Medical Mystery Case: A Rocky Start

PODCAST 32

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Learning Objectives

1. Identify issues with neonates and phlebotomy.
2. Review use of blood analyzers in a NICU setting.
3. Describe the value of point-of-care analyte testing in the NICU.
4. Apply new information and technologies to improve patient care.

Disclosures

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There are no additional disclosures for this program.

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A Rocky Start

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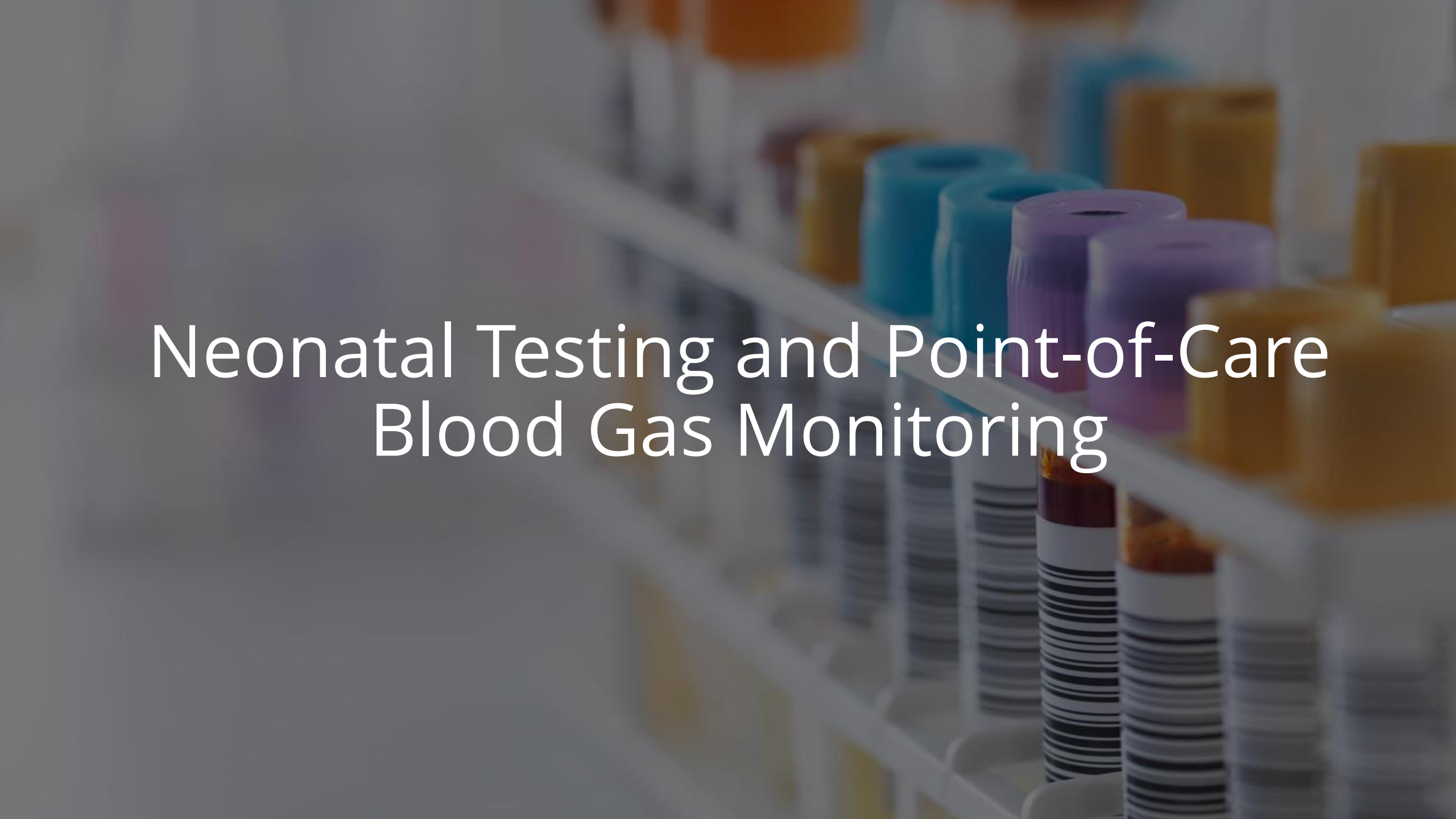


Neonatal Testing and Point-of-Care Blood Gas Monitoring

Risks of Birth

- A newborn infant, or neonate, is a child under 28 days of age.[1]
- During that first 28 days of life
  - Every organ system is involved from the transition from fetus to neonate.[2]
  - There is often a need for medical assistance.[2]
  - A child is at highest risk of dying during this period.[1]
- Neonates have immature organ systems, different airway and lung mechanics, and a higher basal metabolic requirement for oxygen.[3]
- Early signs of clinical deterioration are often nonspecific, making a diagnosis challenging.[4]
- Blood analysis is integral to monitoring Neonatal Intensive Care Unit (NICU) patients.

1. https://www.who.int/westernpacific/health-topics/newborn-health#:~:text=A%20newborn%20infant%2C%20or%20neonate,to%20health%20care%20is%20low. Accessed 30 June 2023.
2. Hillman, N, Kallapur SG, Jobe A. *Clin Perinatol*. 2012 Dec; 39(4):769–783.
3. Saikia D, Mahanta B. *Indian J Anaesth*. 2019 Sep;63(9):690-697.
4. Sullivan BA, Keim-Malpass J. *Hosp Pediatr*. 2021 Sep;11(9):e195-e198.

Premature Infants Are Prone to Rapid Decompensation From Underdeveloped Organ Systems

- Underdeveloped lungs
- Underdeveloped immune system
- Underdeveloped kidneys
- Underdeveloped digestive tract and liver

Premature infants need constant monitoring via labs and imaging.

Balest AL. Preterm (Premature) Newborns. https://www.merckmanuals.com/home/children-s-health-issues/general-problems-innewborns/preterm-premature-newborns. Accessed 20 July 2023.

Neonatal Diagnostic Challenges

- In term and preterm neonates, total blood volume ranges from 80 to 115 ml/kg.[1]
- Studies have shown that reduced fetal hemoglobin levels are related to increased neonatal morbidity rates.[2]
- Too much blood sampling can cause endogenous blood loss and has been associated with the development of bronchopulmonary dysplasia.[2]

1. Proytcheva MA. *Am J Clin Path*. 2009;131(4):560–573.
2. Hellström W, et al. *Acta Paediatr*. 2020 Apr;109(4):679-687.

Babies Have Very Little Blood Volume For Testing

- Blood drawn for laboratory testing should not exceed 5% of the total blood volume per draw.

- A **10 ml blood sample** drawn with standard tubes may represent as much as **10% of the total blood volume** in a preterm neonate.

Proytcheva MA. *Am J Clin Path*. 2009;131(4):560–573.

Capillary Blood Sampling For Blood Gasses is Recommended

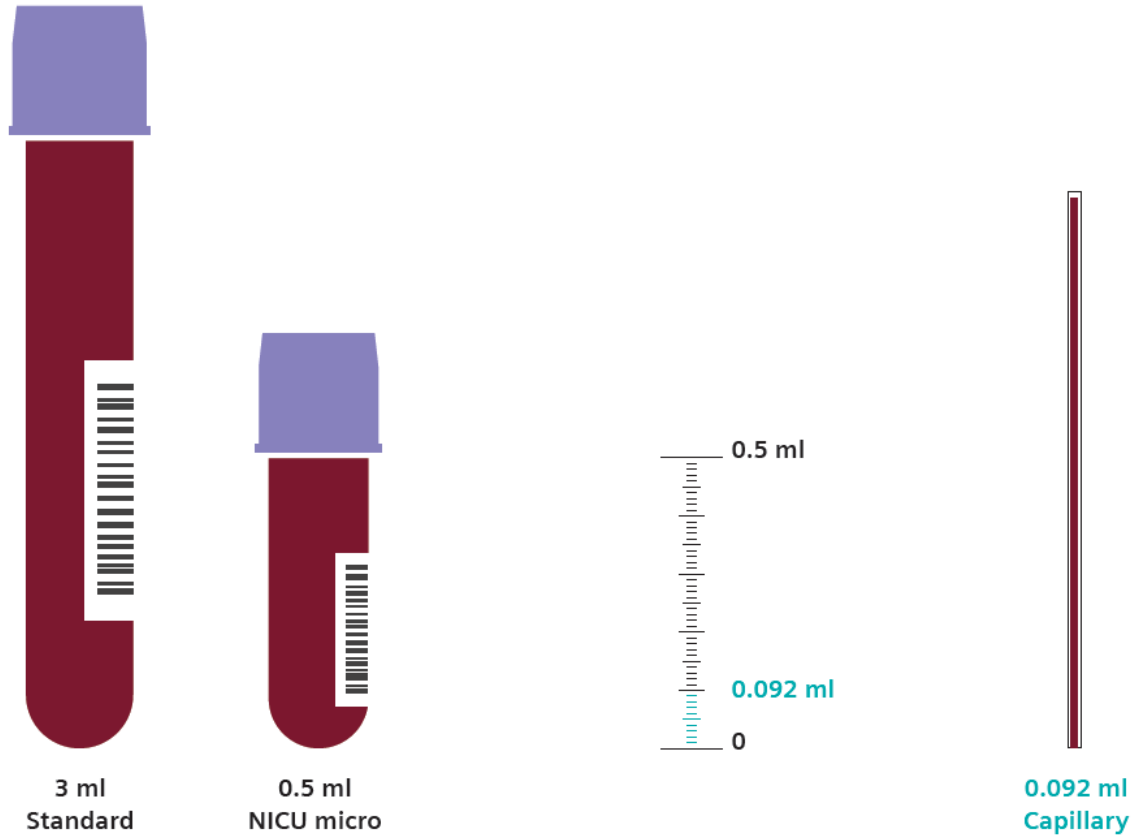
The American Association for Respiratory Care Clinical Practice Guidelines provides specific recommendations regarding capillary sampling for blood gas assessment in neonatal patients.

Capillary blood sampling provides an alternative to arterial blood sampling, and compared with a percutaneous arterial puncture, is less technically challenging with fewer risks of harm.

Evans DL, et al. *Respir Care*. 2022 Sep;67(9):1190-1204.
Richter S, et al. *Br J Hosp Med* (Lond) 2014;75(3):136-142.

Point-of-Care Blood Gas Metabolite Analyzers Use Less Blood than Standard Laboratory Testing

Modern handheld point-of-care analyzers need very little blood compared to a standard laboratory tube which holds ~3 ml of blood.



Less Blood Volume For Testing Reduces Risks and Improves Outcomes

Point-of-care bedside blood analyzers have been shown to reduce red blood cell transfusions in low birth weight infants.

Capillary blood samples require little amounts of blood compared to more difficult neonate blood draws.

Testing can be completed at the patient's bedside, improving response time.

Madan A, et al. *J Perinatol*. 2005 Jan;25(1):21-5.
Mahieu L, et al. *Clin Chim Acta*. 2012;413(1–2):325–330.

Point-of-Care Capillary Blood Gas and Metabolite Testing Can Monitor for Decompensation Without Excess Blood Loss

- Underdeveloped lungs
  - Monitoring for ventilator support and development of respiratory distress syndrome
- Underdeveloped immune system
  - Capillary testing reduces need for central line access that may predispose infants to sepsis
- Underdeveloped kidneys
  - Monitoring for potassium, other electrolytes, and possible acidosis
- Underdeveloped digestive tract and liver
  - Monitoring for hyperbilirubinemia, metabolic acidosis, and hypoglycemia

Balest AL. Preterm (Premature) Newborns. https://www.merckmanuals.com/home/children-s-health-issues/general-problems-innewborns/preterm-premature-newborns. Accessed 20 July 2023.

What About Kemena?

How Did We Get to a Diagnosis?

Part I

PATIENT: Pre-term infant, female	**AGE:** 32 weeks gestation	**WEIGHT:** 3.10 LBS

NOTES: Patient born pre-term at 32 weeks gestation due to chorioamnionitis. Presented with signs of Respiratory Distress Syndrome.

Patient's glucose was a bit low at birth. She was given a peripheral IV with dextrose. Patient kept on a CPAP and fed normally.

Peripheral IV was lost on day 3, oral feedings were increased.

	pH	pCO2	pO2	HCT	Glucose
LABS AT BIRTH	7.29	High, 66	Low, 41	61	Slightly low

How Did We Get to a Diagnosis?
Part II

PATIENT: Pre-term infant, female	**AGE:** DOL 4	**TREATING FOR:** Respiratory Distress Syndrome

NOTES: Patient experienced several apnea spells on day 4.

RADIOLOGY REPORT: Chest x-rays show granular appearance, low lung volume, and mild pulmonary edema. Abdomen – mildly dilated bowel loops present, no free air or pneumatosis visible.

	pH	pCO2	pO2	HCT	HCO3	Base Deficit	Na	K	BUN	Cr	Lactate
DOL 4	7.27	36	44	37%	18	-6	130	5.8	22	1.7	3.1

How Did We Get to a Diagnosis?
Part III

PATIENT: Pre-term infant, female	**AGE:** DOL, 4 + 2 hours	**TREATING FOR:** Necrotizing Enterocolitis (NEC)

NOTES:
Day 4, 2 hours later: Blood gas results demonstrating mixed respiratory and metabolic acidosis.

Glucose is low at 33.

Updated lab results and x-rays confirm diagnosis of necrotizing enterocolitis with small perforation of the bowel.

RADIOLOGY REPORT:
Follow-up chest x-ray revealed endotracheal tube in the mid-trachea, increase lung volumes compared to previous images. Pulmonary edema still present with granular opacities throughout. No evidence of pneumothorax.

Abdomen x-rays revealed dilated and fixed bowel loops with pneumatosis present in the small bowel. Tiny sliver of free air present over the liver.

	pH	pCO2	pO2	HCT	HCO3	Base Deficit	Na	K	BUN	Cr	Lactate
DOL 4 + 2 hours	**7.09**	51	24	29%	**15**	**-13**	122 (low)	6.1 (high)	30 (high)	3.2 (high)	8.6 (high)

What is Necrotizing Enterocolitis?

Necrotizing Enterocolitis (NEC)

Almost exclusively affecting neonates,
NEC has a **50% mortality rate**.

- NEC is the most common gastrointestinal life-threatening emergency in the NICU.
- NEC is caused by a bacterial invasion which leads to inflammation and cellular destruction of the intestinal wall.
- As NEC progresses, it can lead to intestinal perforation causing peritonitis, sepsis, and death.

Ginglen JG, Butki N. Necrotizing Enterocolitis. *StatPearls Publishing*. 2022. https://www.ncbi.nlm.nih.gov/books/NBK513357/. Accessed July 26, 2023.

NEC Distribution

Onset for full-term infants typically begins between 1-5 days of life.
Onset is typically associated with a hypoxic event.
Onset for pre-term infants typically begins during the 2nd to 3rd week of life.
While the exact cause is unknown, it is believed that gastrointestinal immaturity in premature neonates plays a large role.

Ginglen JG, Butki N. Necrotizing Enterocolitis. *StatPearls Publishing*. 2022. https://www.ncbi.nlm.nih.gov/books/NBK513357/. Accessed July 26, 2023.

What Are the Risk Factors for an Infant Developing NEC?

The exact cause of NEC is still a mystery. However, the factors identified here likely contribute to the development of NEC.

Difficult birth

Infections in the intestine

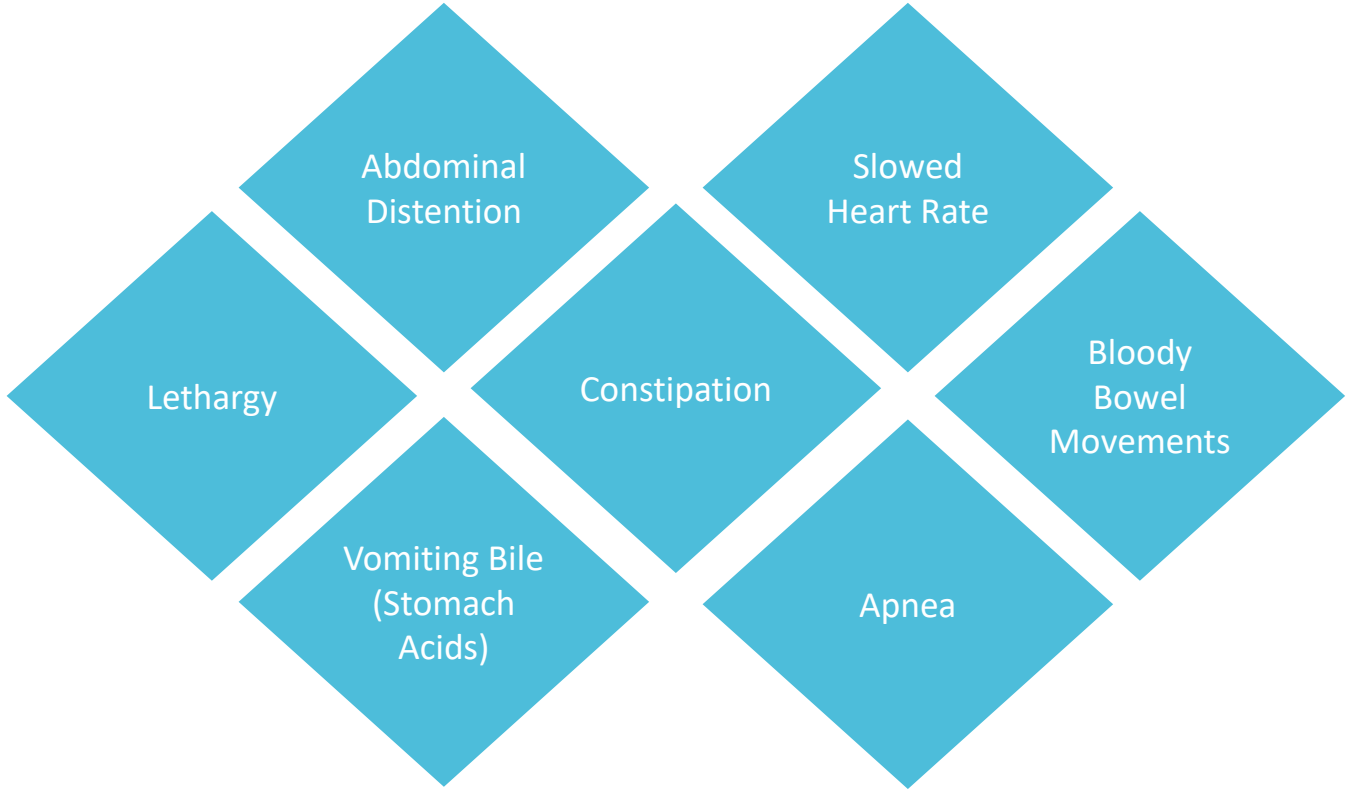
Formula feeding

Preterm birth, 36 weeks gestation or less

Low oxygen levels at birth

Stanford Medicine Children's Health. Necrotizing enterocolitis in the newborn. *Stanford Medicine Children's Health*. https://www.stanfordchildrens.org/en/topic/default?id=necrotizing-enterocolitis-90-P02388. Accessed July 26, 2023.

Symptoms and Presentation of NEC

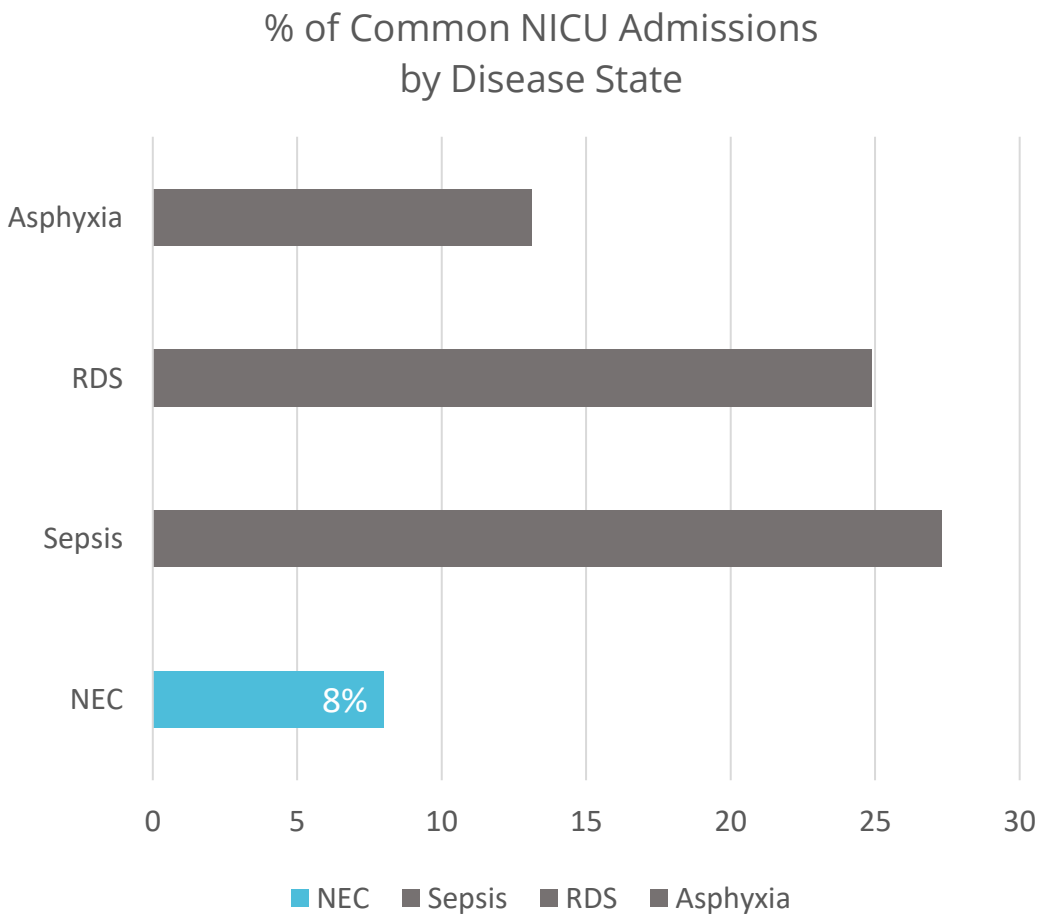


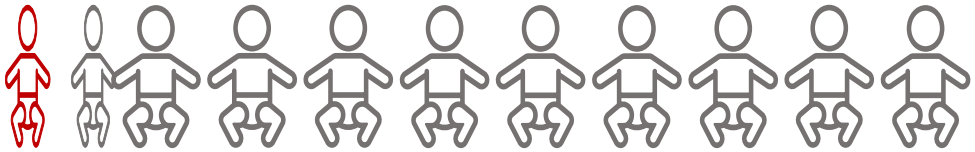
Above are some of the more common symptoms seen with neonatal NEC.

- Necrotizing enterocolitis is often difficult to diagnose due to the vague and varied presentation of the disease.
- Signs and symptoms are often non-specific and subtle.

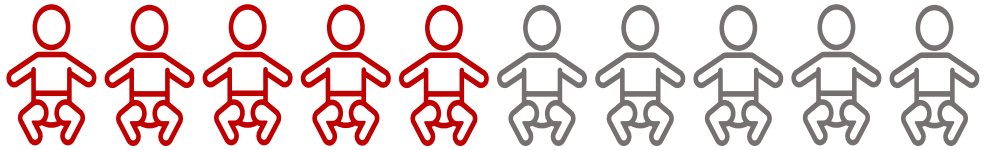
Ginglen JG, Butki N. Necrotizing Enterocolitis. *StatPearls Publishing*. 2022. https://www.ncbi.nlm.nih.gov/books/NBK513357/. Accessed July 26, 2023.

Necrotizing Enterocolitis: By the Numbers





NEC affects **~2-5%** of all premature infants.



The mortality rate for infants with NEC is **10-50%** depending on disease severity.

Al-Momani MM. *Pak J Med Sci*. 2020;36(6):1371-6. doi: 10.12669/pjms.36.6.2281.

Ginglen JG, Butki N. Necrotizing Enterocolitis. *StatPearls Publishing*. 2022. https://www.ncbi.nlm.nih.gov/books/NBK513357/. Accessed July 26, 2023.

Complications of Necrotizing Enterocolitis

- Neurodevelopmental delays
- Failure to thrive
- Inability/reduced ability to absorb nutrients
- Cholestasis
- Intestinal failure
- Sepsis
- Death

- Gastrointestinal complications
  - Intestinal inflammation
  - Tissue death
  - Hole(s) in the intestine
  - Strictures
  - Adhesions
  - Short bowel syndrome

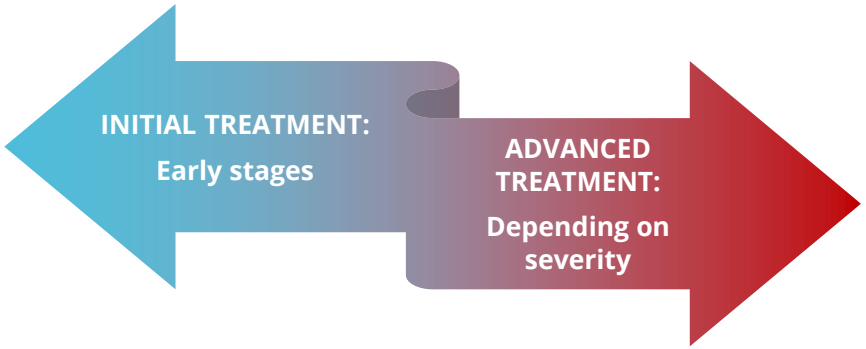
Bazacliu C, Neu J. *Curr Ped Rev*. 2019;15(2):115-124. DOI:10.2174/1573396315666190312093119

Methods of Control & Treatment

Stop all enteral feedings

Replace feedings with IV fluids

Broad spectrum IV antibiotic therapy

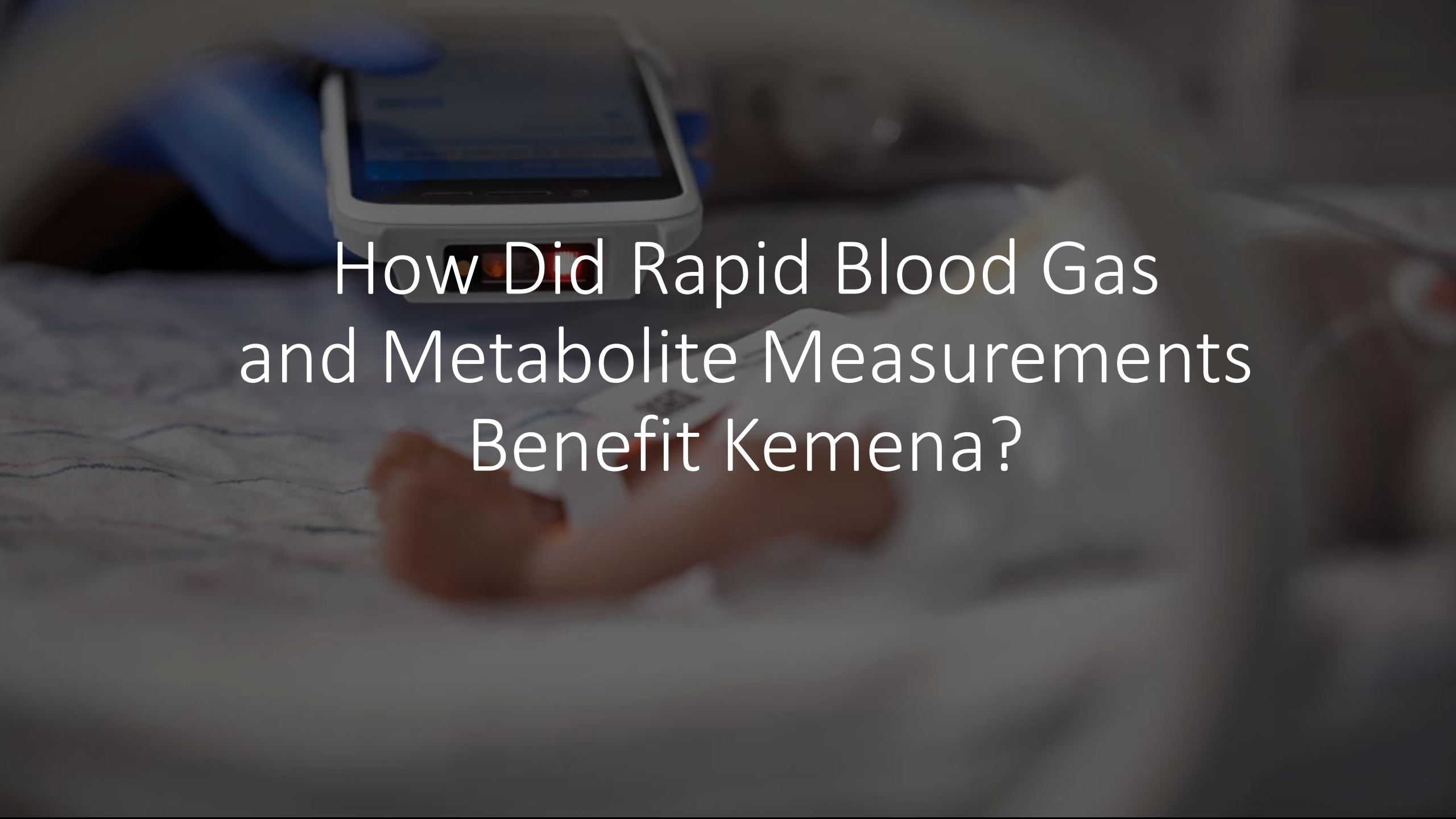


Nasogastric tubing

Bubble CPAP

Surgical intervention

Hackman D. Necrotizing enterocolitis. *Johns Hopkins Medicine*. https://www.hopkinsmedicine.org/health/conditions-and-diseases/necrotizing-enterocolitis. Accessed July 26, 2023.



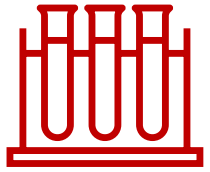
How Did Rapid Blood Gas and Metabolite Measurements Benefit Kemena?

Point-of-Care Blood Gas and Metabolic Panel Measurements Led to Improved Outcomes for Kemena

1. Immediate identification of respiratory distress syndrome a few minutes after birth led to on-site treatment with a CPAP prior to transfer to the NICU.
2. Identification of low blood glucose at birth provided opportunity for early treatment before hypoglycemia became dangerous.
3. During Kemena's rapid decompensation on day 4, identification of metabolic and respiratory distress via blood gas measurements along with elevated metabolic and infection markers suggested a diagnosis of NEC and led to a call for additional imaging to confirm.
    - As a result of rapid identification of NEC, Kemena was able to be treated in time and returned home on her due date.

Summary

Risks of laboratory tests over rapid capillary testing includes blood loss and delay in results that could affect patient outcomes.



Rapid, point-of-care capillary blood analysis systems provide accurate and actionable blood gas, electrolyte, and metabolite test results at the bedside. This allows for more rapid and appropriate decisions to be made, leading to more timely and effective medical care and treatment.

Choi H, et al. *Pediatrics*. 2018;141(1):578. https://doi.org/10.1542/peds.141.1MA6.578
Klunk CJ, et al. *Pediatrics*. 2021;148(1):e2020000570. https://doi.org/10.1542/peds.2020-000570

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