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# Preoperative anesthesia evaluation

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ABSTRACT

The preoperative evaluation is the first step in ensuring the safe conduct of anesthetic care in pediatric patients of all ages. Over time, this process has changed significantly from a time when patients were admitted to the hospital the night before surgery to a time when the majority of patients, including those scheduled for major surgical procedures, arrive the day of surgery. For most patients, the preoperative examiantion can be conducted over the phone by a trained nurse or on-line via a survey thereby eliminating the need for a separate visit merely for the preoperative evaluation. Regardless of where or how it occurs, the goals of the preoperative evaluation are to gain information regarding the patient's current status, comorbid conditions, and the intended procedure. This process allows the identification of patients who require additional preoperative testing or those patients who need to be seen by an anesthesiolgoist prior to the day of surgery. During the preopeative evalaution, decisions are made regarding further laboratory or investigative work-up that are required. The preoperative meeting provides an arena to develop the initial parent-physcian rapport, outline anesthetic risks, and discuss the intended anesthetic plan including options for postoperative analgesia. The process facilitates the care of patients during the perioperative period while limiting surgical cancellations resulting from patient-related issues. The following chapter reviews the essential components of the preoperative evaluation including the appropraite use of preoperative laboratory testing and other investigative procedures including radiologic imaging. Key components of the physical examinatino including the airway examination are reviewed.



## Introduction

Regardless of the type of surgical procedure, the patient's clinical status, and the anesthetic technique that is planned, a preoperative evaluation is the first step in ensuring the safe conduct of anesthetic care in patients of all ages. A thorough and well preformed preoperative evalaution serves to facilitate the care of patients during the perioperative period while limiting surgical cancellations from patient-related issues and its resultant impact on operating room efficiency and fiscal outcomes.[1–4] The initial impetus behind the development of anesthesiology properative clinics was to optimize the medical condition of a patient prior to surgery. However, the interaction of the patient and the anesthesiologist allowed the opportunity for the consideration of the individual and specific needs of a patient before the day of surgery. The end result was that many benefits have resulted from the development of preoperative clinics including the enhancement of patient safety and improved patient satisfaction.[1–4] The preoperative clinic may also improve hospital resource utilization by reducing unnecessary preoperative consults and laboratory testing, reduce the duration fo hospital stay following major surgical procedures, and limit day of surgery cancellations.[4–7] Despite the cost associated with such clinics, the cost savings from the above-mentioned benefits justifies such expenses valuable operating room time and staff may be wasted by surgical delays or cancelations.

While some variation may occur, the same approach to the preoperative evaluation is used regardless of the age of the patient, their clinical status, and the procedure that is be accomplished (Table 1). In many centers, this evaluation is performed well in advance of an elective surgical procedure in a specialized clinic to allow for specific preoperative interventions, consultation or preparation that may be required to allow for the safe completion of the anesthetic care and surgical procedure. Alternatively, the

*Abbreviations:* ACCP, American College of Chest Physcians; ARDS, adult respiratory distress syndrome; ASA, American Society of Anesthesiologists; FVC, forced vital capacity; GA, gestational age; INR, international normalized ratio; MEP, maximum expiratory pressure; MH, malignant hyperthermia; NIV, non-invasive ventilation; NSAID, non-steroidal anti-inflammatory agent; NPO, nil per os; OSA, obstructive sleep apnea; PCA, post-conceptual agent; PCF, peak cough flow; PFT, pulmonary function testing; PONV, postoperative nause and vomiting; PT, prothrombin time; PTT, partial thromboplastin time; SDB, sleep-disordered breathing; URI, upper respiratory infection.

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**Table 1**
Goals of the preoperative assessment.

1. Meet the family and the patient with development of a physician-patient relationship.
2. Ensure that the patient is medically fit as possible for anesthetic care.
3. Identify acute illnesses or co-morbid disease processes that may increase the incidence of complications.
4. Preform a focused physical examination including the airway.
5. Evaluate the procedure to be performed to direct the anesthetic care.
6. Educate and inform that parents about the conduct of anesthesia, its goals, risks, and options available to the patient.
7. Discuss options for anesthetic induction, plans for intraoperative care including monitoring, and decide on a plan for postoperative analgesia.
8. Obtain informed consent.
9. Give parental instructions regarding *nil per os* (NPO) guidelines.
10. Discuss the eventual disposition of the patient including outpatient performance of the procedure versus the need for overnight admission.
11. Determine the need for additional workup or subspecialty consultation.
12. Determine if additional medications are required prior to anesthesia such as agents to decrease gastric contents/acidity or to prevent bronchospasm.

preoperative evaluation can be performed using a standardized survey, via the phone, internet or some other electronic system.[8] This allows for quick, cost-effective, and efficient screening of healthy patients who require limited work-up as well as identification of patients who may require additional evaluation with a more in-depth phone interview with specialist referral, preoperative laboratory evaluation, or further clinical investigations. Much of this can be accomplished by specially trained nurses with back-up by a pediatric anesthesiologist for review of medically complex patients. Time and experience has demonstrated that the majority of pediatric patients can be effectively screened, interviewed and prepared for surgery without a formal in-person evaluation thereby accomplishing the objective of limiting day of surgery cancellations and avoiding the costs of evaluating all patients in person. This also eliminates the need for a separate trip to the hospital for the preoperative visit thereby eliminating parent and parent inconveniences. For patients who are already admitted to the hospital, or those presenting for emergent or urgent surgical procedures, the preoperative evaluation can be performed immediately prior to the surgical procedure.

The goals of the preoperative evaluation are to gain information regarding the patient's current status, comorbid conditions and the intended procedure. This informs decisions regarding laboratory or investigative work-up that may be needed prior to the procedure. The preoperative meeting and examination provides the anesthesiologist an opportunity to meet the patient and their parents or guardians. This provides an arena to develop rapport, , outline anesthetic risk, and present the anesthetic plan for the day of surgery include *nil per os* (NPO) times, premedication, and options for postoperative analgesia. There should also be ample time for questions to be answered and for informed consent to be obtained.

## Preoperative examination: Medications, allergies, and medical history

The preoperative evaluation includes a review of the history of present illness, past medical problems including medication allergies, past surgical and anesthetic history, family history of anesthetic complications, and review of the patient's current and prior medical record including the medication list. The medication list should include prescription and non-prescription medications. Specific questions should be asked regarding the use of non-steroidal anti-inflammatory agents (NSAIDs) given their effects on platelet function and concerns of perioperative bleeding. Other non-presciption medications may also include homeopathic and natural health remedies that may have significant effects during the perioperative period including effects on coagulation function.[9,10] A recent survey of 894 pediatric patients demonstrated that 3.5% of them had been given an herbal or homeopathic medication during the 2 weeks prior to surgery, generally by their parents.[10] The use of these medications did not differ between children with or without coexisting diseases, among ethnic groups or by residence setting (city, suburban, rural). There was increased use in West Coast centers as high as 7.5% in California versus the rest of the country. The most prevalent agent administered was echinacea which has been proposed ,but not proven in evidence-based medicine, to augment the immune system and reduce the symptoms of colds and flu.

Presciption medications are also reviewed and a decision made as to which should be continued during the perioperative period. For the most part, prescription medications are continued throughout the perioperative period with adjustments made in the anesthetic plan based on the potential interactions of these medications and anesthetic needs. Patients with chronic pain problems who are receiving opioids and other analgesic adjuncts should continue these perioperatively with the understanding that these medications may alter the postoperative analgesic needs. Anticonvulsant medications are administered preoperatively and continued intraoperatively and during the postoperative period.[11] At times, these medications must be administered with a small amount of applesauce or other semi-soft food such as pudding to encourage their ingestion. Such flexibility with NPO guidelines is mandatory to ensure the safe care of the pediatric patient. Antidepressants and other psychoactive agents may alter the requirements of inhalational and intravenous anesthetic agents.[12] However, withholding such medications may increase the risk of recurrent psychiatric illnesses. An individual decision must be made at the time of the preoperative evaluation regarding the risk-benefit ratio of these medications. More complex decision processes include patients on long term anticoagulation (coumadin, enoxaparin, and aspirin) and those receiving cardiac medications such as antihypertensive agents, diuretics, and digoxin. For these patients, consultation with a pediatric cardiologist is generally recommended. Patients on long-term anticoagulation and at risk of thrombotic issues such as those with mechanical heart valves require hospital admission and bridging with intravenous heparin during the perioperative period. Given the risk of bleeding and the limited beneficial effect, even in adults, the American College of Chest Physicians (ACCP) recommends that patients scheduled for noncardiac surgery who are at low risk for cardiac disease stop aspirin intake 7-10 days before surgery.[13,14]

Information regarding known medications, food, and environmental allergies is obtained. Food allergies may provide some insight into potential medication allergies such as seafood allergies and interactions with iodinated contrast agents; peanut, egg or soy allergy and potential interactions with propofol (see reference 7 to refute these concerns); kiwi, banana, avocados and chestnut allergies and a higher incidence of latex sensitization; and reactions to Gummi Bears or immunizations as a potential marker for gelatin allergy which may be found in topical thrombotic agents such as Floseal®.[15–17] While the majority of anaphylactoid

reactions result from exposure to antibiotics and neuromuscular blocking agents, with latex a distant third given its intentional removal from perioperative products, knowledge of food allergies may guide perioperative care.[17]

Birth history including gestational age and previous need for neonatal intensive care should also be reviewed for patients less than 1-2 years of age. One significant factor that impacts postoperative disposition is the patient's gestational age (GA) and their current chronologic age. While practices vary from institution to institution, due to the risk of apnea, postoperative monitoring is generally recommended for infants born at less than 37 weeks of gestation who are less than 54–60 weeks post-conceptual age (PCA).[18] The duration of postoperative monitoring that has been recommended has varied from 6-12 hours to overnight based on the presence of specific risk factors as well as the experience of the individual centers. Apnea is strongly and inversely related to both GA and PCA and continuing apnea at home. Small-for-gestational-age infants are somewhat protected from apnea as compared to appropriate- and large-for-gestational-age infants. Anemia (hematocrit less than 30%) is a significant risk factor, particularly for patients that are less than 43 weeks PCA. In general, although monitoring is suggested in preterm infants up to 60 weeks PCA, there is a significant reduction in the incidence of apnea at 52-54 weeks PCA, with an incidence of apnea $\leq$ 1% at 54 weeks PCA.[18]

Family history includes information regarding perioperative complications in immediate family members including specific questions regarding mortality, high fever, and prolonged paralysis. Although uncommon, diseases such as malignant hyperthermia (MH) suggested by perioperative fever or pseudocholinesterase deficiency manifesting as prolonged paralysis have obvious anesthetic implications. MH is an acute hypermetabolic crisis that can be triggered in susceptible patients by the administration of succinylcholine or one of the volatile anesthetic agents.[19] Its incidence varies from 1 in 15,000 in the pediatric population to 1 in 40,000 in adults. If unrecognized and untreated, the mortality rate exceeds 80%. The cellular defect responsible for MH lies in the calcium release channel of the sarcoplasmic reticulum (the ryanodine receptor).[20] Most individuals diagnosed with MH have a parent with MH; however, the parent may not have experienced an episode. The proportion of individuals with MH caused by a *de novo* pathogenic variant is unknown. If there is a question of MH in a direct relative or a history of unexplained high perioperative fever, anesthetic care with non-triggering agents such as propofol and opioids is indicated.

Prolonged recovery from the neuromuscular blocking agent, succinylcholine, may be related to qualitative or quantitive deficiencies of the enzyme responsible for its catabolism, pseudocholinesterase. Quantitive deficiencies may be inherited as an autosomal recessive trait. While the use of succinycholine has decreased, it is still used for rapid sequence intubation or when there are concerns of a potentially difficult airway. Other pertinent family history includes a history of postoperative nause and vomiting (PONV) or motion sickness which may predispose to an increased risk of PONV.

History is obtained regarding the patient's previous exposure to anesthesia and associated comorbid conditions. Information regarding previous anesthetic exposure includes the use of premedication, type of anesthetic induction, perioperative complications including problems with airway management, and the postoperative experience including pain management, PONV, and emergence delirium. The parents and patient may offer preferences as to modifications that they desire in the current anesthetic based on previous experience. Following this, associated comorbid conditions and their current status are explored. The presence of these conditions may suggest the need for specialist consultation or further investigation and laboratory analysis. For elective surgical procedures, the status of co-morbid conditions should be optimized prior to the surgical procedure. Optimization may not be feasible for urgent or emergent cases. In particular, clinical history suggestive of obstructive sleep apnea (OSA) or sleep disordered breathing (SDB) is obtained. Given the potential for adverse postoperative events following general anesthesia in such patients, especially in those requiring opioids for analgesia, prolonged or overnight postoperative monitoring should be considered in patients with a clinical history of loud snoring, gasping or pauses in breathing during sleep.[21–24] The development of clinical pathways is suggested to ensure the safe postoperative care and observation of patients with OSA or SDB.[25]

Finally during the history portion of the preoperative evalaution, acute issues that may impact anesthetic care are evaluated. These are most commonly acute infectious issues including an upper respiratory infection (URI). Previously, the tenet was that patients should be free of any acute infectious process including a viral URI for up to 6 weeks prior to undergoing an elective general anesthetic as airway hyperreactivity may last for up to 6 weeks following URI. Since children, especially those who attend daycare, may have as many as 6 to 8 URIs per year, it may be impossible to schedule elective surgery. Although routine cancellation of surgical procedures because of a URI avoids the increased potential for intraoperative complications, it increases the economic, time and emotional burden on the patient and parents including loss of days at school and work. Routine cancellation is not practical in today's health care environment with increasing caseloads and pressure to maintain efficiency. The need to postpone surgical procedures based on recent URIs has been re-evaluated with an overall trend of decreasing cancellations related to recent or current URIs.[26,27] Currently, children presenting with symptoms of an uncomplicated URI, who are afebrile with clear secretions, and who appear otherwise healthy should be able to undergo surgery. Consideration of cancelling the procedure is suggested for patients with fever, purulent nasal discharge or signs of lower respiratory involvement including tachypnea, wheezing, rales or repetitive coughing. Baseline pulse oximetry screening to document a normal oxygen saturation may be helpful and at times, a chest radiograph should be obtained to rule out pulmonary parenchymal involvement. Tait and Malviya have provided a useful algorithm to aid in this decision process.[26,27] Decisions are based not only on the condition of the patient, but also the length and complexity of the surgical procedure to be performed. When proceeding in the setting of a recent or current mild URI, the anesthesia provider must understand that the most common intraoperative and postoperative complications are respiratory, including laryngospasm, bronchospasm, and oxygen desaturation.[27]

## Preoperative evaluation: Physical examination

The preoperative physical examination is directed primarily at 3 organ systems: 1) the airway and respiratory system; 2) the cardiovascular system, and 3) the central nervous system. In addition, vital signs, weight, height, and a room air oxygen saturation are obtained. Additional aspects of the routine physical examination of other organ systems may be added as needed based on the patient's history and the surgical procedure. The airway examination is a key aspect of the preoperative evaluation. The guidelines of the American Society of Anesthesiologists (ASA) state that "the evaluation of the airway should be conducted, whenever feasible, prior to the initiation of anesthetic care and airway management in all patients".[28] Even in the emergency setting, time must be made for at least a brief,focused examination of the airway with an assessment of the feasibility of endotracheal

intubation. The intent of this examination is to detect physical characteristics that may indicate problems with bag-valve-mask ventilation and/or endotracheal intubation. Although the incidence of such problems is low in the pediatric population, the consequences are potentially devastating and life-threatening.[29–31] The Perioperative Cardiac Arrest (POCA) registry demonstrates that airway and respiratory adverse events are the second most common cause for perioperative cardiac arrest in children following hemodynamic compromise related to blood loss.[32] Although the incidence has decreased in a closed claims analysis from 1973 to 2000, inadequate oxygenation and ventilation leading to death or brain damage still accounted for the majority of the cases.[33] While a significant percentage of difficulties with airway management are encountered in patients with specific clinical syndromes, issues can arise with the apparently normal child with no previous medical history.[34] The use of specific physical assessment tools allows separation of the airway into either the normal airway or the anticipated difficult airway. This begins as noted above with a history regarding previous anesthetic encounters and examination of previous anesthetic records.

Various formulas and screening tests have been suggested for the adult population; however, none of these are readily transferable to the pediatric patient. In a retrospective study over a 5-year period that included 11,219 general anesthetics in infants and children, the incidence of difficult laryngoscopy (defined as a Cormack and Lehane grade III or IV view, Table 2) was 1.35%.[29] Risk factors included age less than 1 year, ASA physical status III or IV, a higher Mallampati Score (III or IV, Table 3), a lower body mass index, and patients undergoing oromaxillofacial surgery or cardiac surgery. The same authors reviewed the anesthetic care of 102,306 adult cases and reported that the overall rate of difficult laryngoscopy was 4.9 %, again defining this as a Cormack and Lehane grade III or IV view.[35] Risk factors included male gender, Mallampati score III or IV, obesity with a body mass index of $\geq$ 35 kg/M$^2$, and ASA physical status III or IV. Again, they noted that specific surgical procedures were associated with a higher incidence of difficult laryngoscopy including oromaxillofacial procedures, ear nose and throat surgery, and cardiac surgery. Other specific phenotypic features, many of which impede the alignment of the oral, pharyngeal, and glottic openings, may be associated with difficulties with airway management (Table 4). An additional physical feature that may alert the anesthesia provider to the potential for a difficult airway is abnormalities of the external ear.[36] In the adult population, severe obesity and a large neck circumference are also associated; however, these associations are less in the pre-adolescent pediatric age group.[37] One final scoring system that merits mention given its frequent use and validity in the adult population is the Wilson risk score (Table 5).[38] Three or more of these physical features predicted 75% of difficult laryngoscopies while 4 or more predicted 90%.[38,39]

The airway examination is followed by a focused examination of the cardiac and respiratory systems. As noted, the respiratory system examination may inform the decision to proceed with anesthesia in patients with a recent URI. The cardiovascular examination may occasionally detect a previously unheard murmur or abnormalities in the rhythm. However, such findings in an otherwise asymptomatic patient rarely change anesthetic practice or suggest the need to delay a surgical procedure while awaiting further diagnostic work-up. Given the limitations of the physical examination in hearing and diagnosing murmurs, there is recent interest in the use of point-of-care echocardiography to aid physical diagnosis.[40,41] To date, this practice has not been widely applied during the preoperative evaluation. Based on the preoperative evaluation and the identification of co-morbid conditions, an ASA Physical Status classification is assigned (Table 6).

**Table 2**
Cormack and Lehane scale.

| | |
|---|---|
| Grade 1 | Full view of glottis |
| Grade 2 | Only posterior commissure is visible |
| Grade 3 | Only the tip of epiglottis is visible |
| Grade 4 | No glottis structure is visible. |

## Preoperative investigations including laboratory evaluation

Laboratory tests and additional investigations are ordered based on the positive findings obtained during the history and physical examination and on the complexity of the surgical procedure.[42,43] It is generally agreed that routine preoperative testing is not cost-effective and unlikely to identify significant abnormalities. Abnormal findings from routine testing are frequently false positives, costly to pursue, and increase the patient's anxiety. Abnormal findings rarely alter the anesthetic plan while incidental findings and false positive results lead to increased hospital visits and needless evaluations. Although still performed, routine testing of coagulation function has specifically been shown to be of limited value when there is no clinical history of bleeding.[44] The most common coagulation disorder that may cause problems intraoperatively is von Willebrand's disease which cannot be identified on routine coagulation screening such as prothrombin time (PT), partial thromboplastin time (PTT), and international normalized ratio (INR).

Indications for preoperative testing are tailored to risk factors identified during the preoperative evaluation and based on the planned surgical procedure. For example, patients with renal or hepatic disease may require preoperative laboratory evaluations, patients taking anticonvulsants may require documentation of therapeutic plasma concentrations, specific medications may require assessment of end-organ effects to rule out toxicity, while patients receiving diuretics may need to have serum electrolytes evaluated although the perioperatieve risks of electrolyte disturbances remains minimal.[45] Even long held tenets regarding the need for electrolyte monitoring and correction of such issues in infants with pyloric stenosis may supportive evidence and warrant further investigation.[46,47]

In patients presenting for surgical procedures that may require the administration of allogeneic blood products, a hemoglobin is assessed and a type and screen obtained. One of the current challenges is to accurately identify patients who will require blood during a surgical procedure to limit the cost and inconvenience of obtaining a routine type and screen.[48–50] Various clinical investigations have demonstrated that a type and screen or type and cross are frequently obtained and not needed further adding to the cost of a surgical procedure.[49,50] In most facilities, when a type and screen is obtained, a type and cross can be quickly accomplished or in the rare emergent situation, type specific blood can be administered. To avoid pain and inconvenience, especially in the pediatric patient in whom awake phlebotomy may be problematic, the type and screen as well as the baseline hemoglobin may be obtained on the day of surgery following the induction of anesthesia and placement of an intravenous cannula. The incidence of random antibodies that complicate the type and cross process is low in patients who have never received a blood transfusion.

Another area of ongoing controversy is the need for routine preoperative pregnancy testing in post-menarchal patients. Given the theoretical potential for anesthetic agents to be teratogenic and the to increase the risk of spontaneous abortion, our current practice during the history is to include specific questioning about the potential for pregnancy including the patient's last menstrual cycle. While there is limited evidence-based medicine, our

**Table 3**
The Mallampati airway classification.

| *Class* | *Anatomical features visualized* |
|---|---|
| Class 1 | Complete visualization of the soft palate, uvula and tonsillar pillars. |
| Class 2 | Complete visualization of the soft palate with partial visualization of the uvula and tonsillar pillars |
| Class 3 | Visualization of only the base of the uvula and the soft palate. No visualization of the distal uvula or tonsillar pillars. |
| Class 4 | No visualization of the soft palate, uvula or tonsillar pillars. |

**Table 4**
Physical features suggestive of a difficult airway.

| *Physical feature* | *Clinical finding* |
|---|---|
| Length of upper incisors | Relatively long |
| Relation of maxillary and mandibular incisors during normal closure | Overbite with maxillary incisors anterior to mandibular incisors |
| Relation of maxillary and mandibular incisors during voluntary protrusion of mandible | Cannot bring mandibular incisors in front of maxillary incisors |
| Inter-incisor distance | Less than 3 centimeters (adult) or less than two finger breadths* |
| Visibility of uvula | Mallampati grade 3 or 4 |
| Shape of the palate | Highly arched or narrow |
| Size and/or integrity of the submandibular space | Small and/or indurated, firm or mass present |
| Thyromental distance | Less than 3 centimeters (adult) or less than 3 finger breaths* |
| Length of neck | Shorter length |
| Neck circumference | Larger neck circumference |
| Range of motion of head and neck | Limited flexion and extension |

* For this evaluation in a child, one should use the patient's own fingers.

**Table 5**
Wilson risk score for difficult endotracheal intubation.

| *Risk factor* | *0* | *1* | *2* |
|---|---|---|---|
| Weight | Less than 90 kilograms | Between 90-110 kilograms | Greater than 110 kilograms |
| Head and neck movement | Greater than 90 degrees | Approximately 90 degrees | Less than 90 degrees |
| Jaw movement | Incisor gap greater than 5 centimeters and subluxation greater than 0 | Incisor gap less than 5 centimeters and subluxation greater than 0 | Incisor gap less than 5 centimeters and subluxation less than 0 |
| Receding mandible | Normal | Moderate | Severe |
| Buck teeth | Normal | Moderate | Severe |

Score of 3 or more predicts 75% of difficult endotracheal intubations while 4 or more predicts 90%.

**Table 6**
American Society of Anesthesiologists (ASA) Physical Status Classification.

| *Classification* | *Description* | *Example* |
|---|---|---|
| 1 | Normal healthy patient | – |
| 2 | Mild systemic disease with no functional limitation | Mild asthma, acyanotic congenital heart disease (atrial septal defect) |
| 3 | Severe systemic disease with functional limitation | Sickle cell disease, cystic fibrosis, palliated cyanotic congenital heart disease |
| 4 | Severe systemic disease that is a constant threat to life | Advanced stages of muscular dystrophy, cyanotic congenital heart disease with pulmonary hypertension |
| 5 | Moribund patient not expected to survive for 24 hours | Perforated bowel with sepsis and shock |
| 6 | Brain-dead patient; organs are being removed for donor purposes | – |
| E | Emergency operation | – |

institution currently uses point-of-care urine pregnancy testing prior to surgical procedures or procedural sedation. Such practice has been questioned. A recent retrospective review of 8245 immediate presurgery pregnancy tests, found that there were 11 positive tests of which 6 were false positives.[51] Given the inaccuracies of pregnancy testing, especially in the early stages, other authors have suggested a more proactive approach with informed consent in the adult population.[52] This involves the patient agreeing that it is important given the risks, that she is not pregnant at the time of surgery and to either to abstain from intercourse or to use appropriate contraception from the first day of the menstrual period before operation until the time of surgery. The patient is asked to sign a declaration before surgery stating that she has avoided pregnancy and that this is her responsibility and that a negative pregnancy test on the day of surgery is not sufficient to exclude pregnancy.

Outside of the patient with complex comorbid diseases, advanced testing such as pulmonary function testing (PFT), electrocardiography, and echocardiography are not indicated. Preoperative echocardiography may be indicated in various clinical situations to define the anatomy in patients with congenital heart disease, evaluate the presence of residual shunts in patients with palliated heart disease or assess structural and valvular issues. Echocardiography is also frequently used to assess function in

patients exposed to anthracycline chemotherapeutic agents, in disease processes with myocardial involvement (muscular dystrophy), and in patients with known cardiomyopathy. While the risk of general anesthetic care is higher in patients with comorbid cardiac disease, there is limited evidence based medicine in the pediatric population to demonstrate the utility of echocardiography in risk stratifying these patients based on ejection fraction. In the adult population, an ejection fraction ≤ 30% has been shown to be associated with an increased risk of perioperative mortality and morbidity.[53] In the pediatric population, high-risk lesions and comorbid diseases include single ventricle anatomy such as hypoplastic left heart syndrome, aortic stenosis, cardiomyopathy with severely depressed function, and pulmonary hypertension.[32,54–56]

As with preoperative cardiac assessment, the majority of data demonstrating the utility of preoperative risk startificaiton based on PFT resides in the adult populations such as those with chronic obstructive pulmonary disease related or tobacco use. For these patients, there is an increased risk of respiratory complications, including the need for postoperative mechanical ventilation in patients with PFT values less than 60% predicted.[57] The pediatric data regarding such factors is generally derived from the perioperative care of patients with muscular dystrophy and is eloquently outlined by the ACCP consensus statement on the respiratory and related management of patients with Duchenne Muscular Dystrophy undergoing anesthesia or sedation.[58] In patients with an oxygen saturation less than 95% in room air, further investigation was suggested with measurement of either the partial pressure of carbon dioxide using a blood gas analysis or end-tidal carbon dioxide. The 95% threshold for the decision tree was based on data from Bach et al. that demonstrated improved outcomes when respiratory therapies were instituted in patients who developed oxygen saturations of these levels.[59] The panel also recommended measuring preoperative forced vital capacity (FVC) with the patient in the seated, upright body position partially based on work performed by Harper et al.[60] These investigators reported on a cohort of 45 patients, 20 of whom had a preoperative FVC ≤ 30% predicted for age. They noted no difference in the duration of postoperative endotracheal intubation, duration of support using non-invasive ventilation (NIV), total time with ventilator assistance, and inpatient stay. However, there were significant cardiorespiratory complications in both groups demonstrating that this is a high risk population. Five of the 20 patients (25%) with an FVC ≤ 30% had complications including adult respiratory distress syndrome (ARDS), respiratory tract infections, and the need for a tracheostomy while four of the 25 patients (16%) with a preoperative FVC ≥ 30% had complications. The one death in the cohort was in a patient with a FVC of 18% who initially had an uncomplicated postoperative course but went on to develop ARDS. The consensus panel from AACP used these data to provide a two-level risk-assessment scale such that preoperative FVC < 50% is suggested to be predictive of an increased risk of perioperative complications while there is a significantly increased risk if the preoperative FVC is < 30% of that predicted. These values can also be used to determine who would benefit from the use of prophylactic use of NIV to facilitate early tracheal extubation. The authors of the consensus statement also suggested the preoperative assessment of cough strength and effectiveness by measuring maximum expiratory pressure (MEP) and peak cough flow (PCF).[61,62] Preoperative training in and the postoperative use of manually and mechanically assisted cough devices was recommended for patients with a preoperative PCF ≤ 270 liters/minute or MEP ≤ 60 cmH2O.

## Preoperative evaluation: The final steps

The planned management of anesthesia is discussed with each patient including options for postoperative analgesia. Risks and possible complications are reviewed followed by obtaining informed consent and assent. Practices vary significantly as to the potential adverse effects and risks of anesthesia that are reviewed during the consent process. Is is necessary to mention the risk of death in the otherwise healthy, ASA 1 patient? In a review that included 56,263 anesthetics over a 68-month period, there was no mortality in patients with comorbid diseases.[56] This led the authors to suggest that during routine consent for anesthesia, it may not be appropriate to list risk of death for children who do not have significant comorbidities.

Following this, questions from the parents and patient are answered followed by a review of the plan for the day of surgery including NPO guidelines. As the preoperative visit may occur days prior to the anesthetic, these instructions should be reviewed during a phone call from a nurse the evening before surgery. This practice may limit misunderstandings such as NPO violations that may result in cancellations. Previously, patients were fasted for 8-12 hours before surgery, generally with NPO after midnight. Based on more recent evidence, there has been a significant revision in the perioperative fasting rules especially for infants and children. It has been demonstrated that clear liquids have a gastric emptying time of 1-2 hours while solids have an unpredictable gastric emptying time that may be greater than 6 hours.[63–70] The ingestion of clear liquids up to 2 hours before surgery does not increase gastric fluid volume or acidity.[63–67] As a result, the liberalization of guidelines for ingestion of clear liquids for elective surgery of otherwise healthy patients has been recommended.[68,69] Suggested guidelines as recommended by the ASA for patients with no known risk factors include no solid food for at least 6 hours before surgery and unrestricted clear liquids until 2 hours before surgery.[70] Instead of merely allowing clear liquids prior to surgery, their administration is encouraged and parents are reminded to allow their children to have clear liquids (apple juice) prior to coming to the hospital. This provides improved hydration and limits irritability related to NPO time.

## Summary

The preoperative evaluation is the first step in ensuring the safe conduct of anesthetic care in patients. Over the years, this process has changed significantly from a time when the majority of patients were admitted to the hospital the night before surgery to a time when the majority of patients, including those scheduled for major surgical procedures, arrive the day of surgery. For most patients, the preoperative examiantion can be conducted over the phone by a trained nurse or on-line via a survey. Regardless of where or how it occurs, the goals of the preoperative evaluation are to gain information regarding the patient's current status, comorbid conditions, and the intended procedure. This process allows the identification of patients who require additional preoperative testing or those patients who need to be seen by an anesthesiolgoist prior to the day of surgery. During the preopeative evalaution, decisions are made regarding further laboratory or investigative work-up. The preoperative meeting provides an arena to develop the initial parent-physcian rapport, outline anesthetic risks, and discuss the intended anesthetic plan including options for postoperative analgesia, and. The process facilitates the care of patients during the perioperative period while limiting surgical cancellations resulting from patient-related issues.

## References

1. Knox M, Myers E, Wilson I, Hurley M. The impact of pre-operative assessment clinics on elective surgical case cancellations. *Surgeon.* 2009;7:76–78.

2. Ferschl MB, Tung A, Sweitzer B, Huo D, Glick DB. Preoperative clinic visits reduce operating room cancellations and delays. *Anesthesiology.* 2005;103:855–859.
3. McKendrick DRA, Cumming GP, Lee AJ. A 5-year observational study of cancellations in the operating room: does the introduction of preoperative preparation have an impact? *Saudi J Anaesth.* 2014;8(Suppl 1):S8–S14.
4. Fischer SP. Development and effectiveness of an anesthesia preoperative evaluation clinic in a teaching hospital. *Anesthesiology.* 1996;85:196–206.
5. Hepner DL, Bader AM, Hurwitz S, Gustafson M, Tsen LC. Patient satisfaction with preoperative assessment in a preoperative assessment testing clinic. *Anesth Analg.* 2004;98:1099–1105.
6. Parker BM, Tetzlaff JE, Litaker DL, Maurer WG. Redefining the preoperative evaluation process and the role of the anesthesiologist. *J Clin Anesth.* 2000;12:350–356.
7. Starsnic MA, Guarnieri DM, Norris MC. Efficacy and financial benefit of an anesthesiologist-directed university preadmission evaluation center. *J Clin Anesth.* 1997;9:299–305.
8. Ireland S, Kent B. Telephone pre-operative assessment for adults: a comprehensive systematic review. *JBI Libr Syst Rev.* 2012;10:1452–1503.
9. Wong WW, Gabriel A, Maxwell GP, Gupta SC. Bleeding risks of herbal, homeopathic, and dietary supplements: a hidden nightmare for plastic surgeons? *Aesthet Surg J.* 2012;32:332–346.
10. Everett LL, Birmingham PK, Williams GD, Brenn BR, Shapiro JH. Herbal and homeopathic medication use in pediatric surgical patients. *Paediatr Anaesth.* 2005;15:455–460.
11. Jones CT, Raman VT, DeVries S, Cole JW, Kelleher KJ, Tobias JD. Optimizing anticonvulsant administration for children before anesthesia: a quality improvement project. *J Pediatr Neurol.* 2014;51:632–640.
12. Peck T, Wong A, Norman E. Anaesthetic implications of psychoactive drugs. *Cont Educ Anaesth Crit Care Pain.* 2010;10:177–181.
13. Devereaux PJ, Mrkobrada M, Sessler DI, et al. POISE-2 Investigators. Aspirin in patients undergoing noncardiac surgery. *N Engl J Med.* 2014;370:1494–1503.
14. Douketis JD, Berger PB, Dunn AS. The perioperative management of antithrombotic therapy: American College of Chest Physicians evidence-based clinical practice guidelines (8th ed) Chest, 133; 2008.p. 299S–339S.
15. Asserhoj L, Mosbech H, Kroigaard M, Garvey LH. No evidence for contraindications to use of propofol in adults allergic to egg, soy or peanut. *Br J Anaesth.* 2016;116:77–82.
16. Hepner DL, Castells MC. Anaphylaxis during the perioperative period. *Anesth Analg.* 2003;97:1381–1395.
17. Mertes PM, Laxenaire MC, Alla F. Anaphylactic and anaphylactoid reactions occurring during anesthesia in France in 1999–2000. *Anesthesiology.* 2003;99:536–545.
18. Ozdemir T, Arıkan A. Postoperative apnea after inguinal hernia repair in formerly premature infants: impacts of gestational age, postconceptional age and comorbidities. *Pediatr Surg Int.* 2013;29:801–804.
19. Britt BA, Kalow W. Malignant hyperthermia: a statistical review. *Can Anaesth Soc J.* 1970;17:293–297.
20. Mickelson JR, Gallant EM, Litterer LA, et al. Abnormal sarcoplasmic reticulum ryanodine receptor in malignant hyperthermia. *J Biochem Chem.* 1988;263:9310–9316.
21. Coté CJ, Posner KL, Domino KB. Death or neurologic injury after tonsillectomy in children with a focus on obstructive sleep apnea: houston, we have a problem! *Anesth Analg.* 2014;118:1276–1283.
22. Goldman JL, Baugh RF, Davies L, et al. Mortality and major morbidity after tonsillectomy. *Laryngoscope.* 2013;123:2544–2553.
23. Kako H, Tripi J, Walia H, Tumin D, Splaingard M, Jatana KR, Tobias JD, Raman VT. Utility of screening questionnaire and polysomnography to predict postoperative outcomes in children. *Int J Pediatr Otorhinolaryngol.* 2017;102:71–75.
24. Raman VT, Splaingard M, Tumin D, Rice J, Jatana KR, Tobias JD. Utility of screening questionnaire, obesity, neck circumference, and sleep polysomnography to predict sleep-disordered breathing in children and adolescents. *Paediatr Anaesth.* 2016;26:655–664.
25. Raman VT, Jatana KR, Elmaraghy CA, Tobias JD. Guidelines to decrease unanticipated hospital admission following adenotonsillectomy in the pediatric population. *Int J Pediatr Otorhinolaryngol.* 2014;78:19–22.
26. Tait AR, Malviya S. Anesthesia for the child with an upper respiratory tract infection: still a dilemma? *Anesth Analg.* 2005;100:59–65.
27. Tait AR, Reynolds PI, Gutstein HB. Factors that influence an anesthesiologist's decision to cancel elective surgery for the child with an upper respiratory tract infection. *J Clin Anesth.* 1995;7:491–499.
28. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists task force on management of the difficult airway. *Anesthesiology.* 2013;118:251–270.
29. Hernrich S, Birkholz T, Ilmsen H, et al. Incidence and predictors of difficult laryngoscopy in 11,219 pediatric anesthesia procedures. *Pediatr Anesth.* 2012;22:729–736.
30. Mirghassemi A, Soltani A, Abtahi M. Evaluation of laryngoscopic views and related influencing factors in a pediatric population. *Pediatr Anesth.* 2011;21:663–667.
31. Frei FJ, Ummenhofer W. Difficult intubation in paediatrics. *Paediatr Anaesth.* 1996;6:251–263.
32. Bhananker SM, Ramamoorthy C, Geiduschek JM, et al. Anesthesia-related cardiac arrest in children: update from the pediatric perioperative cardiac arrest registry. *Anesth Analg.* 2007;105:344–350.
33. Jimenez N, Posner KL, Cheney FW, Caplan RA, Lee LA, Domino KB. An update on pediatric anesthesia liability: a closed claims analysis. *Anesth Analg.* 2007;104:147–153.
34. Butler MG, Hayes BG, Hathaway MM, Begleiter ML. Specific genetic diseases at risk for sedation/anesthesia complications. *Anesth Analg.* 2000;91:837–855.
35. Heinrich S, Birkholz T, Irouschek A, Ackermann A, Schmidt J. Incidences and predictors of difficult laryngoscopy in adult patients undergoing general anesthesia. *J Anesth.* 2013;27:815–821.
36. Uezono S, Holzman RS, Goto T, Nakata Y, Nagata S, Morita S. Prediction of difficult airway in school-aged patients with microtia. *Paediatr Anaesth.* 2001;11:409–413.
37. Kim WH, Ahn HJ, Lee CJ, Shin BS, Ko JS, Choi SJ, Ryu SA. Neck circumference to thyromental distance ratio: a new predictor of difficult intubation in obese patients. *Br J Anaesth.* 2011;106:743–748.
38. Wilson ME, Spiegelhalter D, Robertson JA, Lesser P. Predicting difficult intubation. *Br J Anaesth.* 1988;61:211–216.
39. Shiga T, Wajima Z. Predicting difficult intubation in apparently normal patients: a meta-analysis of bedside screening test performance. *Anesthesiology.* 2005;103:429–437.
40. Panoulas VF, Daigeler AL, Malaweera AS, Lota AS, Baskaran D, Rahman S, et al. Pocket-size hand-held cardiac ultrasound as an adjunct to clinical examination in the hands of medical students and junior doctors. *Eur Heart J Cardiovasc Imaging.* 2013;14:323–330.
41. Stokke TM, Ruddox V, Sarvari SI, Otterstad JE, Aune E, Edvardsen T. Brief group training of medical students in focused cardiac ultrasound may improve diagnostic accuracy of physical examination. *J Am Soc Echocardiogr.* 2014;27:1238–1246.
42. Bock M, Fritsch G, Hepner DL. Preoperative laboratory testing. *Anesthesiol Clin.* 2016;34:43–58.
43. Kaplan EB, Sheiner LB, Boeckmann AI, et al. The usefulness of preoperative laboratory screening. *JAMA.* 1985;253:3576–3581.
44. Burk CD, Miller L, Hander SD, Cohen AR. Preoperative history and coagulation screening in children undergoing tonsillectomy. *Pediatrics.* 1992;89:691–695.
45. Tolksdorf W. Electrolyte disorders relevant to anesthesia. *Acta Anaesthesiol Scand Suppl.* 1997;111:328–329.
46. Kamata M, Cartabuke RS, Tobias JD. Perioperative care of infants with pyloric stenosis. *Paediatr Anaesth.* 2015;25:1193–1206.
47. Pandya S, Heiss K. Pyloric stenosis in pediatric surgery: an evidence-based review. *Surg Clin N Am.* 2012;92:527–539.
48. Grupp-Phelan J, Tanz RR. How rational is the crossmatching of blood in a pediatric emergency department? *Arch Pediatr Adolesc Med.* 1996;150:1140–1144.
49. Kouritas VK, Graham S, Marwah G, Papastefanou SL. Can we reduce routine blood ordering in spinal surgery? *Transfus Altern Transf Med.* 2011;11:138–142.
50. Yang MM, Singhal A, Au N, Hengel AR. Impact of preoperative laboratory investigation and blood cross-match on clinical management of pediatric neurosurgical patients. *Childs Nerv Syst.* 2015;31:533–539.
51. Gong X, Poterack KA. Retrospective review of universal preoperative pregnancy testing: results and perspectives. Anesth Analg (in press).
52. Wingfield M, McMenamin M. Preoperative pregnancy testing. *Br J Surg.* 2014;101:1488–1490.
53. Healy KO, Waksmonski CA, Altman RK, Stetson PD, Reyentovich A, Maurer MS. Perioperative outcome and long-term mortality for heart failure patients undergoing intermediate- and high-risk noncardiac surgery: impact of left ventricular ejection fraction. *Congest Heart Fail.* 2010;16:45–49.
54. Friesen RH, Williams GD. Anesthetic management of children with pulmonary arterial hypertension. *Paediatr Anaesth.* 2008;18:208–216.
55. Ramamoorthy C, Haberkern CM, Bhananker S, et al. Anesthesia-related cardiac arrest in children with heart disease: data from the Pediatric Perioperative Cardiac Arrest (POCA) registry. *Anesth Analg.* 2010;110:1376–1382.
56. van der Griend BF, Lister NA, McKenzie IM, Martin N, Ragg PG, Sheppard SJ, Davidson AJ. Postoperative mortality in children after 101,885 anesthetics at a tertiary pediatric hospital. *Anesth Analg.* 2011;112:1440–1447.
57. Smetana GW, Lawrence VA, Cornell JE. Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for the American College of Physicians. *Ann Int Med.* 2006;144:581–595American College of Physicians.
58. Birnkrant DJ. The American College of Chest Physicians consensus statement on the respiratory and related management of patients with Duchenne Muscular Dystrophy undergoing anesthesia or sedation. *Pediatrics.* 2009;123:S242–S244.
59. Bach JR, Ishikawa Y, Kim H. Prevention of pulmonary morbidity for patients with Duchenne muscular dystrophy. *Chest.* 1997;112:1024–1102.
60. Harper CM, Ambler G, Edge G. The prognostic value of pre-operative predicted forced vital capacity in corrective spinal surgery for Duchenne's muscular dystrophy. *Anaesthesia.* 2004;59:1160–1162.
61. Szeinberg A, Tabachnik E, Rashed N, et al. Cough capacity in patients with muscular dystrophy. *Chest.* 1988;94:1232–1235.
62. Tzeng AC, Bach JR. Prevention of pulmonary morbidity for patients with neuromuscular disease. *Chest.* 2000;118:1390–1396.
63. Crawford M, Lerman J, Christensen S, et al. Effects of duration of fasting on gastric fluid pH and volume in healthy children. *Anesth Analg.* 1990;71:400–403.
64. Shevde K, Trivedi N. Effects of clear liquids on gastric volume and pH in healthy volunteers. *Anesth Analg.* 1991;72:528–531.
65. Phillips S, Hutchinson S, Davidson T. Preoperative drinking does not affect gastric contents. *Br J Anaesth.* 1993;70:6–9.

66. Read MS, Vaughn RS. Allowing pre-operative patients to drink: effects on patients' safety and comfort of unlimited oral water until 2 hours before anaesthesia. *Acta Anaesthesiol Scand.* 1991;35:591–595.
67. Goresky GV, Maltby JR. Fasting guidelines for elective surgical patients. *Can J Anaesth.* 1990;37:493–495.
68. Strunin L. How long should patients fast before surgery? Time for new guidelines. *Br J Anaesth.* 1993;70:1–2.
69. Green CR, Pandit SK, Schork MA. Preoperative fasting time: is the traditional policy changing? Results of a national survey. *Anesth Analg.* 1996;83:123–128.
70. American Society of Anesthesiologists Committee. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: an updated report by the American Society of Anesthesiologists Committee on Standards and Practice Parameters. *Anesthesiology.* 2011;114:495–511.