**DUODENAL ATRESIA / HYPOVOLEMIC SHOCK**
A case for high-fidelity simulation in emergency medicine

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**ABSTRACT**

This educational resource provides the information and materials for a high-fidelity simulation case suitable for resident physicians in emergency medicine and for medical students. This case is currently in use at our institution for 4th year medical students completing required educational time in our Emergency Department Simulation Program. This case has been used for the past two years in our program and has recently been edited and expanded to its existing form.

This high-fidelity patient simulation case involves a 3 day old child with a diagnosis of duodenal atresia. Evaluation in the emergency department demonstrates a severely dehydrated neonate with a history of greenish/yellow emesis. Appropriate treatment with IV fluids will allow stabilization of the patient. Residents will also have to discuss the patient’s disposition with an attending pediatric surgeon. Debriefing materials are provided to illustrate and stimulate discussion of the important concepts for diagnosing and treating patients duodenal atresia and bilious emesis.
I. **Title of Case:** Duodenal atresia / Hypovolemic shock

II. **Target Audience:** Resident physicians and medical students

III. **Learning Objectives:**

   A. **Primary Learning Objectives**
      1. Demonstrate an appropriate initial approach for a patient with hypovolemic shock and duodenal atresia.
      2. Identify and treat hypovolemic shock.
      3. Recognize a “double bubble” sign on radiograph.
      4. List the diagnostic features of duodenal atresia.
      5. Understand the treatment of duodenal atresia with possible malrotation.
      6. Mastering the physical exam of the sick neonate.

   B. **Secondary Goals**
      1. Differentiate between different causes of vomiting in a neonate.
      2. Understand the pathophysiology of duodenal atresia.
      3. Illustrate the emergency department disposition for a neonate with bilious emesis.

   C. **Critical Actions**
      1. Obtain appropriate history of present illness from patient’s family.
      2. Complete pertinent physical examination.
      3. Order plain film x-ray.
      4. Identify hypovolemic shock and begin IV fluid resuscitation.
      5. Diagnose duodenal atresia versus malrotation with volvulus.
      6. Arrange appropriate consultation with pediatric surgery.

IV. **Environment:**

   A. **Lab set up** – Pediatric Emergency Department bed #7 in simulation laboratory.

   B. **Manikin set up** – The manikin will be a clothed baby. At the beginning of the simulation, there are no monitor leads on the patient, no IV has been placed, and patient is not on oxygen.

   C. **Props** – Available for use will be a heart monitor with leads, blood pressure cuff, and pulse oximeter. Supplemental oxygen by nasal cannula and face mask will be available. There will be a medicine cart or tray with a full complement of vasoactive agents, PALS medications, medicines necessary for sedation, rapid sequence intubation, and analgesia. In addition, a fully stocked code cart with defibrillator will be available for use, along with a selection of direct laryngoscopes and intubation supplies.
D. **Audiovisual** – (See Appendix A) Available for review when asked for by participants will be a radiograph and laboratory studies.

E. **Distracters** – Distracters can be added at the director’s discretion. The patient will be cared for in the Emergency Department, but the pediatric surgeon on call will attempt to admit the patient to the PICU without first seeing him. Due to the diagnostic dilemma of duodenal atresia versus malrotation and midgut volvulus, the resident will be required to argue that the patient needs to be seen immediately and needs to go directly to the Operating Room. This case is based on a real patient encounter, including the actual discussions with a consulting pediatric surgeon.

V. **ACTORS:**

A. **Roles** – These can vary depending on the number of participants in the simulation session and on potential actor availability. This case can be implemented using the minimum of one participant and one facilitator/operator who can provide oral feedback via overhead audio and play additional roles via voice only. Realism can be enhanced by using physical actors, such as nursing staff members, but these are not required to successfully implement this case.

B. **Who may play them** - Roles may be played by resident or faculty physicians, nurses, or medical students.

C. **Actions for the roles:**
   a. **Primary physician** - The main scenario participant will act as the primary physician and do the primary evaluation of the patient to include obtaining a history, conducting a physical exam, and ordering any necessary medications or other interventions. The primary physician can perform any needed procedures, or can delegate these to other physicians.
   b. **Secondary physicians** - Other participants in the scenario will serve as collaborators, assistants for any necessary procedures, and consultants.
   c. **Nursing staff** - The role of the nurse will be to administer medications, verify orders, and perform other tasks as directed by the physicians. The nurse can also make observations as needed to stimulate case progression.

VI. **CASE NARRATIVE:**

A. **Scenario Background**
   a. **Chief Complaint:** “Vomiting”
   b. **Triage Nursing Note:** Patient is a 3 day old previously healthy male, who came to the ED today because vomiting. Symptoms began during the first day of life and continued to occur intermittently prior to arrival.
   c. **Vital Signs:** Heart rate 190; Blood pressure unable to obtain; Respiratory rate 50; Pulse oximetry unable to obtain; Temperature 95.7 degrees Fahrenheit
d. **Past Medical History:** Normal term delivery without complication. Mother’s prenatal labs were negative. Child was spitting up in the hospital before discharge. A nurse told the mother that the yellow-green color of the emesis was “because it was amniotic fluid”.

e. **Medications and Allergies:** None

f. **Family and Social History:** No significant family history. Mother denies use of alcohol, tobacco, or illicit drugs

**B. Initial Scenario Conditions**

a. **History given by patient:** The patient’s mother is the historian. She reports that symptoms began shortly after birth several days ago and has worsened. The child would feed vigorously at first and spit up yellowish/greenish color emesis after each feeding. This was not evaluated at the hospital prior to discharge home, and the patient’s mother felt comfortable with her discharge instructions. She has not yet seen a pediatrician. She began to worry when the child began acting “very sleepy” and lost interest in feeding.

b. **Circumstances at symptom onset:** Symptoms started at birth, but worsened in the last day.

c. **Associated symptoms:** *(Review of Systems must be asked for)* Child has not had any wet diapers in the past 2 days, has had no fever, was very fussy initially and earlier today became lethargic.

d. **Initial Exam:**

   i. **General:** Patient is a lethargic neonate, and is clinically dehydrated with poor skin turgor. The patient is breathing spontaneously 50 times per minute and has equal breath sounds. Femoral pulses are present, but weak. Distal pulses cannot be felt. Capillary refill is greater than 5 seconds. Fontanel is sunken.

   ii. **Head, Ears, Eyes, Nose, Throat:** There is no evidence of trauma to head. His pupils are equal, round, and reactive from 4mm to 2mm. Extraocular movements are fully intact. Ears are normal, there is no discharge, the tympanic membranes are clear, with good light reflex, no evidence of perforation. Mucous membranes are dry.

   iii. **Skin:** Pale with tenting. No rashes, petechiae, or purpura. No evidence of trauma (bruises).

   iv. **Cardiovascular:** Regular rhythm and tachycardic rate. Pulses as above. No murmurs, gallops or rubs.

   v. **Lungs:** Clear to auscultation without wheezes, crackles, or rales. Equal breath sounds bilaterally.


   vii. **Genitourinary:** Normal external genitalia. No hernias, no tenderness to palpation.

   viii. **Extremities:** No muscle tenderness with full range of motion in all extremities. No swelling or edema. Symmetric extremities.
ix. **Neurological:** Lethargic with decreased level of activity. Pupils equal, round, and reactive to light and accommodation. Decreased Moro, Grasp and Suck reflexes.

e. **Physiology:** (appears when placed patient is placed on monitor)
   i. Heart rate 190
   ii. Blood pressure not able to be obtained until a fluid bolus is given, then is 57/34
   iii. Pulse oximetry not able to be obtained due to the weakness of the peripheral pulses initially, this changes to 100% after the initial fluid bolus is given
   iv. Respiratory rate is 50 breaths/minute

C. **Scenario Branch points**

a. **Changes in patient condition:** The patient’s condition will improve with a 20 cc/kg isotonic fluid bolus

b. **Request for old records:** Unavailable at this time.

c. **Differential Diagnosis:** The physician managing this case may consider sepsis, inborn errors of metabolism, duodenal atresia, malrotation and midgut volvulus, non-accidental trauma, improperly mixed formula, respiratory illness, or cardiac abnormality.

d. **Intravenous fluid administration:** An IV fluid bolus is indicated by the physical exam showing severe dehydration, and the patient will regain pulses and pulse ox reading as stated above with 20cc/kg normal saline or lactated ringers bolus. The patient will have normal blood pressure and perfusion after a second 10 or 20 cc/kg bolus. (Note: lactated ringer’s in neonate may worsen metabolic acidosis in that the immature liver cannot adequately metabolize lactate to bicarbonate, normal saline is preferred)

e. **Other medical interventions:** Based on the patient’s initial presentation, some participants may choose to intubate the patient. During the actual case this was not required due to rapid resolution of hypovolemic shock with IV fluid boluses.

f. **Laboratory studies:** Laboratory studies can be found in Appendix A. Patients labs will be given with blood sugar of 68, BUN/creatinine elevated, CBC normal, CSF normal, PT/INR normal.

g. **Administration of medication:** The patient may be given antibiotics for possible sepsis, as this is appropriately within the differential diagnosis.
h. **Consultation of specialist:** A pediatric surgeon will be available by telephone only. His instructions after telephone consultation are to admit the child to the PICU directly and he will evaluate the patient there in a few hours. Based on the information available in the ED, it remains unclear with available information whether this is duodenal atresia or malrotation. The patient presented in hypovolemic shock, and thus the participant should request that the surgeon evaluate the patient immediately in the ED and determine whether he needs to be taken directly to the operating room for surgical exploration.

i. **Non-recommended actions:** The participant should not admit the patient directly to the PICU without a pediatric surgeon first seeing the patient in the ED first.

**VII. INSTRUCTOR NOTES:**

A. **Scenario flow** – Instructors can directly influence the flow of the scenario by providing the initial patient history via both nursing report and mother’s verbal responses.

   a. **Key aspect of case** - One key aspect of the case flow is recognition of hypovolemic shock and rapidly correcting this with one or two fluid boluses. After this is accomplished the participant should be asked to verbalize an appropriate differential diagnosis of a sick neonate. The results of the x-ray should trigger a consultation with a pediatric surgeon.

B. **Information for actors** – This case can easily be presented without formal “actors” and by using other participants to serve as the nursing staff or other collaborating physicians. Any specific actors used outside of participants should be briefed about the critical actions and anticipated flow of the case ahead of time.

C. **Scenario programming** – The settings for a high-fidelity patient simulator are fairly straightforward for this scenario and do not require specific programming. Our program typically presents this scenario with the initial vital signs as presented above, with the major branch points to be the correction of hypovolemic shock and the diagnosis of duodenal atresia versus malrotation and midgut volvulus. Use of simulation has been shown to improve the realism of the scenario and help the student perform and learn physical exam.

**VIII. DEBRIEFING PLAN:**

A. **Method of debriefing** – A post-case debriefing conference can be completed immediately following the end of the scenario. Consider including some of the following elements:
a. **Open-ended questions by facilitator** – Consider beginning the session with a question to the primary participant about how they felt the scenario went. This often leads to extensive participant-led discussion that will touch on many of the major issues in the case. Invite any secondary participants and/or observers to comment about how the case unfolded.

b. **Brief didactic review** – Potential materials for review after the scenario have been provided in Appendix B.

c. **Formal participant evaluation** – A feedback form for evaluation has been included in Appendix C.

**B. Actual debriefing materials** – See Appendix B for debriefing materials.

**C. Rules for the debriefing** – You may find that an informal discussion format for the initial portion of the debriefing leads to an open discussion of aspects of the case management that were good, and those areas where improvement can be made. Encourage your participants to discuss the case management decisions in a non-judgmental way. When this case is used for experiential learning (without formal participant evaluation on the specific case) such discussions may be more productive as compared to situations where formal feedback is anticipated. We have found that placing an emphasis on the learning that occurs from experiencing a case like this is very effective, rather than focusing on the “correct answer” or whether the specific management decisions turned out to be the most appropriate.

**D. Questions to facilitate the debriefing** –
   a. What are the causes of vomiting in a neonate?
   b. What is the differential diagnosis of a sick neonate?
   c. What are the signs and symptoms of hypovolemic shock?

**IX. PILOT TESTING AND LESSONS LEARNED:**

**A. Number of participants** – This scenario has been presented for small groups of 3-4 participants, and has been field tested approximately 20 times over the past 2 years. All participants have been 4th year medical students.

**B. Performance expectations** – Our experience to date has shown medical students are able to successfully negotiate this case. The majority of the 20 students (70%) have successfully diagnosed hypovolemic shock and related this to vomiting. A majority (75%) successfully worked through the majority of the possible causes of an ill neonate. While many students are unfamiliar with how to do a complete workup of a neonate, after the discussion and with repetition the majority of participants felt more comfortable with the workup of a sick neonate. The students felt more comfortable with the sick neonate after debriefing. Student input showed us that running the scenario a second time after debriefing made the learning experience complete.
C. Anticipated management mistakes –
   a. Failure to ask consultant to see the patient immediately – A number of
      students have failed to properly appreciate that the concern for midgut
      volvulus in the patient could be life threatening if not differentiated from
      duodenal atresia immediately.

   b. Confusion about the sick neonate workup – We found that a number of
      participants were not completely comfortable with the differential diagnosis of
      a sick neonate and did not complete a full workup of the patient. This
      included considering malrotation with volvulus, sepsis, cardiac abnormalities
      and thyroid dysfunction.

D. Evaluation form for participants – Appendix C includes an evaluation form.

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XI. REFERENCES:


Appendix A

Supplemental Case Materials

James C. O’Neill, M.D.
Michael T. Fitch, M.D., Ph.D.

Department of Emergency Medicine
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Radiologic Imaging
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**Urine Studies**

Negative except for large ketones

Lactic Acid 5.7
Ammonia 45
Cortisol 63
Appendix B

Case Debriefing Materials

James C. O’Neill, M.D.
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Department of Emergency Medicine
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Duodenal Atresia / Hypovolemic Shock

James C. O’Neill, M.D.
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Department of Emergency Medicine
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Duodenal Atresia / Hypovolemic Shock

• Duodenal atresia is a congenital malformation
  – The duodenum does not develop normally
  – Normal digestion is blocked

• Diagnosis occurs in newborn nursery or within the first several days of life

• Can present with bilious emesis
  – Bilious emesis in a neonate is a concerning symptom
  – Must rule out malrotation with midgut volvulus
Pathophysiology of Duodenal Atresia

- **Duodenal atresia is a malformation that occurs during neonatal development**
  - Neonatal ultrasound may show polyhydramnios
  - Persistent vomiting as a newborn may lead to discovery before child has left the hospital
  - Shorter antenatal stays in the hospital has led to this occasionally being discovered in the ED
Clinical Features of Duodenal Atresia

- Vomiting is the most common symptom
  - May be bilious or non-bilious vomiting
    - Depends on the location of duodenal blockage
  - Children often will quickly become dehydrated
  - Can present with hypovolemic shock

- Abdominal exam may be unremarkable
  - Contrasts with the significant abdominal tenderness of malrotation and volvulus
Characteristic Radiograph

“Double-Bubble Sign”

The physician originally reading this x-ray thought it was consistent with midgut volvulus.
Laboratory Studies

Sodium 143
Potassium  5.0
Chloride 100
CO2  14
Glucose 157
**BUN 70**
**Creatinine 2.5**
**Lactic Acid 5.7**

This patient was found to be in acute renal failure that responded to fluid hydration
Vomiting in a Neonate

**Differential Diagnosis**

- Duodenal Atresia
- Malrotation and Volvulus
- Necrotizing Enterocolitis
- Sepsis
- Adrenal insufficiency
Characteristics of Duodenal Atresia

- Occurs in 1 per 5-10,000 live births
- Male > Female
- Down syndrome is present in 25% of patients
- Congenital heart disease in 20% of patients
Characteristics of Duodenal Atresia

- **Atresia is typically in the 2\textsuperscript{nd} part of the duodenum**
  - In 80\% of patients the atresia is distal to the ampulla of Vater
  - This leads to bilious emesis

- **Can be repaired with a straightforward surgical procedure**
Malrotation and Midgut Volvulus

• **Anatomic abnormality with midgut twisting**
  – Clockwise rotation of midgut around the mesenteric vessels
  – Leads to intestinal obstruction
  – May cause infarction of the intestines

• **Inadequate counterclockwise rotation**
  – Midgut suspended around mesenteric arteries
  – Leads to intestinal obstruction

• **Twisting due to peristaltic action**
  – Can lead to strangulation of the blood supply
  – Acute intestinal ischemia and dead bowel
Other Causes of Bilious Emesis

- **Jejunoileal atresia**
  - May have abdominal distention

- **Meconium ileus**
  - May have distention with air-fluid levels on x-ray

- **Necrotizing enterocolitis**
  - Abdominal distention
  - Onset 10-12 days after birth
  - Occurs more frequently in premature infants
Bilious Emesis in a Neonate

Treatment Recommendations

• **Hypovolemic shock**
  – Rehydration with IV fluid boluses for hypovolemia.

• **Consider possible sepsis**
  – The patient in this scenario received antibiotics for sepsis until x-ray and laboratory information returned. An excellent pneumonic for the evaluation of a sick neonate is SCAM (sepsis, cardiac issues, abuse, other medical issues)

• **Pediatric surgery consultation**
  – Emergent evaluation by a pediatric surgeon
  – Operative management versus other testing
  – Midgut volvulus requires surgical treatment
References


Duodenal Atresia / Hypovolemic Shock

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**Simulation Evaluation**

**Participant’s name:**

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**SUBJECT**

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**Case Evaluation**

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**Overall Grade:**

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**Notes:**

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