

Simulation Patient Design (October, 2021) Case of a Pregnant Patient with Diabetic Ketoacidosis

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Introduction:

Diabetic ketoacidosis (DKA) is the most serious acute complication of diabetes. There is a global increase in the prevalence of diabetes, including diabetes during pregnancy and the incidence is expected to continue to rise due to increasing rates of obesity in pregnancy and advanced maternal age. Although DKA is uncommon in pregnancy (incidence 0.5-3%), without prompt diagnosis and treatment it can be life-threatening to the mother and fetus.¹ Maternal complications related to DKA include acute renal failure, acute respiratory distress syndrome, myocardial ischemia, cerebral edema, coma, and death. To prevent maternal morbidity and mortality, maternal stabilization should occur prior to proceeding with delivery. While maternal mortality is reported to be less than 1%, fetal mortality is reported to be 9-36% and perinatal morbidities include preterm delivery, hypoxia, and acidosis.^{1,2} Providers caring for pregnant patients must be familiar with the management of diabetes and have a high level of suspicion for DKA and be ready to initiate prompt treatment with the aim to reduce maternal and neonatal complications.

The incidence of DKA is higher in pregnant patients compared to non-pregnant patients (8.9% vs. 3.1%, respectively).³ Pregnancy is a state of insulin resistance, accelerated starvation, and respiratory alkalosis, especially in the late second and third trimester.¹ Pregnancy hormones such as human placental lactogen and prolactin antagonize the effects of insulin at the cellular level.⁴ Pregnant women are more sensitive to infection and starvation, such that poor nutritional status, persistent vomiting and eating disorders have been associated with development of DKA in euglycemic patients.^{1,3} Additionally, since pregnant women are in a state of respiratory alkalosis due to an increased minute ventilation, respiratory changes are counter regulated by increased renal excretion of bicarbonate which reduces buffering capacity.^{1,4} Because of these physiologic changes during pregnancy, diabetic pregnant women are predisposed to developing DKA as well as experiencing DKA at lower glucose levels than non-pregnant patients.

There are several triggers that can precipitate DKA which include some specific to pregnancy such as vomiting, infection, untreated/undiagnosed diabetes, insulin pump failure, use of beta-sympathomimetic agents for tocolysis, steroid use for fetal lung maturation, and gastroparesis. Infections and omission (or non-compliance) with drug management are the most common precipitants.¹

Due to the insidious presentation and significant consequences of a delayed diagnosis of DKA, providers must maintain a high level of suspicion for DKA. To ensure positive outcomes, providers must order appropriate laboratory studies to make the diagnosis, and promptly intervene with aggressive fluid resuscitation, administer insulin therapy, manage electrolyte derangement, and obtain expert consultation.

Educational Rationale: To teach team skills in early recognition and management of DKA in a pregnant patient

Target Audiences: OB/MFM team, OB anesthesiology team, L&D nursing, ICU staff

Learning Objectives: As per Accreditation Council for Graduate Medical Education (ACGME) Core Competencies. Upon completion of this simulation (including the debrief) learners will be able to:

- *Medical knowledge:* Recognize the clinical presentation of DKA in pregnancy, assess the need for escalation of care and understand the risks to the mother and fetus
- *Patient care:* List tasks for management of DKA in pregnancy – including laboratory and clinical assessments, initial drug(s) and fluid management, plan for disposition of the patient, and management of fetal distress in the setting of DKA
- *Practice-based learning and improvement:* Demonstrate appropriate use of drugs and fluids, methods of intervention, and timely laboratory (or additional) assessments for management
- *Interpersonal and communication skills:* Designate a team leader and communicate using SBAR and closed-loop communication. Obtain appropriate consultations for the management of DKA.
- *Professionalism:* Demonstrate respect for the expertise of all team members
- *Systems-based practice:* Identify existing barriers within the system (such as shortages of equipment or personnel) that need change in order to improve patient outcomes

Questions to ask after the scenario:

1. How was the response to the situation managed, and were management steps clearly outlined by the team?
2. Did each team member have a well-defined role, and was a team leader identified?
3. Was the emergency response team appropriately consulted/activated?
4. Were any barriers or system issues identified when caring for this patient?
5. Would cognitive aids have been helpful in this scenario?
6. What factors might influence the decision for an emergent cesarean delivery?

Assessment Instruments:

1. Learner Knowledge Assessment form (Appendix 1)
2. Simulation Activity Evaluation form (Appendix 2)
3. Algorithm for the Management of DKA in the Pregnant Patient (Appendix 3)

Equipment Needed and Set-up:

In-situ set-up

1. Simulated patient
2. Blood pressure, pulse oximeter, ECG and fetal monitor on patient
3. IV supplies and IV fluids

Simulation Scenario Set-up:

The case

A 34 year-old patient (G2P1) at 34 weeks gestation presents to L&D triage complaining of a two-day history of nausea and vomiting. Her past medical history includes type 2 diabetes mellitus managed on insulin during pregnancy, obesity, and chronic hypertension. The patient looks acutely ill with rapid, deep breathing.

Vital signs: HR 120 bpm, RR 30/min, BP 100/70 mm Hg, SpO₂ (RA) 96%, temp 37.1°C

Simulation Pre-brief

- Read the scenario and instruct team members on their role during the simulation
- The learners take their places on L&D
- L&D nurse as confederate to prompt decision-making regarding delivery indications

Scenario Details

Trigger	Patient Condition	Action	Done	Time	Comments
<p>Patient in L&D triage</p> <p>Patient reports 2-day history of vomiting</p>	<p>Patient is responsive to questions but appears lethargic + tachypneic</p> <p>HR 120 bpm BP 100/70 mm Hg SpO₂ 96% (air) Resp 30/min Temp 37.9°C FHR 130</p>	<p>1. L&D triage nurse performs initial patient evaluation + examination</p> <ul style="list-style-type: none"> <input type="checkbox"/> Call OB team to assess the patient <input type="checkbox"/> Notify Anesthesiology team <input type="checkbox"/> Place 18G IV x 2 <input type="checkbox"/> Send labs: CBC (with diff), BMP, LFTs, ABG, lactate <input type="checkbox"/> Send blood cultures <input type="checkbox"/> Check urine + serum ketones <input type="checkbox"/> Check capillary glucose level 			
<p>Laboratory results provided (for the tests requested by the learners)</p>	<p>Lab results:</p> <p>Na 132 mmol/L K 4.6 mmol/L Cl 96 mmol/L CO₂ 14 mmol/L Cr 0.8 mg/dL Glucose 302 mg/dL</p> <p>WBC 14 x 10⁹/L Hgb 11 g/dL Hct 35% Plt 215 x 10⁹/L</p> <p>ABG pH 7.15 pO₂ 91 mm Hg pCO₂ 29 mm Hg BE -10 Bicarb 14 mmol/L Lactate 1.8 mmol/L</p> <p>Urine 3+ glucose 3+ ketones</p> <p>Beta-hydroxybutyrate 3.3 mmol/L</p>	<p>1. Team to discuss differential diagnoses</p> <ul style="list-style-type: none"> <input type="checkbox"/> Defer delivery to stabilize maternal status <p>2. Activate emergency response team or ICU consultation</p> <p>3. Initiate DKA management (see Appendix 3):</p> <ul style="list-style-type: none"> <input type="checkbox"/> Place 2 large-bore IVs (if not performed already) or central IV access <input type="checkbox"/> Initiate fluid resuscitation: Administer normal saline, initially 1-2 L/h for 2 h (deficit typically 100 mL/kg) <input type="checkbox"/> Initiate insulin regimen: Short-acting bolus (10 units IV), followed by an IV infusion (1-2 units/h) <i>Or as per institutional protocol</i> <input type="checkbox"/> Administer serum potassium replacement (deficit can occur due to insulin treatment) 			

<p>Bedside nurse states she is concerned about fetal status + need for delivery</p>	<p>Non-reassuring fetal heart trace</p> <p>Absent variability with recurrent decelerations</p>	<ol style="list-style-type: none"> 1. Team to acknowledge that medical stabilization of the patient takes precedence 2. Acknowledge the fetal status should improve with correction of maternal acidemia/hyperglycemia 			
<p><i>If team omits potassium replacement, patient becomes hypokalemic (2.4 mmol/L)</i></p>	<p><i>Telemetry shows U waves + frequent ectopy</i></p>	<ol style="list-style-type: none"> 1. <i>Administer potassium replacement</i> 2. <i>Hold insulin therapy until serum potassium level normalizes</i> 			
<p>Patient remains on L&D + labs checked 2 hours after therapy initiated</p> <p>If team already requested transfer to ICU, can be awaiting transfer</p>	<p>HR 100 bpm BP 110/70 mm Hg RR 25/min SpO₂ 97% Temp 37.0°C</p> <p>Na 137 mmol/L K 4.0 mmol/L Cl 102 mmol/L CO₂ 18 mmol/L Glucose 180 mg/dL</p> <p>ABG: pH 7.29 pO₂ 94 mm Hg pCO₂ 34 mm Hg BE -7 Bicarb 17 mmol/L</p> <p>FHR 130 baseline, minimal variability, no decelerations</p>	<ol style="list-style-type: none"> 1. Defer delivery due to maternal status <ul style="list-style-type: none"> <input type="checkbox"/> Normalize anion gap <input type="checkbox"/> Normalize bicarbonate 2. Continued fluid management <ul style="list-style-type: none"> <input type="checkbox"/> Dextrose 5% in Normal saline 100-200 mL/h (since glucose <250 mg/dL) 3. Team to investigate any precipitating factors + perform infectious disease work-up 4. Continued insulin infusion at same rate (<i>or following institutional protocol</i>) 5. Continue lab assessment every 2 h until anion gap + bicarb normalize 			
<p>Patient disposition</p>		<ol style="list-style-type: none"> 1. Team to discuss appropriate disposition <ul style="list-style-type: none"> <input type="checkbox"/> To ICU with continuous monitoring 2. Explain situation to the patient + support person 			

Appendix 1

Learner Knowledge Assessment Labor and Delivery Multidisciplinary Team Simulation

Name of simulation: _____

Date: _____

OB Nursing Anes

Each item has two components. The “Before the simulation” column (left side) examines your perspective at the beginning of the simulation. The “End of Simulation” column (right side) is to evaluate your perspective at the completion of the simulation.

1. How would you rate your ability to recognize DKA?

BEFORE THE SIMULATION							END OF SIMULATION						
1	2	3	4	5	6	7	1	2	3	4	5	6	7
Little/none					Knowledgeable		Little/none					Knowledgeable	

2. How would you rate your ability to list the differential diagnosis of DKA?

BEFORE THE SIMULATION							END OF SIMULATION						
1	2	3	4	5	6	7	1	2	3	4	5	6	7
Little/none					Knowledgeable		Little/none					Knowledgeable	

3. How would you rate your ability to manage DKA in pregnancy?

BEFORE THE SIMULATION							END OF SIMULATION						
1	2	3	4	5	6	7	1	2	3	4	5	6	7
Little/none					Knowledgeable		Little/none					Knowledgeable	

4. How would you rate your ability to decide on the appropriate timing of delivery in a pregnant patient presenting in DKA?

BEFORE THE SIMULATION							END OF SIMULATION						
1	2	3	4	5	6	7	1	2	3	4	5	6	7
Little/none					Knowledgeable		Little/none					Knowledgeable	

5. How would you rate your overall confidence in managing a pregnant patient with DKA?

BEFORE THE SIMULATION							END OF SIMULATION						
1	2	3	4	5	6	7	1	2	3	4	5	6	7
Little/none					Knowledgeable		Little/none					Knowledgeable	

Appendix 2

Simulation Activity Evaluation

DATE OF SIMULATION: _____

OCCUPATION: Consultant PG Yr 1 2 3 4 STUDENT NURSE MIDWIFE OTHER

SPECIALTY: _____ YEARS IN PRACTICE: _____

Please rate the following aspects of this training program using the scale listed below:

1 = Poor 2 = Suboptimal 3 = Adequate 4 = Good 5 = Excellent

Use "N/A" if you did not experience or otherwise cannot rate an item

INTRODUCTORY MATERIALS

Orientation to the simulator	1	2	3	4	5	N/A
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PHYSICAL SPACE

Realism of the simulator space	1	2	3	4	5	N/A
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EQUIPMENT

Satisfaction with the patient/mannequin	1	2	3	4	5	N/A
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SCENARIOS

Realism of the scenarios	1	2	3	4	5	N/A
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Ability of the scenarios to test technical skills	1	2	3	4	5	N/A
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Ability of the scenarios to test behavioral skills	1	2	3	4	5	N/A
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Overall quality of the debriefings	1	2	3	4	5	N/A
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DID YOU FIND THIS USEFUL?

To improve your clinical practice?	1	2	3	4	5	N/A
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To improve your teamwork skills?	1	2	3	4	5	N/A
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To improve your VERBAL communication?	1	2	3	4	5	N/A
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To improve your NONVERBAL communication?	1	2	3	4	5	N/A
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FACULTY

Quality of instructors	1	2	3	4	5	N/A
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Simulation as a teaching method	1	2	3	4	5	N/A
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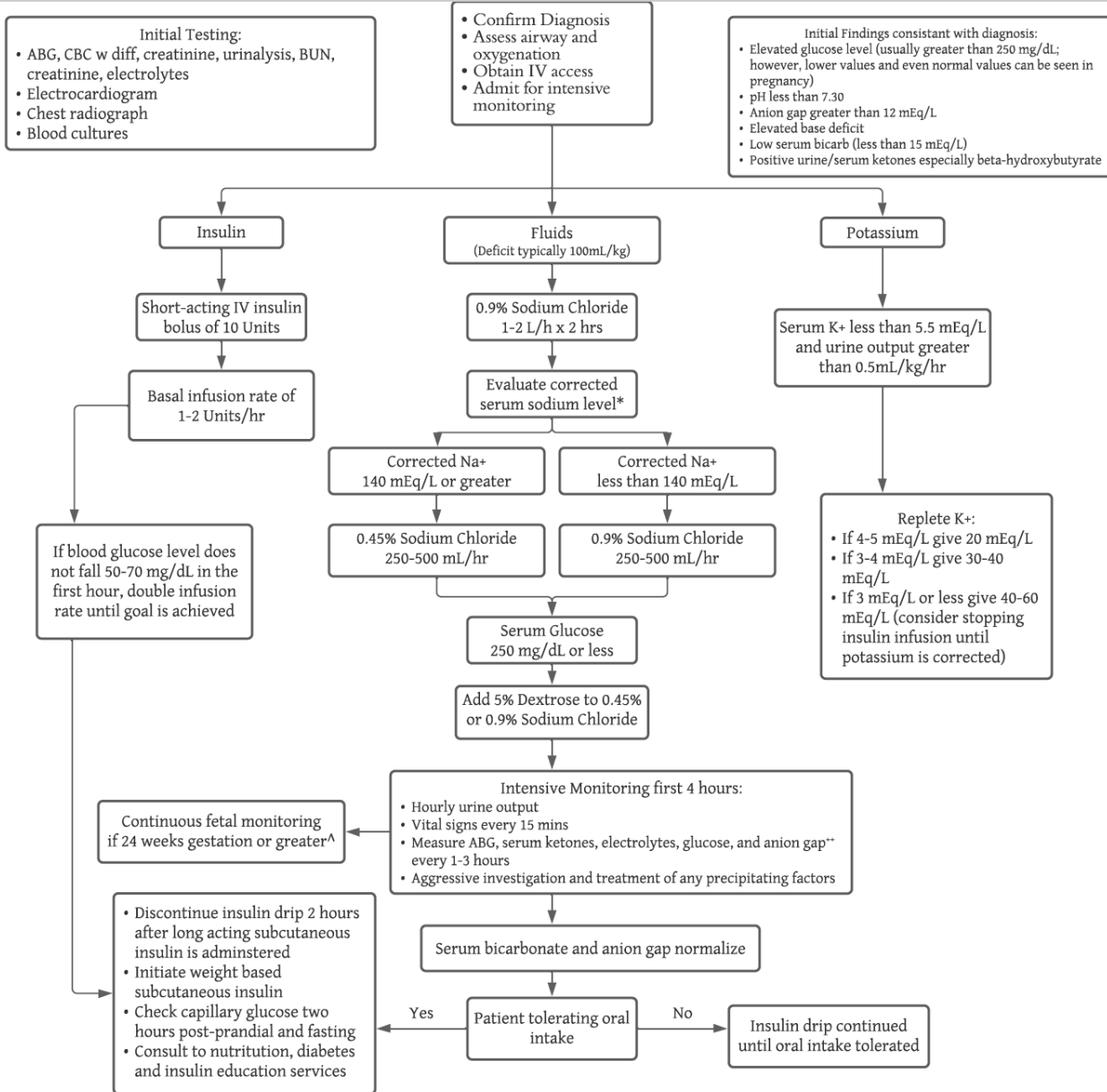
COMMENTS/SUGGESTIONS:

Appendix 3

Algorithm for the Management of Diabetic Ketoacidosis in the Pregnant Patient

Adapted by Dr McKenzie, from:

- Sibai BM, Viteri OA. Diabetic ketoacidosis in pregnancy. *Obstet Gynecol.* 2014;123(1):167-178
- Kitabchi AE, Wall BM. Management of diabetic ketoacidosis. *Am Fam Physician.* 1999;60(2):455-464 (<https://www.aafp.org/afp/1999/0801/p455.html> accessed Sept 2021)



*Corrected serum sodium: $\text{Serum Na}^+(\text{mEq/L}) + (1.6 \text{ mEq/L for each } 100\text{mg/dL glucose level greater than } 100 \text{ mg/dL})$

**Anion gap: $[\text{Na}^+] - [\text{Cl}^-] + \text{HCO}_3^-$

^ No interventions on fetal behalf should be performed until stabilization of acute maternal condition has been achieved

References:

1. Sibai BM, Viteri OA. Diabetic ketoacidosis in pregnancy. *Obstet Gynecol.* 2014 Jan;123(1):167-178. doi: 10.1097/AOG.0000000000000060
2. Schneider M, Umpierrez G, Ramsey R, Mabie W, Bennett K. Pregnancy complicated by diabetic ketoacidosis: maternal and fetal outcomes. *Diabetes Care* 2003;26:958-9. doi:10.2337/diacare.26.3.958
3. Guo RX, Yang LZ, Li LX, Zhao XP. Diabetic ketoacidosis in pregnancy tends to occur at lower blood glucose levels: case-control study and a case report of euglycemic diabetic ketoacidosis in pregnancy. *J Obstet Gynaecol Res.* 2008 Jun;34(3):324-30. doi: 10.1111/j.1447-0756.2008.00720.x
4. Carroll MA, Yeomans ER. Diabetic ketoacidosis in pregnancy. *Crit Care Med.* 2005 Oct;33(10 Suppl):S347-53. doi: 10.1097/01.ccm.0000183164.69315.13
5. Obr C, Mueller A. Diabetic ketoacidosis in the obstetric population: a simulation scenario for anesthesia providers. (accessed September 2021)
https://www.mededportal.org/doi/10.15766/mep_2374-8265.10406
6. Kitabchi AE, Wall BM. Management of diabetic ketoacidosis. *Am Fam Physician.* 1999;60(2):455-464 <https://www.aafp.org/afp/1999/0801/p455.html> (accessed September 2021)