Clinical Communications: Adults

MIND THE GAP

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Abstract—The “oxygen saturation gap” is the difference between the calculated oxygen saturation from a standard blood gas machine and the reading from a pulse oximeter. If it is greater than 5%, the patient’s hemoglobin may be abnormal, representing carbon monoxide poisoning, methemoglobinemia, or sulfhemoglobinemia. We report a case where awareness of the saturation gap led to the diagnosis of carbon monoxide poisoning. © 2007 Elsevier Inc.

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INTRODUCTION

If the difference between the calculated oxygen saturation from a standard blood gas machine and the reading from a pulse oximeter is greater than 5%, it is likely that the patient has an abnormal hemoglobin (either carboxyhemoglobin, methemoglobin, or sulfhemoglobin; cyanohemoglobin does not result in this finding). This is referred to as a “saturation gap.” We report a case where awareness of the saturation gap led to the diagnosis of carbon monoxide poisoning.

CASE REPORT

A 48-year-old-man on no medications with a past medical history of hypertension was found in bed by his family, unconscious with agonal respirations. There was a suicide note but no pill bottles were found around him. Paramedics arrived, giving him 4 mg of naloxone without response, and nasotracheally intubating him in the field. His initial heart rate was 123 beats/min, blood pressure 110/80 mm Hg, and oxygen saturation on room air was 94%. On physical examination, he was unresponsive with pin-point, sluggish pupils. He had normal patellar reflexes, no Babinski sign, and his only spontaneous movement was some perioral muscle activity. In the Emergency Department (ED), the basic biochemical profile was normal, including a blood glucose of 150; the electrocardiogram showed sinus tachycardia, computed tomography scan of the head was negative for any acute pathology, and a comprehensive drug screen was pending. A blood gas revealed: pH 7.33, pCO2 36, pO2 418, HCO3 19, base deficit 6, SaO2 60%. Based only on the low oxygen saturation of 60% and the presence of a saturation gap, a carbon monoxide level was checked; this was reported as 38.

Upon questioning family members for a potential source, the patient’s wife found a charcoal grill in the patient’s bedroom. The patient had no prior suicide attempts but was supposed to go to a court hearing the day

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he presented to the Emergency Department (ED). In the ED he developed spontaneous movement of all extremities. The patient received three treatments of hyperbaric oxygen. He recovered fully with a normal gait, clear speech, and a normal mini mental examination. His hospital course was significant for mild rhabdomyolysis with a peak CPK of 1144 and an elevated troponin I of 0.86 without any signs of ischemia on electrocardiogram. He admitted to attempted suicide and was transferred to a psychiatric facility for inpatient treatment. Plans were made for an outpatient stress test.

DISCUSSION

Pulse oximetry is based on measurement of a ratio of light absorption by tissues at a red wavelength (660 nm) and at an infrared wavelength (940 nm). This measured absorption ratio is related to arterial oxygen saturation levels by empirically derived calibration curves developed by simultaneously measuring absorption ratios and sampling arterial blood in healthy adult human volunteers subjected to varying levels of hypoxia. The curves assume that only two hemoglobin species are present: O₂Hb and reduced hemoglobin.

The arterial blood gas analysis calculates oxygen saturation from the measured oxygen tension using an assumed standard oxygen-hemoglobin dissociation curve. CO-oximetry determines oxygen saturation by detecting the absorption of four different wavelengths, enabling it to directly measure levels of four types of hemoglobin species: oxyhemoglobin, reduced hemoglobin, carboxyhemoglobin, and methemoglobin.

The oxygen saturation gap refers to the gap between oxygen saturation as measured by pulse oximetry and the actual arterial oxygen hemoglobin saturation. Some refer to it as the difference between the oxygen saturation calculated from routine blood gas analysis and the oxygen saturation measured by pulse oximetry. Others use this term for the difference between the calculated oxygen saturation from a standard blood gas machine and the measured value from a co-oximeter. An oxygen saturation gap is present when there is more than a 5% difference.

Toxins that are associated with an elevated oxygen saturation gap include carbon monoxide, methemoglobinemia, and hydrogen sulfide (1,2). Cyanohemoglobin does not result in this finding (3). Although cyanide poisoning may result from smoke inhalation, it is not associated with an oxygen saturation gap, but rather with an elevated serum lactate and a severe metabolic acidosis.

A broad differential is necessary to make the diagnosis of occult poisoning. The practice of Emergency Medicine is dependent on basic clinical skills with limited testing options. Attention to minor details can lead to important discoveries. The ‘oxygen saturation gap’ is readily available and is a clinically important phenomenon beyond historical interest. It should be calculated on patients when there is a suspicion of carbon monoxide, methemoglobinemia, or hydrogen sulfide toxicity. Possible clinical scenarios for carbon monoxide poisoning include: multiple family members with headaches or confusion; acute onset of behavioral changes; environmental conditions such as cold weather in the absence of central heating; and flooding with the need for indoor pumping with machines that produce carbon monoxide. An oxygen saturation gap should clue in the diagnostician to the evaluation of carbon monoxide, methemoglobinemia, and hydrogen sulfide to avoid neurological, metabolic, and cardiovascular sequelae.

CONCLUSION

The ‘oxygen saturation gap’ is a clinically important phenomenon beyond historical interest. Its presence should clue in emergency physicians to the diagnosis of carbon monoxide poisoning, hydrogen sulfide poisoning, or methemoglobinemia.

REFERENCES