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THE ROLE OF LABORATORY TESTS IN DETERMINING PATIENTS' NEEDS FOR NUTRITION AND RESPIRATORY THERAPY BEFORE ANESTHESIA

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Abstract

Laboratory Tests to Evaluate Patients' Needs for Nutrition Therapy and Respiratory Therapy before Anesthesia Anesthesia is a sleep-like condition with controlled consciousness, pain sensitivity, and muscle relaxation. It is used during surgical procedures to make the patient unconscious and to prevent any pain. Before anesthesia, it is important to examine patients' disabilities and the provision of appropriate therapy to improve safety and outcomes. Laboratory tests are important because they provide quantitative data about patients. Hence, they can be used to check patients' needs for nutritional therapy and respiratory therapy. It is hypothesized that laboratory tests can adequately evaluate patients' needs for nutrition therapy and respiratory therapy. The hypothesis will be examined in patients pre-anesthetized for elective surgical procedures in this study. The main themes of the study are the role of laboratory tests in determining patients' needs for nutrition therapy and respiratory therapy prior to anesthesia. In the pre-anesthesia period, factors affecting the anesthetic approach must be evaluated and relevant therapies provided. Anesthetics affect the central nervous system and artificially control consciousness, perception of pain, and responses to stimuli. During anesthesia, nutrition and respiratory function are suspended, but they are interconnected ((Suglo et al., 2020)). Therefore, it is important to evaluate both prior to anesthesia, and to prepare the anesthetic approach accordingly. The purpose of this study is to examine the role of laboratory tests in determining patients' needs for nutrition therapy and respiratory therapy prior to anesthesia. It is conducted as a preliminary investigation involving a small number of patients. Anesthesia is a medically induced controlled state of unconsciousness, analgesia, and muscle relaxation. Perioperative anesthesia involves a pre-anesthesia period, an induction period, an maintenance period, and a recovery period. The pre-anesthesia period encompasses the time prior to anesthesia induction and involves planning an anesthetic approach based on the evaluation of patients' physical conditions and other factors affecting anesthesia ((Pike et al., 2020)). Attention during the pre-anesthesia period is focused on possible disabilities that may complicate anesthesia. It is important to determine the degree of disability and to provide

appropriate therapy to improve safety and outcomes. There are several possible causes of disabilities affecting respiratory function and anesthetic safety.

Keywords

Keywords: Laboratory Tests, Nutrition, Respiratory Therapy, Anesthesia

1. Introduction

As surgical procedures grow in number and complexity, the need for anesthesia increases as well. This in turn necessitates a greater need for thorough evaluations prior to anesthesia. Consequently, this creates a need for preventive measures against undesirable anesthetic outcomes. There are many factors that could affect the outcomes of anesthesia, but among them, nutrition and respiratory health are especially pivotal factors. Therefore, pre-anesthesia evaluations regarding these laboratory conditions is vital in forming an understanding of patient needs (Kumar & Srivastava, 2011). This is particularly important as the depth and scope of health care provided to patients continues to broaden with the advancement in surgical technologies and medical know-how. The laboratory tests in the considerations of nutrition and respiration presented herein, and how they could be most effectively applied in clinical settings will be assessed.

Anesthesia is commonly a routine part of the surgical process, but a great amount of care and complexity is involved in its management. There are numerous intrinsic patient factors that can greatly influence the effects that anesthesia will have on a patient. Most of these factors cannot be directly observed, and so there are many assessments that must be done prior to surgery under anesthesia in order to prevent anything adverse from taking place. As such, a thorough understanding of a patient's conditions regarding health is needed prior to deciding how to go about conducting their surgery. Similarly, outside of just patient intrinsic factors, there are also numerous extrinsic factors regarding the approach to health management that could affect the outcome from surgery under anesthesia. Out of all the external factors, laboratory assessments have become a routine part of the health management process. However, there are still some concerns regarding exactly how to appropriately apply lab tests to best progress in understanding a patient's needs. In regard to these understandings, considerations will be given to how laboratory tests regarding nutrition and respiration could be most effectively applied and how these considerations were formed based on a review of current literature.

2. Importance of Pre-Anesthesia Assessment

Before anesthesia is administered, patients must be thoroughly assessed to limit any potential complications during their surgery. Assessments are crucial to ensuring patient safety and yielding successful surgical results. A patient's age, weight, and numerous other factors can influence how anesthesia should be managed (Kumar & Srivastava, 2011). Most importantly, a patient's underlying health can significantly affect how they respond to anesthesia and has the potential to cause serious complications that may result in death. A specific team of medical professionals is responsible for the pre-anesthesia assessment that evaluates each patient's individual risks concerning anesthesia. During these assessments, most obvious concerns regarding a patient's health are addressed. However, an important part of the pre-anesthesia assessment is the laboratory tests that patients are required to undergo before meeting with the anesthesia care team. Often, patients are unaware of the laboratory tests being conducted prior to anesthesia and the importance of the results in determining care plans. Although the safety of patients undergoing anesthesia has greatly increased due to advancements in technology and research, there are still potential complications that may arise. Anesthesia care teams make

every effort to avoid complications by carefully assessing each patient prior to their surgery. A vast majority of the observations made by the anesthesia care team during a pre-anesthesia assessment come from a successful physical examination. Still, there are abnormalities that physical examinations cannot reveal; therefore, laboratory tests are required. For instance, it is not uncommon for patients to display low levels of hemoglobin that could indicate anemia. Such an abnormality would go unnoticed without a complete blood count test. Results from laboratory tests reveal hidden abnormalities that would otherwise not be apparent, allowing the anesthesia care team to take the necessary precautions to prevent possible complications. Every patient assessed by the anesthesia care team should have a personalized anesthetic plan based on the input gathered from their assessment. Each plan is designed to maintain the safety of a patient throughout their anesthesia experience, especially considering that no two patients are alike. However, specific precautions cannot be taken without the knowledge gained from laboratory tests, as certain risks would go unnoticed. For example, a patient may have a heart condition that puts them at risk for arrhythmia during anesthesia. If this risk is known, steps can be taken to manage it, such as administering medication to stabilize the heart before anesthesia is induced. Without the necessary tests and a thorough evaluation of the results, such precautions may not be taken, and the patient would be put under anesthesia blindly. Ultimately, it is in the best interest of the patient safety and care quality for laboratory tests to be conducted prior to meeting with the anesthesia care team. Having the input of the laboratory tests results allows for better-informed decisions on care and the overall quality of patient safety to be maintained. The pre-anesthesia evaluation takes place over many one-on-one meetings between patients and the medical professionals involved in their surgery. The first meeting involves the surgeon inquiring about the patient's overall health and specific concerns regarding the surgery. After the meeting, the patient is sent to an intensive care unit where they will meet with the team responsible for conducting the pre-anesthesia assessment, monitoring the patient during anesthesia, and tending to them immediately following recovery from anesthesia. The medical professionals involved in these procedures include an attending anesthesiologist, anesthesia residents, and nurse anesthetists. During this meeting, the anesthesia care team will complete the pre-anesthesia assessment comprised of a physical examination and input from laboratory tests and vital signs recorded prior to the patient's meeting with the team. Having the vital signs and laboratory test results prior to the meeting allows for a more thorough and efficient assessment process. During the assessment, the anesthesia care team will evaluate the input gathered and determine the anesthetic plan for the patient. The plan is designed to mitigate any risks discovered during the assessment for implementation during the procedure, but this would not be possible without collaboration among medical professionals. Each member of the anesthesia care team contributes unique expertise to the assessment process, and this collaboration enhances the quality of patient care. For instance, an attending anesthesiologist may recognize a risk that a resident anesthesiologist overlooks due to their extensive experience. Additionally, each member of the anesthesia care team monitors patients in various surgical specialties, meaning they may discover risks concerning anesthesia that would go unnoticed by medical professionals focusing solely on surgery. Having the unique perspectives and expertise of all the medical professionals involved in a patient's anesthesia care during the assessment process is crucial to quality care. Pre-anesthesia assessments are attended to by multiple medical professionals, but the patient only interacts with one individual during the assessment process. Each resident or nurse anesthetist completes a number of assessments, and the attending anesthesiologist reads over the

assessments before the care plan is implemented. If plans allow for it, the attending anesthesiologist may also observe the assessment process or discuss plans with the involved resident or nurse anesthetist. Regardless, the collaborative nature of the assessment process highlights its importance in maintaining the quality of patient care during anesthesia. Pre-anesthesia assessments that take into consideration the input of laboratory test results, vital signs, and thorough physical examinations should be prioritized in clinical practice to enhance patients' safety during anesthesia. Despite advancements in technology and research that make anesthesia safer than ever, it is not without risks. Efforts should be made to have every patient anesthesia care team assessed, as it is a crucial part of determining the risks of anesthesia for individual patients and designing care plans to control those risks.

3. Nutritional Assessment Before Anesthesia

Nutritional assessment is an essential part of pre-anesthesia evaluations. Patient's needs for nutrition therapy should be evaluated as a part of pre-anesthesia laboratory workup. Considerations on how to assess nutritional needs of patients prior to general anesthesia are discussed. Nutritional support interventions are vital to improve surgical outcomes. Laboratory tests offer quantifiable data to support assessment of nutritional needs. These data helps providers to design patient specific nutritional support plans prior to anesthesia. Evaluating need for nutritional support prior to general anesthesia help to improve patients surgical outcomes (R. Hirsch et al., 2021).

Evaluation of nutritional status can be achieved by a combination of approaches, which include anthropometric measurements, dietary history, and biochemical markers. Anthropometric measurements include weight, height, body mass index (BMI), calf circumference, or tricep skin fold thickness. Dietary history needs to include history of oral intake, appetite, weight change, and difficulty in chewing and swallowing. Biochemical markers can include serum albumin, pre-albumin, total cholesterol, or lymphocyte count. Hypoalbuminemia is the most widely used screening tool for nutritional assessment prior to surgery. However, albumin level can also be low due to other reasons than malnutrition. Still, many studies demonstrated that patients who are malnourished as defined by albumin level are at an increased risk for complications during and after anesthesia (Caccialanza et al., 2015).

It is interesting to note that patients can be hypoalbuminemic due to reasons aside from a low protein intake. For example, thoracic or abdominal diseases can cause a patient to have a low albumin level, but without any evidence of malnutrition. Thus, surgeons should be cautious about over-interpreting albumin levels when considering a patient's nutritional status. On a different note, it has been observed that specific nutrition deficits can mostly affect respiratory function. The need for higher doses of narcotics can be driven by the patient's nutritional status, weight, and frailty. For these reasons, it is vital to identify patients who are at risk of becoming malnourished and to treat them prior to surgery. Ideally, malnourished patients should have nutritional interventions performed at least 7-10 days prior to elective surgeries.

3.1. Indications for Nutritional Assessment

Nutritional assessment prior to anesthesia is critical for certain patient populations. Those considered "at-risk" should receive a comprehensive nutritional assessment before procedures requiring anesthesia. A patient's history and laboratory tests can help determine if a dietary and metabolic assessment is necessary (R. Hirsch et al., 2021). Indicators that may require a nutritional assessment include: 1) significant, unintentional weight loss (≥5% over 1 month, ≥10% over 6 months); 2) chronic illness or disability; 3) altered dietary patterns for ≥2 weeks; 4) unintentional weight loss and poor dietary intake; 5) metabolic stress; 6) drug or alcohol

abuse; 7) gastro-intestinal disease associated with malabsorption; 8) complicated diabetes; 9) surgical procedures that may predispose to nutritional deficiencies; 10) age over 70 years and one other risk. Recognizing these indications will assist staff in prioritizing patients requiring a nutritional assessment. The priority list for dietary and metabolic assessment should include patients with the above risk factors. Studies show early identification of malnutrition to be beneficial in the conduct of dietary and metabolic treatment, therefore minimizing post-operative complications. Comprehensive nutritional care plans initiated pre-operatively can reduce the need for post-operative intensive care, duration of hospitalization, and increase the proportion of patients sent home. These criteria assist in patient care by proactively identifying those who would benefit from a detailed assessment, thereby improving surgical care quality.

3.2. Types of Nutritional Assessment Tests

Nutritional assessment tests offer a variety of objective and subjective measures to evaluate nutritional status. Subjective measures are traditionally simple tools that require the patient's or the assessor's input. This category includes dietary recalls, 24-hour dietary history, food frequency questionnaires, and subjective global assessment scoring systems. These tests are relevant in uncovering nutritional excesses or deficiencies, such as obesity or a specific vitamin deficiency. On the other hand, laboratory or biochemical analyses, anthropometrics, and physical examinations fall under the objective measure category. The former group usually requires a complicated clinical setup, while the latter group can be adapted to rural settings with limited resources (KARIM KIANI et al., 2022). Each of these tests can be utilized to assess a specific aspect of the patient's nutritional profile, but no single test can comprehensively represent the overall nutritional status. Most clinical applications use a combination of assessment methods, employing subjective measures to screen for likely candidates requiring extensive objective testing (Hamada, 2018). Screening generally aims to determine the likelihood of a particular condition, while assessment determines the presence or severity of that condition. In continuous care situations, nutritional status is preferably monitored and reassessed periodically rather than solely screening or assessing it.

Laboratory tests determine the objective nutritional status. However, many clinical laboratories only offer routine biochemical analyses without specific nutritional parameters. As a result, nutritional assessment based on objective criteria is often infeasible. Due to the narrow interpretation of some laboratory tests, objective nutritional status determination may not be possible despite the availability of relevant data. For example, serum albumin and prealbumin concentrations are often misused as indicators of nutritional status in critically ill patients. To compensate, clinical labs can easily adopt and implement nutritional tests, which often merely elaborate on existing biochemical data. Nevertheless, careful consideration of the confounding effects of collection, storage, and systemic factors is crucial for the reliable interpretation of these tests. Ultimately, it is necessary to emphasize that the limitation of the laboratory approach is not in the methodology itself but in the clinical interpretation of results. If applied correctly, nutritional tests can yield insights into patients' nutritional status or requirements on a par with quantifying other physiological variables. Nutritional screening, assessment, and monitoring are integral components of pre-anesthetic care, as inadequate nutrition affects surgical outcomes. Evaluating nutritional status is vital for planning perioperative care, and assessment methodology assists in forming intervention strategies. Nutritional tests can help identify patients at risk of post-operative complications or those requiring therapy enhancement.

4. Respiratory Assessment Before Anesthesia

Respiratory function is integral to the safety of anesthesia administration. Respiratory health has important effects on the selection and administration of anesthetic agents. A thorough evaluation of respiratory function should be performed as part of the pre-anesthesia assessment. The assessment may be comprised of clinical evaluation and pertinent laboratory tests. Authentic clinical evaluation of respiratory function demands knowledge of basic respiratory anatomy and physiology, as well as familiarity with clinical signs of respiratory compromise. The ability to recognize high-risk patients is critical to anesthetists' clinical practice, particularly so in the case of patients exhibiting chronic respiratory pathology. Such patients may require additional consideration when administering anesthesia, as altered respiratory function can strongly affect the choice of anesthetic agents and techniques (Karcz & J Papadakos, 2013). Thus, understanding the pathological underpinnings of respiratory disease allows provision of safer anesthetic management.

Preoperative assessment in general is aimed at classifying the degree of surgical risk and preventing avoidable post-operative morbidity and mortality. Although many different factors must be taken into account when estimating surgical risk, respiratory disease and function are in many ways of paramount importance. This is because the integrity of the respiratory system is critical to consideration of perioperative safety. Strategies directed at reducing perioperative respiratory diagnostic or therapeutic intervention associated with compromised function can result in improved clinical outcome and substantial reduction in complications (Schwartz et al., 2020). In fact, the degree of respiratory compromise is one of the most important determinants of overall perioperative outcome. Robust assessment of respiratory function prior to anesthesia thus has far-reaching implications regarding the safety of surgical intervention. Proactive identification and rectification of pathological states and anesthetic planning based on these assessments are critical to optimizing perioperative safety. It should also be noted that surgical or anesthetic intervention can in some cases result unanticipated deterioration of a normally well-functioning respiratory system, so these assessments are of use for planning contingency measures in advance. Accordingly, pre-anesthesia evaluations of respiratory function are typically conducted in patients at the upper end of the risk spectrum (e.g., patients with complex or high-risk procedures or those with significant pre-existing compromise). In light of this, respiratory assessments prior to anesthesia should be fully comprehensive, incorporating both clinical evaluation and appropriate laboratory test (e.g., spirometry, blood gas analysis). The perioperative period is a particularly vulnerable time for patients with pathologies of the respiratory system, which has led to the development of best practice guidelines for their ongoing management. These typically emphasize a collaborative, multi-disciplinary approach to consideration of respiratory concerns in surgical candidates and include extensive procedures for respiratory assessment directly prior to surgery. Thus, respiratory assessment prior to anesthesia ought to be considered routine practice.

4.1. Indications for Respiratory Assessment

Before anesthesia, laboratory tests play a critical role in determining patients' needs for nutrition and respiratory therapy. A nutritional assessment is essential to evaluate a patient's nutritional status, intake, and requirements before surgery. It should involve a dietary history, anthropometric measurements, and laboratory tests. Common laboratory tests include serum/urine electrolytes, urea, creatinine, glucose, liver enzymes, and albumin. These tests can indicate dehydration, kidney dysfunction, diabetes, liver dysfunction, and nutritional status (Schwartz et al., 2020). On the other hand, a respiratory assessment is crucial to evaluate a

patient's respiratory function and needs for respiratory therapy before surgery. The assessment should consider a patient's medical history, co-morbidities, symptoms, and medication history, focusing on respiratory diseases and treatments. Additional information can be obtained from laboratory tests like arterial blood gases or pulmonary function tests. It is essential to identify patients at risk for obstructive sleep apnea and ventilation issues. The patient's health status determines which assessments take priority. Anesthetic plan adjustments rely on recognizing other comorbidities and risks. Analyses on patients' needs for nutrition and respiratory therapy before anesthesia highlight the importance of these assessments. A comprehensive respiratory assessment should be undertaken when a patient has pre-existing respiratory disease, recent upper/lower respiratory infection, a history of tobacco usage, or presents other comorbidities (obesity, cardiovascular problems). Prior to an anesthetic, it is essential to recognize patients at risk for obstructive sleep apnea (OSA), as this may compromise some aspects of safety normally associated with general anesthesia. Some patients may need specialist assessment regarding ventilation issues. The presence of one co-morbidity may worsen the effect of other co-morbidities; for example, obesity may impair respiratory function, while concomitant cardiac problems may increase sensitivity to such impairment during anesthesia. It is the responsibility of the anesthesia provider to ensure appropriate pre-anesthetic respiratory assessment to detect and lessen the effect of risks prior to the anesthetic. A detailed respiratory assessment including history and examination should be undertaken if, prior to anesthesia, the patient presents with any of the following: clinically evident respiratory disease; recent upper respiratory infection within 6 weeks; recent lower respiratory infection or exposure within 3 months; reduced exercise tolerance, unexplained breathlessness or other respiratory symptoms; a history of excessive alcohol or other sedative use; a history of excessive tobacco use; or an abnormality detected on respiratory/oxygenation observations.

4.2. Types of Respiratory Assessment Tests

To identify patients at risk of pre-anesthesia respiratory failure, prior respiratory capacity estimation is necessary. Respiratory assessment tests can determine if patients are in need of respiratory therapy prior to anesthesia. Respiratory assessment tests prior to anesthesia include a combination of subjective and objective tests carried out by health care providers. Subjective tests include reviewing past hospital admissions, comorbidities, and symptoms, while objective tests include pulmonary function tests, imaging studies, and clinical assessments. Objective tests provide insight into a patient’s respiratory capacity and function, which in turn allows for risk stratification prior to anesthesia (Rehouma et al., 2020).

Pulmonary function tests (PFTs) measure different parameters of respiratory capacity and function. PFTs are both non-invasive and objective, which make them ideal for pre-anesthesia screening. PFTs can be conducted via spirometry or plethysmography. Spirometry is the most common PFT that measures the volume of air in liters inhaled and exhaled per time unit, typically in seconds. Forced Vital Capacity (FVC) is the total volume of air exhaled after maximal inhalation, and Forced Expiratory Volume in 1st second (FEV1) is the volume exhaled in the first second. The ratio of these two is the FEV1/FVC ratio, which is a proportion of lung volume exhaled to lung capacity. Imaging studies visually assess the anatomy of the respiratory system, which can provide insight on pathologies such as atelectasis or pneumonia. Clinical assessments are subjective tests used to estimate risk of obstructive sleep apnea, which is important to assess prior to anesthesia. A combination of these tests can be employed to develop a comprehensive understanding of a patient’s respiratory health.

5. Laboratory Tests for Pre-Anesthesia Assessment

Pre-anesthesia assessment for anesthesia usually comprises an evaluation of the patient's medical history, physical findings, and laboratory tests. Each patient's laboratory tests are different and based on the clinical judgment of the anesthetist. The results of these tests, combined with the history and physical findings, provide data regarding the patient's health status and help the anesthetist decide on the type of anesthesia (Kumar & Srivastava, 2011). The variety of laboratory tests essential in conducting thorough pre-anesthesia assessments is described here. Routine laboratory tests before surgery are commonly performed by anesthetists. Key laboratory tests conducted pre-anesthesia and their relevance in assessing patient fitness for anesthesia are summarized.

A complete blood count (CBC) is a broad screening test that checks for disorders such as anemia, infection, and many other diseases. The complete blood count is one of the most common blood tests. It typically requires taking a sample of blood from a vein in the arm. In infants and young children, the blood can be drawn from a heel prick or from a vein in the hand or wrist. A CBC measures several components and features of a patient's blood, including red blood cells (RBCs), white blood cells (WBCs), hemoglobin, hemocrit, and platelets. The CBC provides information about the cells in a patient's blood. The basic CBC test counts the number of each type of blood cell and measures some of their characteristics, such as the size of the cells. A blood count provides information on the presence of various blood disorders, including anemia and leukemia. Patients with low levels of hemoglobin may require blood transfusions. If signs of infection are present, a differential white blood cell count may be requested.

Electrolyte balance is vital for the normal functioning of cells and organs, and the heart is no exception. An electrolyte panel is usually conducted to monitor electrolyte levels and kidney function in patients with conditions that can cause an electrolyte imbalance, such as medications that affect kidney function, eating disorders, prolonged vomiting, or diarrhea, and excessive sweating. Electrolytes are minerals in the blood and other body fluids that carry an electric charge. The body needs proper electrolyte levels for several essential functions, including regulating nerve and muscle function, hydrating the body, balancing blood acidity and pressure, and rebuilding damaged tissues. An electrolyte panel measures the amounts of several electrolytes in the blood, including sodium, potassium, bicarbonate, chloride, calcium, and magnesium. The panel may also include tests to measure kidney function, including blood urea nitrogen (BUN) and creatinine levels, which provide additional information. Sodium and chloride levels are usually controlled with the administration of intravenous fluids. Potassium levels must be closely monitored because an increase in potassium can lead to arrhythmias and cardiac arrest.

A liver function test panel measures different enzymes, proteins, and substances in a patient's blood that help evaluate the performance of the liver and diagnose liver diseases. The liver has many critical functions, including manufacturing proteins, cleaning the blood of harmful substances, regulating cholesterol levels, and metabolizing drugs. These tests can determine if the liver is damaged or diseased and how well it is functioning. Some standard liver function tests include albumin, alkaline phosphatase (ALP), alanine transaminase (ALT), aspartate transaminase (AST), bilirubin, and gamma-glutamyl transferase (GGT). Total protein, prothrombin time (PT), and some tests of viral hepatitis may also assess liver function. Pre-anesthetic assessment should include a liver function test, especially in patients with a history of alcohol abuse or taking medications that may cause an adverse effect on the liver.

Renal function tests like serum creatinine and blood urea nitrogen (BUN) are routinely measured to assess renal function or as part of an electrolyte panel. A more comprehensive assessment of renal function can be obtained using creatinine clearance or estimated GFR and by measuring a urine sample. Creatinine is a waste product generated constantly from muscle metabolism. Creatinine is freely filtered across the glomerulus and is not secreted or reabsorbed in significant amounts, making it an excellent endogenous marker of GFR. The serum creatinine is measured, and the patient's age, sex, and race are used to estimate creatinine clearance. Serum creatinine is usually elevated only after a significant loss of renal function (≥50%). Thus, in acute kidney injury, the creatinine clearance may be measured using a 24-hour urine collection. Coagulation studies, such as prothrombin time (PT)/international normalized ratio (INR) and activated partial thromboplastin time (aPTT), are most often obtained to evaluate patients taking anticoagulant medications prior to surgery. PT/INR is obtained to evaluate the extrinsic pathway of coagulation, while aPTT evaluates the intrinsic pathway.

5.1. Complete Blood Count (CBC)

As one of the most commonly performed laboratory tests, the complete blood count (CBC) provides fundamental information about a patient's hematological status. The test measures the total number of red blood cells (RBCs), white blood cells (WBCs), and platelets, along with hemoglobin concentration, hematocrit, and red cell indices for RBC size and volume. The CBC WBC differential count quantifies the percentage of each of the five leukocyte subtypes: neutrophils, lymphocytes, monocytes, eosinophils, and basophils (Seo & Lee, 2022). The platelet volume is also measured in addition to total platelet number. During the perioperative period, several CBC parameters can shed light on a patient's need for nutritional therapy and/or respiratory therapy prior to anesthesia. In particular, hemoglobin concentration is critical in evaluating a patient's anemia status, which is one of the most common co-morbidities in the surgical population (Tefferi et al., 2005). Anemia can compromise a patient's physiologic reserve and damage end organs, increasing the risk of adverse perioperative outcomes. Thus, it is essential to perform a CBC as part of a pre-anesthesia assessment to prevent critically low hemoglobin concentration from going undetected. Other important CBC parameters are those that indicate inflammatory or infectious states, which may change a patient's need for anesthesia and surgery as well as overall risk during the perioperative period. Total WBC count and the CBC WBC differential count can inform the perioperative physician of such states that warrant postponing an elective procedure or changing anesthesia technique. CBC platelet count is informative of bleeding tendency secondary to a coagulopathy. A coagulopathy may arise from underlying liver disease, which is critical to recognize due to a heightened risk of anesthetic and surgical intervention. If coagulopathy is suspected based on a CBC platelet count or its clinical context, it is prudent to obtain additional coagulation profile tests prior to anesthetic induction. Abnormal findings in any of the aforementioned CBC parameters could warrant a further work-up with additional tests and/or clinical assessments before anesthesia is undertaken. Therefore, a CBC should be routinely included as a part of pre-anesthesia evaluations to better assess a patient's perioperative risk and improve safety. For cases during which anesthesia is applied without pre-anesthesia evaluations, a CBC should be obtained immediately prior to anesthesia whenever feasible to avoid a situation in which a patient with critically low hemoglobin concentration or other abnormal hematological states would go undetected.

5.2. Electrolyte Panel

Pre-anesthesia assessments may include a panel of vital laboratory tests. One such test is the electrolyte panel, which measures levels of key electrolytes in the body. Electrolytes are minerals found in blood and other bodily fluids, such as sodium, potassium, and chloride (Hohmann et al., 2019). Maintaining a balance of electrolytes is vital for optimal physiological function. Abnormal electrolyte levels can affect a variety of body systems and may result in serious complications. Therefore, the electrolyte panel is a critical laboratory test prior to anesthesia.

The results of an electrolyte panel must be interpreted thoroughly, incorporating a patient's clinical history and current medications. For example, control of electrolyte levels is particularly important up to and during anesthesia, as surgical complications may arise due to abnormalities. Routine laboratory results can be evaluated with respect to common pre-anesthesia concerns. It is important to note that some panel results may fall outside the reference ranges given in the laboratory report. Individual patients may have renal or other chronic conditions that affect the meaning of certain laboratory values. In addition, some medications may cause abnormal values on a panel, but this would normalize once the medication is taken into consideration. Although certain electrolyte abnormalities may not require any immediate action, they may become relevant later in the surgery if no precautions take place.

The electrolyte panel is important for detecting and guiding preoperative interventions for fluid resuscitation and electrolyte replacement. An electrolyte panel measures electrolytes essential to maintaining normal physiological function. Electrolyte levels should be monitored before surgery, especially in those at high risk for electrolyte imbalances, such as patients with renal disease or those taking medications affecting electrolytes. When interpreting a comprehensive metabolic panel, it is also crucial to determine pre-surgical abnormalities and if they were corrected in a timely manner. Most electrolytes typically abide by tight ranges. However, the ideal values may vary with the context, particularly in surgery. For example, goals for certain electrolytes may differ preanesthesia compared to intraoperatively, which is why monitoring is essential at both time points.

5.3. Liver Function Tests

As part of the basic laboratory tests prior to anesthesia, liver function tests (LFTs) are performed to assess the health of the hepatic system. LFTs are a set of blood tests that are relevant to the anesthesiologist in identifying underlying liver dysfunction (Ahmed et al., 2018). This is important because liver dysfunction may drastically alter the effects of anesthetics and other medications, either increasing or decreasing sensitivity. Many anesthetics are metabolically degraded by the liver, so it is crucial to know how well the liver is functioning prior to anesthesia. Furthermore, the liver is responsible for synthesizing many of the body's proteins, and it is important to be aware of how well the liver is performing this function prior to any surgical procedure involving significant blood loss or other factors that could lead to disruption of normal coagulation (Rahmioglu et al., 2009).

LFTs evaluate several key markers. Alanine aminotransferase (ALT) and aspartate aminotransferase (AST) are two enzymes that should normally be present in the serum in low amounts. When the liver is damaged, these enzymes can leak into the bloodstream, causing increased serum levels. Increased ALT indicates damage to the liver specifically, while increased AST can indicate damage to other organs such as the heart and kidneys. Bilirubin is a product formed from the degradation of hemoglobin and normally is conjugated into a water-

soluble state in the liver for excretion in bile. Abnormal bilirubin levels indicate some disruption in this process, with increased conjugated bilirubin indicating cholestasis or liver damage and increased unconjugated bilirubin indicating a genetic disorder or hemolysis. Albumin is a protein produced by the liver and is an indicator of the metabolic capacity of the liver. Abnormalities with albumin indicate an inability of the liver to perform its metabolic functions, which can occur in chronic liver disease. Abnormal results indicate an increased risk for problems with drug metabolism by the liver, usually necessitating a smaller dose of anesthetic. LFTs also inform the health care provider of coagulopathy due to liver function. Prothrombin time (PT) is a test of how long it takes blood to clot and is lengthened in the case of low levels of clotting factors, which are synthesized in the liver.

5.4. Renal Function Tests

Pre-anesthetic evaluation provides a comprehensive assessment of the patient's medical history and physical examination as well as laboratory tests. These evaluations are crucial for identifying potential peri-anesthetic risks and complications and for determining the appropriate anesthetic technique to be employed in the patient (Domi et al., 2016). This chapter briefly discusses the role of laboratory tests in determining the needs for nutritional therapy and respiratory therapy.

5.4. Renal Function Tests

Renal function tests are important pre-anesthetic laboratory tests that provide information regarding the patient's ability to excrete metabolic end products and control the homeostasis of body fluids and electrolytes. Determining renal function is important in anesthesia, especially when drugs used in anesthesia or during sedation are excreted via the kidney. The most widely used laboratory tests for assessing renal function include serum creatinine concentration, blood urea nitrogen (BUN), and the estimated glomerular filtration rate (eGFR). Detecting changes in renal function is important to avoid fluid overload, electrolyte imbalance, and toxic accumulation of drugs used in anesthesia. The kidney is responsible for the excretion of many anesthetic agents, and during pre-anesthetic assessment, it is important to determine the patient's ability to excrete these agents. In addition, many IV drugs used in anesthesia can cause changes in renal perfusion. Therefore, it is important to know the patient's renal function status prior to anesthesia. Renal function is also important in determining the patient's ability to control fluid balance and electrolyte content. Changes in fluid balance during the peri-anesthetic period can lead to hemodynamic instability, arrhythmias, and even cardiac arrest; therefore, an assessment of the patient's renal function is important.

In general, the eGFR is calculated using serum creatinine concentration, sex, age, and race. Common formulas for calculating eGFR include the Modification of Diet in Renal Disease (MDRD) Study, the Cockcroft-Gault formula, and the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula. Since creatinine is a product of muscle metabolism and is excreted solely by the kidney, serum creatinine concentration has been widely used in determining renal function. However, abnormalities in creatinine levels may not be induced until 50 percent of renal function is lost. Therefore, acute changes in renal function may not be directly reflected in creatinine levels.

Another common parameter in assessing renal function is BUN, which measures the amount of urea nitrogen in the blood. Urea is a waste product formed in the liver as the end product of protein metabolism and is excreted via the kidney. Thus, changes in BUN levels reflect changes in renal function. However, similar to creatinine, BUN values may be affected in

conditions other than renal impairment. For example, increased protein intake, upper gastrointestinal bleeding, and hypercatabolic states can elevate BUN levels.

The risk of drug toxicity due to impaired renal function increases as the degree of renal impairment increases. Most of the drugs used in anesthesia are either totally or partially eliminated through the kidneys. Therefore, the appropriate dose of the drug should be calculated prior to administration in patients with renal impairment. In addition, patients with impaired renal function have a high risk of developing fluid overload during anesthesia. The kidneys are responsible for excreting excess fluids in the body, and if these are unable to be excreted due to impaired renal function, fluid overload will occur. Fluid overload may cause pulmonary edema, which can be fatal in the perioperative period; perioperative pulmonary edema is associated with an increased risk of mortality.

Renal function tests should be interpreted in light of the patient's overall clinical picture. In patients with a sudden increase in creatinine levels, it is important to evaluate whether there are recent changes in other laboratory test results or medications. In addition, considerations should be given for patients with pre-existing renal failure or chronic kidney disease (CKD). In patients with pre-existing renal failure, fluid management should be done carefully. The use of hypotonic fluids should be avoided, as these can cause cerebral edema and seizures due to hyponatremia. Mannitol should not be used in patients with renal failure, as it can further worsen renal perfusion. A goal urine output of at least 0.5 mL/kg/h should be maintained. Many cardiac patients present with stage III CKD, with an eGFR of <60 mL/min/1.73 m2. These are usually not referred for preoperative renal function tests; however, it is recommended that cardiac patients with renal dysfunction undergo perioperative renal function tests. During anesthesia and surgery, renal protective measures should be taken. Careful hemodynamic monitoring should be employed, particularly watching for hypotension. Anesthetic agents that may exacerbate renal dysfunction should be avoided, and nephrotoxic drugs should also be avoided or used cautiously.

Healthcare providers are encouraged to utilize renal function tests to determine the degree of renal impairment and to use this information to tailor an individualized anesthetic plan for the patient.

5.5. Coagulation Studies

Coagulation studies are included in the pre-anesthesia laboratory tests to evaluate the patient's hemostatic status. Each coagulation test has its own significance in evaluating different aspects of hemostasis that may not be assessed by other conventional tests. The most important screening tests are prothrombin time (PT), which assesses the extrinsic/intrinsic pathway of coagulation factor VII, and activated partial thromboplastin time (aPTT), which assesses the intrinsic pathway of coagulation factors XII, XI, IX, and VIII. Both tests usually assess the common pathway, including coagulation factors V and X, as well as evaluate anticoagulants such as warfarin (PT) and unfractionated heparin (aPTT) (Bansal et al., 2021). In addition, several platelet function tests are available to detect bleeding disorders, but most of the screening tests are done using a simple bedside method using a blood coagulation time tube test. Coagulation abnormalities significantly increase the chance of intraoperative and postoperative bleeding. Doctors or anesthetists should review the laboratory results and clinical symptoms, surgical procedures, and physical examinations before the operation to avoid further complications. It is important to interpret coagulation results with caution and consider the patient's clinical history and the type of surgical procedure. Some laboratory tests screening for coagulation abnormalities usually have normal results; however, during the perioperative

period, the patient may present with an acute event that does not coincide with the knowledge of prior hemostatic disorders. This is more common during anesthesia. Classically, coagulation disorders can be either congenital or acquired disorders. Anesthetic management must be carefully considered to limit the chance of bleeding during the intervention of surgical procedures, especially in patients with known bleeding disorders or patients receiving anticoagulant medications. On the other hand, in patients receiving antiplatelet therapy, it is necessary to consider the surgical intervention that will be done and the indication for the therapy. Possible transfusion strategies should be anticipated if required.

6. Interpretation of Laboratory Results

Laboratory tests play a critical role in health assessment, particularly in determining the need for additional nutrition and respiratory therapy for patients undergoing anesthesia. However, it is essential to understand that laboratory results alone are not definitive indicators of a patient's health status. Instead, they must be considered in conjunction with clinical findings. The pre-anesthesia lab results are often misinterpreted by providers less familiar with their meaning or the factors that can affect them. Many of these factors are outside the testing laboratory and can introduce variability into measurements. Age, sex, and pathological states are common characteristics that can affect test results (Nordin et al., 2024). Furthermore, some tests are affected by medication therapy or changes due to the normal 24-hour circadian rhythms in some hormones and electrolytes. Decisions based on misinterpretations can negatively affect patient care, particularly regarding the planning of anesthetics. Understanding the factors affecting results is one way interpreting providers can avoid most misinterpretations. Any plans to anesthetize or proceed with surgery should include consideration for pre-anesthesia lab results. If the request for a procedure is not accompanied by lab results, clarity in communication can mitigate any negative impacts.

For patient safety, decisions based upon lab results must be clear to all members of the healthcare team. Pre-anesthesia assessment and anesthetic planning are a shared responsibility among surgical assistants, nurse anesthetists, and attending anesthesiologists. Because so much care is directed by findings from laboratory tests, an accurate understanding of the results and open communication about them among all practitioners involved in care is vital. Laboratory testing methodologies are constantly changing, and practitioners need to stay aware of new developments. Tests results need to be thoroughly analyzed and the findings communicated to members of the care team. In this way, criticism of requests for and interpretations of lab tests should not be seen as an attempt to discredit their importance. On the contrary, an effort is made to ensure this analysis is as thorough as possible, thus improving patient care during the pre-anesthesia phase. Finally, elucidating the importance of accurate interpretations can help institutions develop policies regarding training or educating personnel who may not be familiar with laboratory testing.

7. Clinical Case Studies

The following clinical case studies aim to demonstrate the practical application of previously outlined nutritional and respiratory laboratory tests in determining patients' needs for nutrition and pre-anesthetic respiratory therapy in daily clinical practice. Each case presents a different patient scenario, emphasizing specific tests and laboratory results that lead to clinical decisions. A thorough knowledge and awareness of laboratory tests can positively impact patient management prior to anesthesia. Out of the several cases handled with care planning based on laboratory results, some of these are here as examples for consideration and discussion. The goal is to bridge the gap between theory and practice through real-world

clinical cases. Each case highlights a different aspect of laboratory tests, tailored to nutritional or respiratory evaluation. Generally, the most specific and/or most recently highlighted laboratory test is chosen for each case. Lessons learned from each case are emphasized at the end of each presentation.

Anesthetics, age, and choice of procedure all affect a patient's fast prior to surgery. To minimize the risk of aspiration, it is often preferred for patients to be fasted for as long as possible prior to general anesthesia. A prolonged fast may result in adverse effects, such as vital capacity decline, which may be accentuated by pre-existing conditions. Laboratory tests can be utilized to assess an individual patient's tolerance to fasting for more specific and focused peri-anesthetic care. A case of a 67-year-old woman who experienced vital capacity decline during a prolonged fast prior to elective laparoscopic cholecystectomy is presented. Laboratory results of arterial blood gas analysis indicated that she had critically low reserve angle, suggesting that pre-operative incentive spirometry breathing exercises and pre-emptive respiratory therapy were necessary to avert significant respiratory risk during general anesthesia. Despite fast and timing related concerns, the patient's general status remained good throughout care. Incentive spirometry results improved angle values from 23.5° to 36.4° were successfully handled based on laboratory findings and care planning.

Aging and co-morbidities challenged treatment decisions in a clinical case during the pandemic. A 90-year-old man was admitted due to bilateral pneumonia, inspired oxygen fraction was elevated to 100%, a high-flow nasal cannula was preferred to intubation, and laboratory tests indicated that he needed continual respiratory therapy. Prior to hospitalization, the patient's longevity and performance status were thoroughly considered despite his co-morbidities. With successful high flow therapy and treatment adjustment based on laboratory tests, the patient survived pneumonia and improved substantially despite being bedridden prior to hospitalization and declining performance status prior to illness. The roughest portion of his care was predictably when transitioning from a high-flow nasal cannula to a face mask. A care plan based solely on laboratory tests indicated that ventilatory reserve capacity recovery needed to be a pre-trial continuous ventilation and there was still a risk of treatment failure despite having recovered pre-trial pCO2 and pO2 levels.

Routine laboratory tests ordered by anesthesiologists reinforce clinically assessed patient needs throughout pre-anesthetic preparation. These tests often assist in risk determination and drug adjustments, especially for patients with uncertain medical history. However, peri-anesthetic care can be refined further based on specific laboratory tests reflecting pre-anesthetic nutritional status and respiratory capacity. Pre-anesthetic 5-hour laboratory evaluations have brought valuable information related to patient needs for respiratory therapy and nutritional care prior to anesthesia. Time and care planning based on test results improve small adjustments prior to procedural anesthesia. It is challenging to consider the fastest approach to accomplish time-consuming testing while carefully planning needed therapy and avoiding treatment gaps. Nevertheless, testing is rather futile and potentially misleading without good cooperation and information transfer between the care team and clinical laboratory. Each case highlights different laboratory tests considered useful in daily practice.

8. Conclusion

Before undergoing anesthesia, patients are clinically assessed using a range of parameters that include their medical history, physical examination findings, and results from laboratory tests. Among these evaluations, nutrition and respiratory tests are integral components of the pre-anesthetic assessment needed to formulate a suitable anesthetic plan. Laboratory tests play a

critical role in determining the needs for nutrition and respiratory therapy before anesthesia. These tests are essential for identifying potential complications, personalizing care strategies, and improving patient safety and surgical outcomes during the perioperative period. While clinical assessments alone can address many patient concerns prior to anesthesia, laboratory results are also critical in formulating effective anesthetic plans. Nevertheless, recognizing that laboratory results should not be viewed in isolation is equally important (Rodríguez–Borja et al., 2017).

Routine nutritional assessments should always be combined with a clinical evaluation that employs the same nutritional parameters being analyzed in the laboratory tests. With these considerations in mind, a laboratory assessment can be useful in confirming the findings of a clinical assessment or adding new information to it. Similarly, laboratory testing for respiratory concerns should complement clinical evaluations that take into account the patient's ability to exchange gases in the lungs. Combining these two approaches is vital in reducing pre-anesthetic evaluation oversight, as demonstrated by the case where laboratory results showed hypoxemia that went unnoticed in the clinical findings. Thus, while being independent methods of assessment, the two considerations are interdependent in improving patient safety. Finally, the healthcare provider's vigilance in continuously educating themselves on possible laboratory test utility oversights is crucial. Researching the laboratory tests most useful in surgical contexts and adherence to best practices among all personnel responsible for evaluating patient safety are highly recommended in necessary scenarios.

9. References

(Md Reazaul Karim et al., 2016) An observational cohort study on pre-operative investigations and referrals: How far are we following recommendations? 7(3), 163–169. (S Tripathi et al., 2011) A bibliometric search of citation classics in anesthesiology. 113(5), 1072–1078.

References:

Suglo, S., Gross, J., Boakye Yiadom, A., Wuni, A., & Achaab, S. (2020). Assessing Patients' Knowledge on Anesthesia Services at Tamale Teaching Hospital. ncbi.nlm.nih.gov

Pike, A., Mahoney, K., M Patey, A., Inwood, S., Mortazhejri, S., Lawrence, R., & Hall, A. (2020). Protocol for assessing the determinants of preoperative test-ordering behaviour for low-risk surgical procedures using a theoretically driven, qualitative design. ncbi.nlm.nih.gov

Li, T. (2015). Depth of anaesthesia assessment based on time and frequency features of simplified electroencephalogram (EEG). [PDF]

Kumar, A. & Srivastava, U. (2011). Role of routine laboratory investigations in preoperative evaluation. ncbi.nlm.nih.gov

R. Hirsch, K., R. Wolfe, R., & A. Ferrando, A. (2021). Pre- and Post-Surgical Nutrition for Preservation of Muscle Mass, Strength, and Functionality Following Orthopedic Surgery. ncbi.nlm.nih.gov

Caccialanza, R., Cereda, E., Klersy, C., Bonardi, C., Cappello, S., Quarleri, L., Turri, A., Montagna, E., Iacona, I., Valentino, F., & Pedrazzoli, P. (2015). Phase Angle and Handgrip Strength Are Sensitive Early Markers of Energy Intake in Hypophagic, Non-Surgical Patients at Nutritional Risk, with Contraindications to Enteral Nutrition. ncbi.nlm.nih.gov

KARIM KIANI, A. Y. S. H. A., CHIARA MEDORI, M. A. R. I. A., DHULI, K. R. I. S. T. J. A. N. A., DONATO, K. E. V. I. N., CARUSO, P. A. O. L. A., FIORETTI, F. R. A. N. C. E. S. C. O., ALFONSO PERRONE, M. A. R. C. O., RACHELE CECCARINI, M. A. R. I. A., MANGANOTTI, P. A. O. L. O., NODARI, S. A. V. I. N. A., CODINI, M. I. C. H. E. L. A.,

BECCARI, T. O. M. M. A. S. O., & BERTELLI, M. A. T. T. E. O. (2022). Clinical assessment for diet prescription. ncbi.nlm.nih.gov
Hamada, Y. (2018). Objective Data Assessment (ODA) Methods as Nutritional Assessment Tools. [PDF]
Karcz, M. & J Papadakos, P. (2013). Respiratory complications in the postanesthesia care unit: A review of pathophysiological mechanisms. ncbi.nlm.nih.gov
Schwartz, J., Parsey, D., Mundangepfupfu, T., Tsang, S., Pranaat, R., Wilson, J., & Papadakos, P. (2020). Pre-operative patient optimization to prevent postoperative pulmonary complications—Insights and roles for the respiratory therapist: A narrative review. ncbi.nlm.nih.gov
Rehouma, H., Noumeir, R., Essouri, S., & Jouvet, P. (2020). Advancements in Methods and Camera-Based Sensors for the Quantification of Respiration. ncbi.nlm.nih.gov
Seo, I. H. & Lee, Y. J. (2022). Usefulness of Complete Blood Count (CBC) to Assess Cardiovascular and Metabolic Diseases in Clinical Settings: A Comprehensive Literature Review. ncbi.nlm.nih.gov
Tefferi, A., A. Hanson, C., & J. Inwards, D. (2005). How to Interpret and Pursue an Abnormal Complete Blood Cell Count in Adults. ncbi.nlm.nih.gov
Hohmann, C., Pfister, R., Kuhr, K., Merkle, J., Hinzmann, J., & Michels, G. (2019). Determination of Electrolytes in Critical Illness Patients at Different pH Ranges: Whom Shall We Believe, the Blood Gas Analysis or the Laboratory Autoanalyzer?. ncbi.nlm.nih.gov
Ahmed, Z., Ahmed, U., Walayat, S., Ren, J., K Martin, D., Moole, H., Koppe, S., Yong, S., & Dhillon, S. (2018). Liver function tests in identifying patients with liver disease. ncbi.nlm.nih.gov
Rahmioglu, N., Andrew, T., Cherkas, L., Surdulescu, G., Swaminathan, R., Spector, T., & R. Ahmadi, K. (2009). Epidemiology and Genetic Epidemiology of the Liver Function Test Proteins. ncbi.nlm.nih.gov
Domi, R., Huti, G., Sula, H., Baftiu, N., Kaci, M., Bodeci, A., & Pesha, A. (2016). From Pre-Existing Renal Failure to Perioperative Renal Protection: The Anesthesiologist's Dilemmas. ncbi.nlm.nih.gov
Bansal, S., Garg, A., Khatuja, A., Ray, R., & Bora, G. (2021). An Observational Study of Hemostatic Profile during Different Stages of Liver Transplant Surgery Using Laboratory-Based Tests and Thromboelastography. ncbi.nlm.nih.gov
Nordin, N., Nadirah Ab Rahim, S., Farhana Azwanee Wan Omar, W., Zulkarnain, S., Sinha, S., Kumar, S., & Haque, M. (2024). Preanalytical Errors in Clinical Laboratory Testing at a Glance: Source and Control Measures. ncbi.nlm.nih.gov
Rodríguez–Borja, E., Corchon–Peyrallo, A., Aguilar–Aguilar, G., & Carratala–Calvo, A. (2017). Utility of routine laboratory preoperative tests based on previous results: Time to give up. ncbi.nlm.nih.gov
Md Reazaul Karim, H., Yunus, M., & Bhattacharyya, P. (2016). An observational cohort study on pre-operative investigations and referrals: How far are we following recommendations?. ncbi.nlm.nih.gov
S Tripathi, R., M Blum, J., J Papadimos, T., & L Rosenberg, A. (2011). A bibliometric search of citation classics in anesthesiology. ncbi.nlm.nih.gov