchange. Neurogenic pulmonary edema due to SAH compounds this problem.

Table 1: ECG and Myocardial Dysfunction Among Patients with SAH

Benign Changes	Wall Abnormalities	Myocardial Injury
Sinus bradycardia	Symmetrical T-wave inversion	Q wave
Sinus tachycardia	Prolonged QT interval	ST-segment elevation
Atrial-ventricular dissociation	ST-segment elevation	Elevated CK
Premature ventricular contractions		Elevated troponin
Nonspecific ST depression		
T-wave inversion		
U wave		

Arteriovenous Malformations

As AVMs are highly vascular, intraoperative massive blood loss is a significant risk during microsurgery, so patients should be typed and cross-matched and generous vascular access should be available.

The patient's Spetzler-Martin grade can predict the surgical risk associated with AVM resection.

Due to loss of cerebral vascular autoregulation and "normal perfusion pressure breakthrough" phenomenon, I maintain the patient's systolic blood pressure during surgery ~20-30% below its preoperative baseline value. This range is strictly continued for about 2-3 days postoperatively to minimize the significant risk of postoperative hematoma and edema. Supratherapeutic levels of anticonvulsant medications are pertinent to prevent perioperative seizures and associated spikes in blood pressure.

Posterior Fossa Procedures

Procedures in the posterior fossa typically require that the patient be placed in a lateral position to allow access to the cerebellopontine angle, clivus, petrous ridge, and foramen magnum. Positioning for these procedures can exert excess demand on the cardiopulmonary systems that should be examined preoperatively. Preoperative evaluation should also consider the symptoms and signs of brainstem compression.

Manipulation of cranial nerves (CNs), especially CNs V, IX, and X, as well as tentorium and petrous dura, may lead to temporary asystole or cardiac arrhythmias. Appropriate precautions for treatment of these cardiac irregularities are warranted.

Electrophysiologic monitoring may be used in any neurosurgical procedure, but most often during posterior fossa and brainstem surgery around the cranial nerves. Somatosensory evoked potentials (SSEPs), motor evoked potentials (MEPs) and electromyography (EMG) may be used for monitoring and mapping cranial nerves and spinal cord function. Brainstem auditory evoked potentials (BAERs) monitor the function of the brainstem and CN VIII. Anesthetic

adjustments, including avoidance of paralytic medications during monitoring motor function, are required.

Head-Injured Patients

Head-injured patients most often undergo emergency surgery, and therefore their preoperative evaluation is limited due to time constraints. Maintenance of adequate airway, breathing, and circulation is critically important.

The goal is to avoid any further neurologic injury that can be caused by hypoxemia, hypercapnia, hypo/hypertension, hyperglycemia, increased ICP, seizures, and vasospasm. Cervical spine injuries complicate tracheal intubation. Once an airway is established, hyper/hypocapnia should be minimized and cerebral perfusion pressure should be optimized and maintained above 60 mmHg. Blood products should be typed and cross-matched as soon as possible.

Epilepsy Disorders

Epilepsy procedures may be performed with the patient under local anesthesia with minimal IV sedation for an awake craniotomy. This allows the surgeon to communicate with the patient and more accurately map the location and extent of resection using electrocorticography.

Blood levels of anticonvulsant medications should be carefully adjusted. Phenytoin (Dilantin) leads to more resistance to nondepolarizing neuromuscular blocking drugs that are important for anesthesia induction and maintenance.

Other Considerations

If a patient has previously undergone an operation by another

surgeon, a phone conversation with the primary surgeon is important to elucidate the difficulties encountered during the initial operation. Review of the operative notes can be nonrevealing and at times confusing. Similarly, if a patient has undergone an operation by the same surgeon, all operative notes should be reviewed in detail.

Most patients are referred after their MR imaging or CT scan. Imaging studies older than 3 months should be repeated because lesional progression during this time period may affect operative planning.

I review the operative plan and the desired physiologic parameters (blood pressure and volume parameters) immediately before surgery with the anesthesia team. I also describe the risk of blood loss or necessity for electroencephalographic burst suppression. Neurophysiologic monitoring needs are also discussed because these needs will affect the mode of anesthesia.

If an awake craniotomy is contemplated, I usually review the details of the case with our anesthesia team a day before the procedure and allow additional time immediately before the surgery for the team to describe the nuances of mapping to the patient and discuss concerns and questions.

In select patients who are suspected to have poor nutritional status, a serum prealbumin level test can assess their nutritional status. Importantly, a consultation with a nutritionist is essential to optimize the patient's status before surgery.

Pearls and Pitfalls

- Although many general principles for preoperative evaluation apply to neurosurgical patients, these patients suffer from different pathologic conditions and are undergoing procedures that require tailored evaluation and monitoring in the

perioperative period.

- Successful intraoperative management relies on a thorough preoperative evaluation and an understanding of the patient's physiology, the lesion's pathophysiology, and the demands on the patient during the procedure.

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