Chapter 31
Allergy/Immunology

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An 8-year-old 25 kg boy is scheduled for functional endoscopic sinus surgery. He has a history of common variable immunodeficiency (CVID) with hypogammaglobulinemia, was diagnosed at 4 months of age with recurrent sinus and respiratory tract infections, and was seen in the emergency department 2 weeks ago requiring an epinephrine injection for moderate respiratory distress. He has a productive cough constantly and bronchiectasis by x-ray. His medications include Singulair, Atrovent, and an infusion of intravenous immune globulin G every 3 weeks. Vital signs are BP 90/60 mmHg, P 100 bpm, R 18/min, and T 37 °C, and his Hb is 13 gm/dL.

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Preoperative Evaluation

1. Is this a B-cell or T-cell deficiency, or both? Of what significance is the comparison? What is the immune globulin that is deficient?

2. What is bronchiectasis? Of what importance is it to anesthetic management? Of what significance is the recent visit to the E.D? Do you desire additional information regarding his chronic lung disease? Specifically? Why? Is a chest x-ray necessary? Why/why not? Do you need to identify which inhaler he is using? Why? Relevance?

3. What effect does his lung disease have on his cardiovascular system? How will you evaluate this preoperatively? Why? What are the anesthetic implications? Are there tertiary effects of such cardiac disease on other organ systems?

Preoperative Evaluation

1. B cells are functionally deficient rather than decreased in number. Progression through the normal stages of B-cell development into memory B cells appears to be delayed or blocked. In addition, non-B cells may have abnormalities as well, for example, low numbers of CD4+ cells and high numbers of CD8+ T cells. Natural killer (NK) cells are typically lower than normal. CVID is a pan-hypoglobulinemia; there are decreased levels of IgG and IgA. IgM antibodies are decreased in about 50 % of affected patients as well. Recurrent infections are the typical presentation, with *H. influenza*, *S. pneumoniae*, and *S. aureus* the frequent causes. Respiratory tract infections are most common, along with sinuses, eyes, skin, and gastrointestinal manifestations. Bronchiectases are the anatomic result of severe recurrent pulmonary infections.

2. Bronchiectasis is characterized by weakness and loss of cartilaginous integrity of the bronchial wall as a result of chronic inflammation, infection, and abscess. It is usually the result of chronic focal or diffuse lung infections. Anesthetic management is influenced by the presence of chronic secretions, mucous plugging of the airways, impaired gas exchange, and air trapping affecting shunt as well as dead space. Patients often have chronic pulmonary disease such as cystic fibrosis or impaired immune defense mechanisms such as hypogammaglobulinemia. The recent visit to the ED suggests that the patient's compensation may be marginal. It would be helpful to know whether he is on bronchodilators and what those are, whether supplemental oxygen is required at home, whether he has been treated with steroids recently, and whether his respiratory difficulties are associated with any other medical abnormalities. A chest x-ray is helpful if the history points to an acute exacerbation above his usual baseline. It is important to identify the inhaler he uses because you might wish to employ additional inhalers or intravenous medications that may work additively or synergistically with his home medication.

3. Chronic pulmonary disease with hypoxemia may result in gradual elevation of pulmonary artery pressure and pulmonary vascular resistance, with eventual right heart strain. Ultimately, right heart failure will affect not only pulmonary circuit volume but also systemic cardiac output and contribute to left ventricular failure and impaired perfusion. Because general anesthesia typically involves the use of positive pressure ventilation, which can adversely affect cardiac filling as well as cardiac performance and also involves the use of volatile anesthetics, myocardial performance can be severely affected. Tertiary effects of impaired cardiac disease include hypoperfusion to the splanchnic circulation and protein-losing enteropathies, hepatic and splenic congestion, and renal failure.

4. The child is quite anxious and the mother tells you the anxiety can initiate asthma symptoms. Would you order premedication? If not, why not? If so, what? Rationale. Should this patient receive preoperative antibiotics? Why/why not?

Intraoperative Course

1. What monitors will you select? Why? How will your chosen monitors assist in evaluation of his pulmonary function? Will $P_{ET}CO_2$ accurately represent his $PaCO_2$? Explain. Would you consider an arterial catheter for ABG assessment? Why/why not? How will you place lines? What is the risk of infection? Is this patient colonized? Why?

2. This child is terrified at prospect of an IV and will not cooperate. How will you induce anesthesia? Rationale. Colleague suggests IM ketamine. You respond? How will you prepare the skin? Why? Should antibiotics be administered before oral intubation? What is your choice? Why?

4. Mothers usually know their children best, and premedication may not be a bad idea for this patient. On the other hand, he is 8 years old and conversation may do well at this age; children younger than school age will need premedication more often. Oral midazolam would probably work well, but should be used in an effective dose; 15–20 mg seems reasonable to achieve a good anxiolytic effect. Other alternatives might include intramuscular ketamine, midazolam, and glycopyrrolate. Preoperative antibiotics, if given well in advance (e.g., 2–3 days), may aid in decreasing various sites of infection within ectatic segments of the patient's lungs. In addition, these patients may have other foci of infection, such as the sinuses, which may become important as a source of infection in the perioperative period.

Intraoperative Course

1. At this point, standard noninvasive monitors should be sufficient for the planned procedure. SpO_2 should be sufficient to judge the efficiency of oxygenation and changes in shunting throughout the case, and the $ETCO_2$ should be sufficient to judge the adequacy of ventilation and any changes in dead space. $PETCO_2$ should be a reasonable reflection of $PaCO_2$ because carbon dioxide is so much more diffusible than air; however, much depends on the extent of the bronchiectasis. While one lobe may not change the dead space to tidal volume ratio significantly, multi-lobe bronchiectasis could. If the bronchiectasis was extensive or perioperative ventilatory failure was anticipated, then an arterial line would be useful for following blood gases frequently. In this case, the line should be placed with good sterile technique because the risk of infection from opportunistic organisms as well as the patient's own colonized flora could be significant.

2. I don't think it would be bad to start off with a mask induction, but if he is terrified of the IV, he may be terrified of the mask. Alternatives include an oral or intramuscular premed (but what about the needle stick with the IM shot?) or the use of eutectic mixture of local anesthetics (EMLA) cream applied about an hour in advance. Antibiotics may not be a bad idea, and a broad-spectrum antibiotic such as ampicillin, clindamycin, or Zosyn would probably be reasonable choices to cover a wide range of oral and respiratory flora.

3. What agent(s) would you use to maintain anesthesia? Why? Would you avoid N_2O? Benefits? What is the role of nitrous oxide use with regard to immunosuppression? Methionine synthetase regulation? Would you favor spontaneous ventilation or would you control ventilation? Why? Would you use a muscle relaxant? Why/why not?

4. Toward the end of surgery, the inspiratory pressure during controlled ventilation rises from a previous high of 24 cm H_2O to 60 cm H_2O, along with a drop in oxygen saturation to 85 % and a drop in blood pressure to 72/40. Discuss your considerations? Diagnostic steps? Therapy?

3. Anesthetic maintenance should ideally be carried out with a balanced technique for a few different reasons. First of all, the volatile agent will act to attenuate bronchoreactivity and will also allow a higher F_iO_2 than would a high inspired concentration of nitrous oxide. The use of an opioid, on the other hand, would decrease the amount of postoperative coughing that would undoubtedly follow the anesthetic and would also allow for more rapid emergence because of the decreased requirement for the volatile agent. If the patient remains well oxygenated, then nitrous oxide need not be avoided, although nitrous oxide has been shown to worsen elevated pulmonary artery pressure in patients with known elevated pulmonary vascular resistance due to heart disease. Nitrous oxide has also been shown to interfere with methionine synthetase when used in inspired concentrations greater than 50 %. There may be a role for spontaneous ventilation in decreasing turbulence in already turbulent airways and therefore enhancing gas exchange, but if the patient's airflow is that turbulent, one might be better off delaying the surgery anyway. The use of a muscle relaxant may allow a lighter plane of anesthesia and therefore faster emergence, but the lighter plane of anesthesia may worsen bronchoreactivity and bronchospasm. There is also a relationship between bronchospasm, airway reactivity, and laryngospasm, so it may nevertheless be worthwhile considering the use of muscle relaxants as an adjunct, but they are not intrinsically necessary to the procedure.

4. The most likely consideration is bronchoreactivity and bronchospasm with an acute elevation in airway pressure and significant impairment of systemic cardiac output because of the mechanical effect of the increased intrathoracic pressure on left ventricular output (due to shifting of the interventricular septum) and impaired venous return because of the increase in intrathoracic pressure. This picture would account for the acute elevation of airway pressure, the drop in oxygen saturation, and the drop in blood pressure. The differential would also include a pneumothorax and pneumohemothorax, an accidental mainstem intubation with resulting bronchospasm, and pulmonary edema, all of which should be carefully considered. A judgment should be made about any changes in the depth of the endotracheal tube, the chest auscultated, the length of the tube examined, and the beneficial effect of withdrawing the tube if deemed necessary. Pneumothorax should initially be evaluated by auscultation and a chest x-ray if needed; placement of a chest tube may be required and nitrous oxide should be discontinued. Pulmonary edema will likely be obvious because of the frothy material in the endotracheal tube and the copious secretions during suctioning.

Postoperative Course

1. Discuss your extubation sequence if compliance is normal without wheezing. Awake vs. “deep”? Why?

2. In PACU, after extubation child becomes combative. How will you proceed? Why? What if you had given ketamine? Why?

Additional Topics

1. The embryologic derivation of the thymus and the parathyroids has certain specific anesthetic implications besides an associated T-cell dysfunction. Explain. What are the immunological implications? Why? What are the metabolic abnormalities you would anticipate? Why?

Postoperative Course

1. Here the data is controversial. Although many would prefer to extubate deep, I would tend to extubate awake, reasoning that if, at the end of surgery and with emergence, the patient was lightening and therefore bronchospasm worsened, I would remove the endotracheal tube with the expectation that the bronchospasm would resolve. The alternative would be to extubate deep and hope that the patient passes through the excitement stage uneventfully, which seems more hazardous, although both methods have been used successfully.

2. The combativeness can be difficult to deal with and dangerous for the patient because he can pull out IVs, etc. A rapid assessment must be made for hypoxia or any other cause of instability, pain, and/or delirium. If the patient is not conversing or answering questions, it is reasonable to try some pain medication first (morphine, fentanyl) before going on with the differential; however, if they seem delirious rather than in pain, a watch and wait attitude seems safest. Small doses (or continuous infusions) of propofol have been used to get through this stage of emergence, particularly following sevoflurane anesthesia, but in the end, the patient often ends up where he started off, and one still needs mild (personal) restraint and careful protection of the patient to get through the emergence stage.

Additional Topics

1. The thymus and parathyroids are derived from the third and fourth pharyngeal pouches. Although anatomic abnormalities may result from congenital malformations, such as abnormalities of the tracheal or branchial cleft sinuses, these are rare in the third and fourth pouches. Concurrent abnormalities in other organ systems may include cardiac abnormalities, micrognathia, and low-set ears (from a concurrent failure of the second branchial pouch). However, failure of normal formation of the thymus and parathyroid results in the DiGeorge syndrome, with low parathormone levels, hypocalcemia, and immunological problems. If the thymic hypoplasia is minimal, T-cell function may be almost normal; there may be variable degrees of severity. The decreased serum ionized calcium may result in tetany, myocardial depression, and seizures.

2. How should blood be prepared for a patient with severe combined immunodeficiency syndrome? Why? What if the blood was a month old? Other than the risks of infection, are there any other risks of transfusion in this patient?

3. The mother of a 5-year-old spina bifida patient scheduled for tendon lengthening tells you that the child's lip swelled at the dentist recently. What else would you like to ask? How likely do you think it is that this patient is truly latex allergic? How would you test for this allergy? Is RAST testing as sensitive/specific as patch testing? What precautions will you take? If the patient develops wheezing and urticaria, how much epinephrine is effective?

2. Severe combined immunodeficiency syndrome is a primary T-cell abnormality that also results in failure of formation of the thymus. Patients are vulnerable to overwhelming viral infections, and often die in the first few years of life. The risk of infection is constant, and because of chronic anemia, transfusions are often required. However, graft versus host disease is a risk of transfusion. Lymphocytes in blood are viable for 3 weeks; therefore, blood must be irradiated prior to transfusion in order to kill lymphocytes. If the blood was a month old, then theoretically, lymphocyte viability should not be a significant clinical consideration, but other problems of using a month-old blood should be considered.

3. Children with spina bifida are at high risk for developing latex allergy. There is increasing evidence for a genetic predisposition, and in addition, patients who have catheterized for bladder emptying with natural rubber latex catheters have been chronically exposed to the latex antigen. Because dentists often use natural rubber latex dams, more than 50 % of latex allergic patients will have their initial allergic presentation at the dentist's office. The suspicion for true latex allergy should be very high in spina bifida patients for the above reasons as well as for their typical history of multiple surgical procedures. Testing for confirmation can consist of patch testing or epicutaneous (intradermal) testing, but probably the most common initial test is a latex RAST test, which is an in vitro test of the patient's IgE specific antibody for latex. It is almost as sensitive and specific as patch testing and is a good approximation for intradermal testing, which is more risky because of its in vivo nature. Epinephrine in doses of 0.1 mcg/kg intravenously can be used to treat anaphylactic reactions.

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