Rhino-Orbital Cerebral Mucormycosis in a Diabetic Ketoacidosis Patient

A Case Review

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Introduction

Diabetic ketoacidosis (DKA) is a medical emergency. DKA occurs when an insulin deficiency causes the breakdown of fats as an alternative energy source. When the liver processes these fats, it releases ketones into the blood, which causes acidosis.[5] DKA is characterized by hyperglycemia, metabolic acidosis, and ketonemia.[9] Hyperglycemia, dehydration, and acidosis further worsen DKA.[9] DKA can occur in both type 1 and type 2 diabetes mellitus patients, though it is much more rare in type 2.[9] DKA can be prevented. The key to prevention is patient education on how to properly manage their diabetes and monitor their blood glucose levels. Rapid recognition and treatment of DKA are critical to prevent morbidity and mortality, and understanding the guidelines to care for a DKA patient in the operating room is important.[6]

Learning Objectives:

1. Understand the anesthetic management of DKA
2. Learn how mucormycosis presents in patients
3. Understand how mucormycosis can develop in those with DKA

Uniqueness of case

Mucormycosis is a rare and deadly fungal infection. Mucorales fungi, otherwise known as black mold, causes this infection and can be abundant in the environment. Inhalation of mucorales spores via the respiratory route is the most common entryway to the human body.[1] Even though humans often inhale these spores, this ingestion rarely leads to infection.[1] However, in those who are immunocompromised, exposure can be detrimental. Patients undergoing chemotherapy, transplantation immunosuppression, burns, blood dyscrasias, COVID-19, or poorly controlled diabetes are at an increased risk.[10] Uncontrolled diabetes is the most common cause of mucormycosis.[10] This is because chronic insulin resistant hyperglycemia leads to ketoacidosis, and fungi thrive in an acidic environment. Iron is bound and unavailable to fungi at a normal pH, but when iron is released in an acidotic state, such as DKA, this proliferates the fungal growth.[10] Hyperglycemia also decreases the number and phagocytic activity of neutrophils, further encouraging the fungal infection to thrive.[10]
Mucormycosis can affect any body system, i.e., pulmonary, gastrointestinal, and cutaneous, with Rhino-orbital cerebral mucormycosis (ROCM) being the most prevalent.[1] The predisposing disease of the patient will often determine the preference for which body system the infection presents in.[1] The usual symptoms of ROCM are facial pain, fever, and confusion, and these cases are often sporadic and not contagious.[2] Mucormycosis is exceedingly rare, with fewer than 1000 cases in the United States yearly.[12] ROCM mortality rates are 85-93% despite treatment in immunocompromised patients.[8] Emergent debridement and aggressive antifungal treatment can reduce mortality.[8] Intravenous amphotericin B and surgical debridement have been the mainstay of treatment.[1]

Patient Description

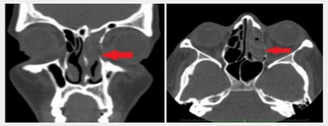
A 45-year-old Spanish-speaking male presented to the emergency department with a 2-day history of R-sided facial pain, numbness, swelling, and nasal congestion. The pain progressed to a severe degree, and visual disturbances progressed in his right eye. A Spanish interpreter was utilized. The patient had no known medical history or allergies and was 164.1 cm tall and weighed 65.4 kg with a BMI of 24.29 kg/m^2.

Vital signs: Blood pressure was 157/97, heart rate was 122, oxygen saturation was 100% on room air, and respiration rate was 19 unlabored breaths per minute.

Head, eyes, ears, nose, and throat exam (HEENT): A demarcated area of duskiness involving the right mid-face with periorbital distribution extending on the right side wall of the nose was noted. A central area of necrosis was reported, involving the right nasal ala. An intranasal examination demonstrated black nasal mucosa involving foul odor. Intraoral examination revealed a 3 x 4 cm necrotic patch of mucosa involving the right hard and soft palate with extension onto the maxillary gingiva on the right side. The right eye was proptotic and ophthalmoplegic. The pupil was nonreactive. The conjunctiva was pallorous in appearance compared to the left.

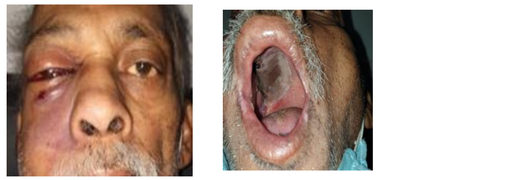
Laboratory data: Elevated white blood cell count of 25.1 × 10^9/L, elevated glucose of 376 mg/dL, elevated anion gap of 26 mmol/L, low CO2 of 5 mmol/L, hyponatremia, hypochloremia, and hypoalbuminemia.

Imaging studies: A computed tomography (CT) scan of the neck with contrast was reviewed. The CT demonstrated mucosal edema and thickening of the right ethmoid and maxillary sinuses with air-fluid involving the right maxillary sinus. There was an irregularity in the contour of the anterior lateral floor of the orbit on the right side. There was soft tissue edema and proptosis noted to involve the right eye. The subcutaneous soft tissue had a prominent irregularity involving the right midface and mandibular area.



CT abnormalities in a patient with ROCM. There is opacification of the frontal, ethmoid and maxillary sinuses.[11]

Impression: The clinical findings strongly suggested the presence of invasive mucormycosis, DKA, and sepsis.
The patient was scheduled for a Nasal Cavity Debridement and Orbitotomy, and started on an insulin infusion of 4U/h, amphotericin B, Zosyn, and Vancomycin.
The anesthetic plan consisted of general anesthesia with a rapid sequence intubation (RSI), American Society of Anesthesiologists (ASA) standard monitors, an arterial line, fluid replacement, and hourly arterial blood gas (ABG) monitoring. Hourly blood gases and insulin management will be at the forefront of care.
The patient was emergently brought to the room with two 20G intravenous lines on each upper extremity, and Plasmalyte and Noperatingormal Saline (NS) bags were hung on each IV. General anesthesia was induced uneventfully. Although the patient had a poor mouth opening and a Mallampati score of IV, intubation was successful with a Glidescope. An arterial line was placed post-induction. The patient remained ventilated on SIMV PCV- VG. The patient's blood pressure was controlled with 16mcg boluses of Norepinephrine and a 0.05 mcg/kg/min infusion of Norepinephrine when indicated.



Orbital Mucormycosis with sinus involvement (A) and hardpalate black necrosis (B) in a ROCM patient.[7]

	0913	0947	1102	1223	1335	1450
FiO2	0.37	0.91	0.93	0.91	0.91	0.29
pH Arterial 7.35 - 7.45	7.10 ↓	7.13 ↓	7.26 ↓	7.25 ↓	7.25 ↓	7.22 ↓
pCO2 Arterial 35 - 45 mmHg	32 ↓	37	33 ↓	37	34 ↓	34 ↓
pO2 Arterial 80 - 100 mmHg	165 ↑	154 ↑	173 ↑	169 ↑	266 ↑	181 ↑
HCO3 Blood Gas 21.0 - 28.0 mmol/L	9.7 ↓	11.8 ↓	14.2 ↓	15.6 ↓	13.7 ↓	13.7 ↓
Base Excess Blood Gas -2.0 - 3.0 mmol/L	-18.8 ↓	-16.4 ↓	-11.8 ↓	-10.7 ↓	-12.8 ↓	-12.8 ↓
Hematocrit Blood Gas %	32	32	29	26	27	27
Hemoglobin Blood Gas 12.9 - 16.1 gm/dL	11.0 ↓	10.8 ↓	9.7 ↓	9.0 ↓	9.3 ↓	9.3 ↓
O2 Hemoglobin Arterial 95.0 - 98.0 %	98.4 ↑	98.4 ↑	98.3 ↑	98.5 ↑	98.1 ↑	98.1 ↑
Carboxyhemoglobin Blood Gas 0.5 - 1.5 %	0.2 ↓	0.3 ↓	0.4 ↓	0.2 ↓	0.7	0.7
Methemoglobin Blood Gas <=3.0 %	0.2	0.1	0.3	0.3	0.3	0.3
O2 Saturation Arterial 90.0 - 100.0 %	98.5	98.3	99.0	98.9	99.6	98.6
O2 Content Arterial 15 - 24 vol %	16	15	14 ↓	13 ↓	13 ↓	13 ↓
Sodium Blood Gas 136 - 144 mmol/L	132 ↓	136	135 ↓	133 ↓	135 ↓	135 ↓
Potassium Blood Gas 3.4 - 4.5 mmol/L	3.5	2.9 ↓	2.6 ↓	3.0 ↓	3.5	3.6
Ionized Calcium Blood Gas 1.15 - 1.33 mmol/L	1.13 ↓	1.14 ↓	1.05 ↓	1.14 ↓	1.18	1.18
Chloride Blood Gas <98 - >107 mmol/L	109 ↑	109 ↑	109 ↑	109 ↑	109 ↑	108 ↑
Glucose Blood Gas 65 - 100 mg/dL	258 ↑	229 ↑	239 ↑	266 ↑	238 ↑	238 ↑
Lactic Acid Blood Gas 0.36 - 0.75 mmol/L	0.64	0.78	0.92 ↑	1.06 ↑	0.76 ↑	0.76 ↑
Additional Information						
Specimen Collected:	10/08/24 09:47	10/08/24 11:02	10/08/24 12:23	10/08/24 13:35	10/08/24 14:50	

0913- Induction of anesthesia administered with 100mg of Lidocaine 2%, 100 mcg of Fentanyl, 100mg of Succinylcholine, and 120mg of Propofol. The patient was relaxed with 30mg Rocuronium.

0947- Metabolic acidosis with a pH of 7.10. Glucose was 258 mg/dL, and potassium was within normal limits at 3.5 mmol/L. **A crystalloid bolus, 50 mEq bicarbonate, 500mg calcium chloride, 3U insulin, and a 4U/h insulin infusion were administered.**

1102- Potassium dropped to 2.9 mmol/L. Glucose was at 229 mg/dL, and acidosis slightly improved. **A 10 mEq/h potassium infusion began. 3 U of Insulin administered, and the Insulin infusion rate was increased to 6U/h..**

1223- Potassium further dropped to 2.6 mmol/L, with glucose increasing to 239 mg/dL. **Acidosis continued to improve. Insulin infusion was stopped, and 1000 mg calcium was administered.**

1335- Potassium improved to 3.0 mmol/L while glucose rose to 266 mg/dL. **Acidosis was slightly worsening. Albumin was administered.**

1450- Potassium back to within normal limits at 3.5 mmol/L, glucose was 238 mg/dL, and pH was 7.22.

1542- Patient was extubated and transported to ICU.

Discussion

Understanding the guidelines to care for a DKA patient in the operating room is important to decrease morbidity and mortality. On average, a DKA patient's fluid deficit is about 6 L.[4] NYSORA recommends the use of colloids for fluid replacement if the patient is clinically hypovolemic (i.e., hypotensive and tachycardic) and NS if not.[4] In this case, albumin should have been infused sooner, as the patient was showing signs of hypovolemia before induction. Historically, base excess and lactate values have been used as indicators of hypovolemia.[3] Tissues produce lactate as a byproduct of anaerobic metabolism due to hypoperfusion, and lactate values increase. Base excess measures the amount of base needed to restore a liter of blood to a normal pH and is a good indicator of acid-base disturbances within the body.[3] According in my research, base excess values are more clinically useful.[3] The patient's base excess value of -18.8 mmol/L indicated the need for fluid therapy. NYSORA advises changing the fluid replacement therapy to a mixture of half 5% dextrose in water (D5W) and half NS if blood sugar drops, to allow insulin to continue to improve acidosis without causing hypoglycemia.[4] Pulse pressure variation (PPV) above 13% can also be used to indicate a fluid deficit and guide fluid replacement therapies in DKA patients. In total, the patient received 500 mL of albumin, 1300 mL of PlasmaLyte, and 1000 mL of NS. The patient produced 2125 mL of urine. The base excess continued to improve during the procedure which showed evidence toward improvement of the fluid deficit and acidosis. The lactic acid values trending upward throughout the procedure, indicating an increase in tissue hypoperfusion.
NYSORA's insulin recommendations are a 10 U IV bolus followed by an infusion at (blood glucose/150) U/h.[4] It is also advised not to stop the insulin infusion if glucose becomes less than 90, but to increase i.v. Glucose administration.[4] **NYSORA recommends potassium infusions of 10-15 mEq/h for at least the first 4 hours, irrespective of the initial potassium level, for a goal of 4–5 mEq/L.**[4] Acidosis corrects itself with proper insulin treatment, which is displayed in this patient's ABG values, as the degree of acidosis improved by the procedure's end. Upon reflection of this case, a potassium infusion should have begun sooner to prevent the decision for the insulin infusion to stop due to hypokalemia.[4]
NYSORA recommends the administration of bicarbonate only if pH <7.0 or hemodynamic instability.[4] The patient in this case received bicarbonate with a pH of 7.10 due to the bicarbonate level being staggeringly low at 9.7 mmol/L.
The intraoperative balance between administering insulin and maintaining healthy potassium levels can be difficult. Close monitoring of ABG values can aid in titration of infusions and ensure the best possible stabilization of DKA.
Due to the concern of delayed gastric emptying as a sequelae of DKA, an orogastric tube (OG) should have been suctioned after intubation to ensure completely emptying of the patient's stomach.[6] An nasogastric (NG) would be contraindicated in this patient due to the surgical field involving the sinuses.

Conclusion

Patients with DKA should be optimized before elective surgery. For this patient, the need for surgical debridement was emergent. Patients with DKA should be monitored with standard ASA monitors and an arterial line. DKA patients should have at least two IVs for urgent fluid replacement therapy, and an ABG should be promptly taken to indicate the degree of acidosis and electrolyte derangements.[6] Due to DKA, the patients' are in a hypovolemic state and acidotic, therefore induction of anesthesia should be carefully titrated to prevent any further hemodynamic instability.[6] Because of gastric stasis, a rapid sequence intubation is advised for DKA patients, and a NG or OG tube should also be placed before induction.[6] Hourly monitoring of ABGs is required, and this close monitoring will ensure that any electrolyte derangements are treated as indicated.[6] Patients should be ventilated to ensure no iatrogenic respiratory acidosis. [6]

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