

## Supplementary File S1

### Case Synopsis and Guiding Questions

The case was developed by a team of basic science and clinical faculty in the Frank H. Netter MD School of Medicine at Quinnipiac University. The objective was to develop student curriculum that longitudinally integrated basic science from the pre-clinical (years 1 and 2) medical curriculum with the clinical practice of students during the year 3 pediatric clerkship. The case was structured to meet learning objectives in the following domains: Anatomy, Allergy/ Immunology, Biochemistry, Microbiology, Pharmacology, Physiology, and Social and Family Determinants (Figure 2). To guide student discussion, prompts and questions in these domains were inserted throughout the presentation; these are noted below as bullet points. In addition, prompts requiring students to apply their current experience in clinical practice in their pediatrics clerkship were included.

Following is the description of the case with the questions posed to the students for their review before the program and during the small group breakout rooms.

The case follows the course of Marcus, an 8-year-old male child, with a past medical history of asthma, who presents to the ER with shortness of breath at 11 pm. Marcus had previously been stable off medication; however, earlier in the day was wheezing while playing basketball with friends and was found to have an empty inhaler. At home, his father had administered repeated albuterol nebulizer treatments that did not improve his condition. His older brother took him to the hospital.

- *What are the hypersensitivity reactions?*
- *Which type is playing a role in the pathology of asthma?*

At 11:05 pm, vital signs are taken in triage in the ED. The child is normotensive (BP-100/60), although tachycardic (HR-142), and tachypneic (RR-36) with low O<sub>2</sub> saturation levels (88%). His physical exam reveals expiratory wheezing throughout the chest and the presence of eczematous rashes.

- *How do you know when a patient is in respiratory distress?*
- *What on physical exam indicates this?*
- *Think not just about vital signs and auscultation but also what you will observe when you walk into the room.*

Marcus's past medical history reveals pre-term birth with extended stay in the NICU. The history is further significant for many aspects that paint a picture of a classic triad of atopy including bronchiolitis in the 1<sup>st</sup> year, recurrent otitis media in the 1<sup>st</sup> 2 years, diagnosis of

asthma at age 3, chronic atopic dermatitis, tonsillectomy at age 5, and anaphylactic reaction to bee stings, peanuts, and tree nuts. Medications include Pro-air (albuterol) inhaler prn, Albuterol nebulizer prn; 2% hydrocortisone cream prn, and an Epi-pen prn.

- *What are the risk factors for asthma here? (consider: preterm birth, stress, air pollution, tobacco smoke, physical activity)*
- *Review embryonic lung development and why preterm children often have lung issues.*
- *How is a diagnosis of asthma made?*

Marcus's social history provides information about his mother who is employed by the military and is presently deployed abroad for 3 months. The child is currently living with his father (43), brother (19), and sister (15). His father works nights. There is tobacco use in the home by multiple family members, and the home is situated next to a major interstate expressway.

- *In a patient with an obstructive lung disease, what changes in pulmonary function tests (PFTs) may occur following albuterol administration?*
- *Interpret PFTs given in a series of graphs in the context of obstructive and restrictive lung disease.*
- *How is the whole family affected by asthma?*
- *Think about how chronic, life-long, and life-threatening illnesses impact individual patients and their families throughout the lifespan.*

Ten minutes after Marcus's vitals are taken in triage in the ER, he is administered IV dexamethasone and nebulized albuterol via face mask. Vitals improve, notably the O<sub>2</sub> saturation changes from 88% to 98% on room air although the patient remains tachypneic and tachycardic.

- *What is the mechanism of action of dexamethasone?*
- *Why was Marcus administered IV steroids rather than via inhaler or a nebulizer?*

Results of a basic metabolic panel and ABG show that the patient has an anion gap metabolic acidosis, respiratory acidosis, and hypoxemia. Normal renal function, and plasma Na<sup>+</sup>, K<sup>+</sup>, and Cl<sup>-</sup> are noted.

- *Calculate the anion gap and explain the results.*
- *Explain the bicarbonate level.*
- *Brainstorm some explanations for the mixed acidosis that Marcus is experiencing at this time.*
- *Do you think this child's symptoms could be due to an infection? If yes, which organisms could be responsible, and how would you confirm your suspicion?*

A repeat ABG and metabolic panel were done 2 hours later. Despite treatment, Marcus is still showing an anion gap metabolic acidosis, respiratory acidosis, and hypoxemia. Hypoglycemia and elevated lactate levels are also noted. CBC is remarkable for leukocytosis, polycythemia, a mildly elevated band cell count, and mild eosinophilia.

- *What are possible consequences of the patient's prolonged tachypnea on the ABG? What is the cause of the elevated lactate levels? Comment on potential causes of hypoglycemia. How do you explain the CBC results? Is there anything different about taking an ABG from a child vs. an adult?*

A chest x-ray (CXR) is taken in the ED.

- *Define findings of asthma on a CXR.*
- *Compare the CXR of asthma compared with a lower respiratory tract infection.*

The case next provides histological images illustrating the pathology of asthma with visible inflammatory infiltrate, disordered epithelial architecture, edema, smooth muscle hypertrophy, and mucus.

- *Describe the structures of and the boundary between upper and lower airways. Compare normal airway structures with that of an asthmatic.*
- *Describe the change in cellular functioning and how it relates to observable clinical symptoms.*
- *How do changes in upper vs. lower airway structures correlate with presenting symptoms/signs?*

Data are next provided from a 3rd ABG that reveals no significant changes. Despite treatment over the past 3 hours, Marcus is still showing metabolic acidosis, respiratory acidosis, and hypoxemia.

- *Differentiate Type A from Type B lactic acidosis and identify the clinical findings that help differentiate between the two acidosis.*
- *Compare the physical exam findings of a patient presenting with active asthma to a patient presenting with metabolic acidosis secondary to a hyperadrenergic state.*
- *Review the biochemistry of the metabolic acidosis created by a hyperadrenergic state (including catecholamine regulation of carbohydrate metabolism in liver and adipose tissue and the effect of fatty acid oxidation on pyruvate metabolism).*

At 3 am (4 hours following arrival at the ED), Marcus is admitted and continues receiving nebulized albuterol every two hours with on-going slow improvement. The admitting physician ponders whether to start him on antibiotics. Marcus's brother leaves the hospital to get some sleep, leaving the patient alone overnight.

- *Would you start Marcus on antibiotics? What needs to be done before starting?*
- *What is the role of infection in hyperreactive airway disease?*
- *Which organisms are usual causative agents in children's lung disease?*
- *Think about the experience of a child left alone overnight in a hospital.*

The patient has been receiving additional nebulizer treatments every 2 hours overnight. The following morning Marcus reports dizziness: vital signs show that he is now hypotensive (90/40), despite being normotensive earlier, and he remains tachycardic, and tachypneic. A repeat ABG displays sustained metabolic acidosis and respiratory acidosis, but worsened hypoxemia (PaO<sub>2</sub> has dropped to 52 from 70). The patient is started on 2 L normal saline.

- *The patient's blood pressure drops following additional nebulizer treatments: explain how might excess albuterol be related to hypotension and the acid-base disturbances that the patient is experiencing.*
- *What social determinants of health, and other environmental and socioeconomic factors, might affect short- and long-term prognosis and morbidity and mortality risks in a child with asthma? How would knowledge of these factors affect the provider's treatment decisions and discharge planning, as well as patient and family education strategy?*

After several more doses of albuterol, steroids, antibiotics, and fluid boluses, Marcus's blood pressure rises to 103/60 in the early afternoon. Approximately 24 h after presenting to the ED, he is discharged.

- *Develop a discharge plan.*
- *What discharge instructions are to be given to the father?*
- *What medications should Marcus be discharged on?*