UCSF Benioff Children's Hospitals

Alphabet soup of preemie problems… MBM & NEC

Tanya Kamka, MSN, RNC-NIC
Neonatal Outreach Educator

Samantha Wynn, RN, BSN, Cynthia Jensen, MS

Objectives

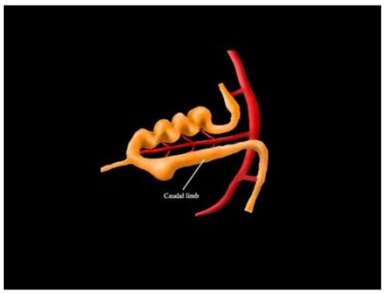
Upon completion of this presentation the participant should be able to:

- Describe fetal GI development
- Differentiate between the term and preterm GI system
- Describe nutritional goals for the preterm infant
- Identify risk factors for necrotizing enterocolitis (NEC)
- Identify signs and symptoms of NEC
- Describe medical and surgical treatment plans for NEC

UCSF Benioff Children's Hospitals

Embryologic GI Development

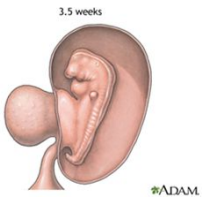
- Fetal gut complete by 20-22 weeks
- Functional development begins in utero and continues into infancy

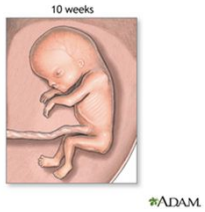


UCSF Benioff Children's Hospitals

Gastrointestinal Development

- By 4 weeks the embryo has a single tube intestine, liver bud, and hepatobiliary system
- At 5-9 weeks rapid small intestine growth causes herniation
- By 10 weeks, intestines reenter the abdomen. Villi and microvilli are formed



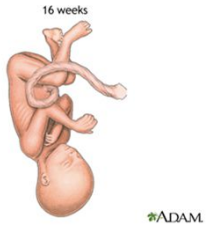


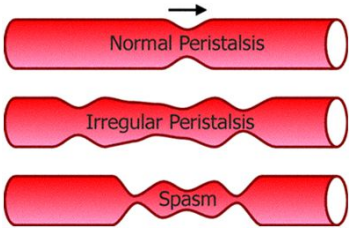
Medline Plus. (2017). *Fetal development: MedlinePlus Medical Encyclopedia.Medlineplus.gov*. Retrieved 15 April 2017, from https://medlineplus.gov/ency/article/002398.htm

UCSF Benioff Children's Hospitals

Gastrointestinal Development

- At 16 weeks the fetus begins sucking & swallowing, meconium is present
- By 24 weeks the intestines secrete digestive enzymes
- At 32 weeks the fetus begins normal gastric emptying. At 34-36 weeks suck swallow coordination occurs, along with rapid peristalsis





5 Medline Plus. (2017). *Fetal development: MedlinePlus Medical Encyclopedia.Medlineplus.gov*. Retrieved 15 April 2017, from https://medlineplus.gov/ency/article/002398.htm

UCSF Benioff Children's Hospitals

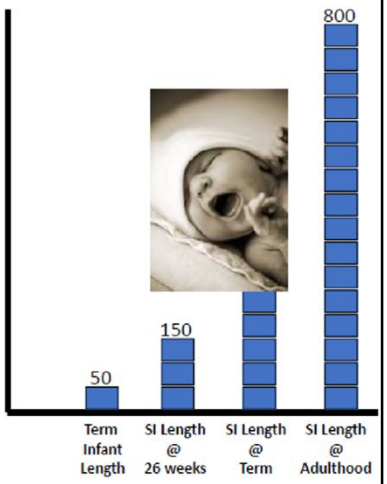
How long are the small intestines?

- The intestines are the largest part of our body that interact with the external environment

6 McElroy, S. (2017). *Innate Immunity and NEC*. Presentation, UC Davis.

UCSF Benioff Children's Hospitals

How long are the small intestines?



7 McElroy, S. (2017). *Innate Immunity and NEC*. Presentation, UC Davis.

UCSF Benioff Children's Hospitals

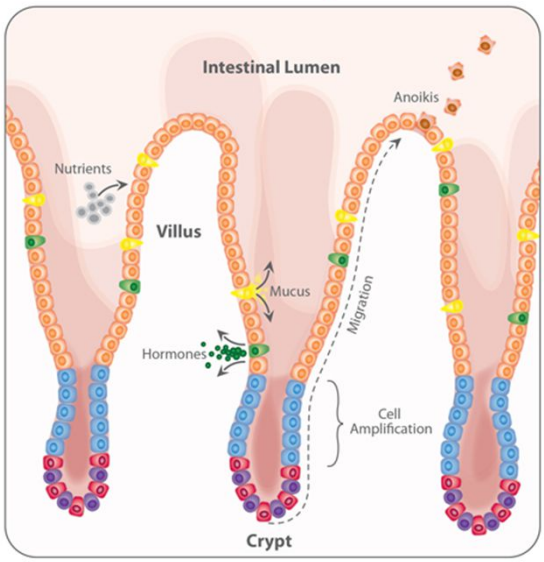
Structure of the Small Intestines

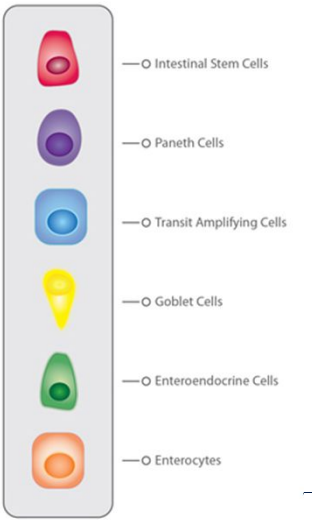
- https://www.youtube.com/watch?v=qq5k1sWqLO0

9

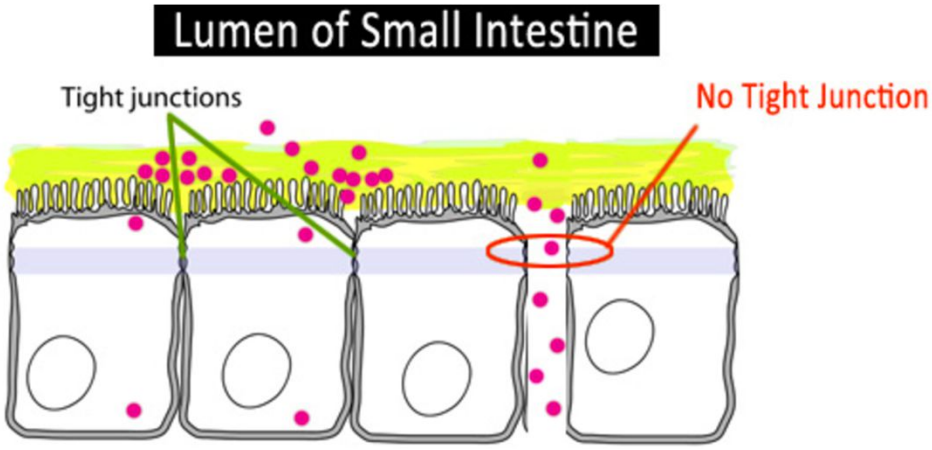
UCSF Benioff Children's Hospitals

The Intestinal Epithelium





Small Intestines Tight Junctions



UCSF Benioff Children's Hospitals

Gastrointestinal Development

Neonatal phase

- Exposure to enteral nutrition leads to rapid differentiation and development
- Development of GIT mucosal immunity due to dietary antigens (or lack of)
- Mucosal immune system begins to distinguish between safe nutrients and foreign pathogens
- What are we putting into our babies??

UCSF Benioff Children's Hospitals

Case Study

- DOL 9
  - "small and weak"
  - Copious green-stained diarrhea
  - Intense perianal redness
  - Swollen abdomen
- DOL 11
  - Large bloody stools
  - Vomiting
  - Cold, livid extremeties
  - Tense belly
  - Extremely slow heartbeat
  - Intense perianal redness
  - Swollen abdomen
  - Dies that evening with a large liquid black stool

13 Dunn, P. (1990). Charles-Michel Billard (1800-1832): pioneer of neonatal medicine.*Archives Of Disease In Childhood*, *65*(7 Spec No), 711-712. http://dx.doi.org/10.1136/adc.65.7_spec_no.711

UCSF Benioff Children's Hospitals

Case Study Continued

Upon autopsy

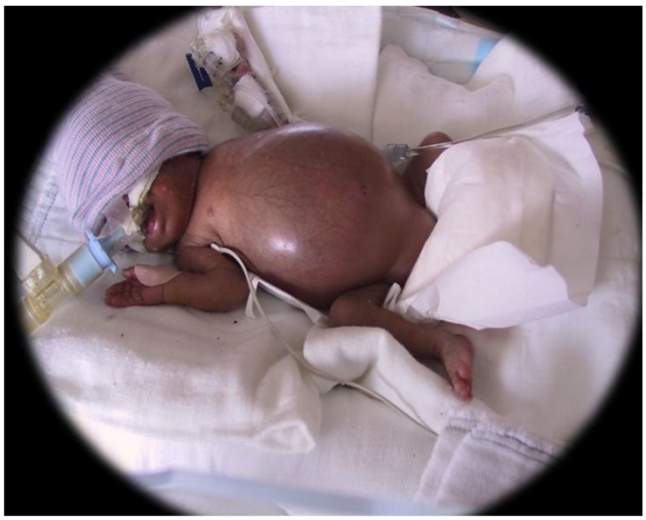
- Terminal ileum intensely red and swollen
- Mucosa friable, covered in blood
- "Mucosa is so soft it turns to mash when scraped with the fingernail…"

-Reported by Charles Billard in 1826

14

UCSF Benioff Children's Hospitals

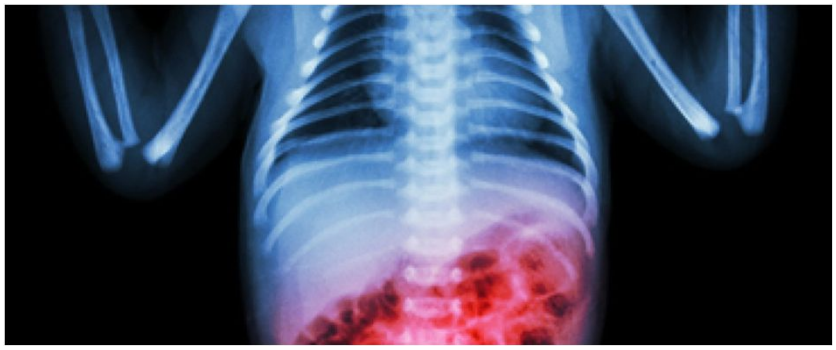
When Good Guts Go Bad…



15

UCSF Benioff Children's Hospitals

Necrotizing Enterocolitis



16

UCSF Benioff Children's Hospitals

What is NEC?

- **Definition**: an acquired disease that affects the GI system, particularly that of *premature infants*. It is characterized by **inflammation** of the bowel wall followed by areas of **necrosis**, most commonly in the terminal ileum and proximal colon, but may affect any or all of the small and large intestines.

17 Verklan, M., & Walden, M. (2015). *Core curriculum for neonatal intensive care nursing* (5th ed.).

UCSF Benioff Children's Hospitals

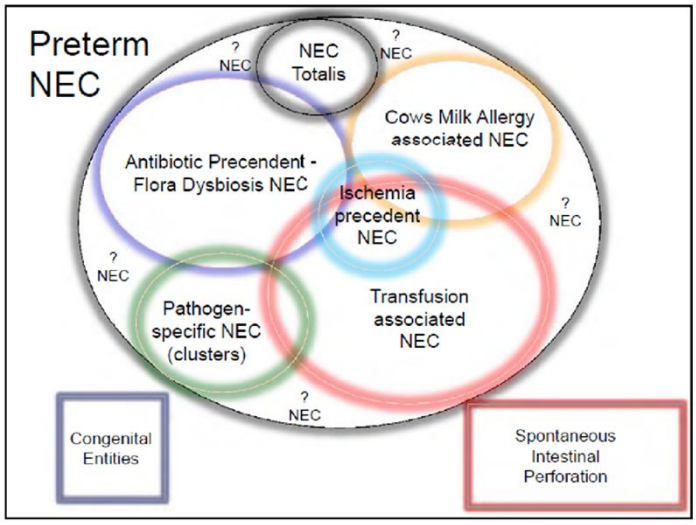
Incidence

- BW 501 to 750 g – 12 percent risk, 42 percent mortality with NEC
- BW 751 to 1000 g – 9 percent risk, 29 percent mortality with NEC
- BW 1001 to 1250 g – 6 percent risk, 21 percent mortality with NEC
- BW 1251 to 1500 g – 3 percent risk, 16 percent mortality with NEC

18 Verklan, M., & Walden, M. (2015). *Core curriculum for neonatal intensive care nursing* (5th ed.).

UCSF Benioff Children's Hospitals

What is or isn't NEC?



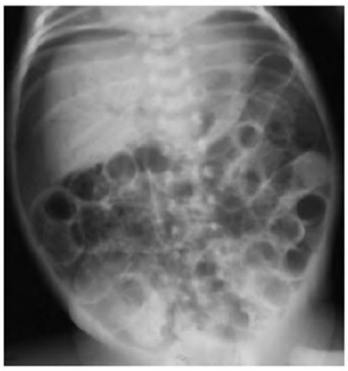
Gordon, P. (2017). *We have to redefine NEC*. Presented at, UC Davis

19

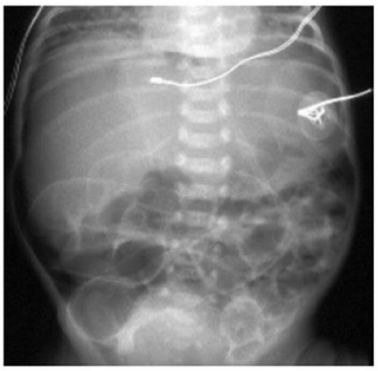
UCSF Benioff Children's Hospitals

Which baby has NEC?

Baby X



Baby Y



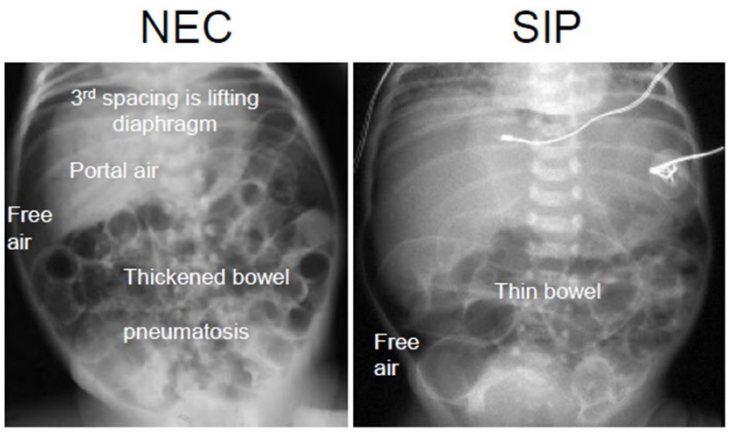
Gordon, P. (2017). *We have to redefine NEC*. Presented at, UC Davis

20

UCSF Benioff Children's Hospitals

Which baby has NEC?

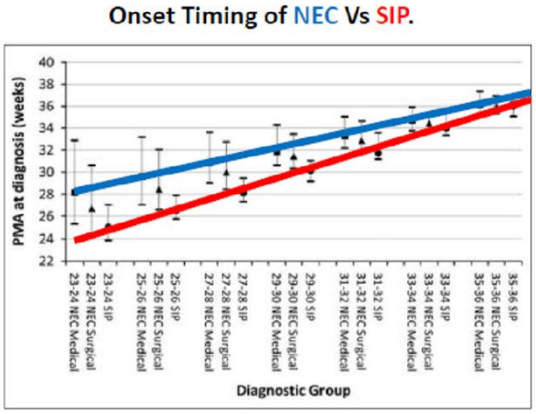
Many cases of NEC and SIP can be differentiated by an x-ray but unfortunately not all



Gordon, P. (2017). *We have to redefine NEC*. Presented at, UC Davis

UCSF Benioff Children's Hospitals

NEC vs SIP



Can a national dataset generate a nomogram for necrotizing enterocolitis onset?.

Gordon, P; Clark, R; Swanson, J; Spitzer, A

Journal of Perinatology. 34(10):732-735, October 2014.
DOI: 10.1038/jp.2014.137

Figure 3. The median postmenstrual age at diagnosis of NEC-Medical ([black small square]), NEC-Surgical ([DELTA]) and SIP (*) within gestational age groups showing how postmenstrual age at diagnosis increases with increasing gestational age. NEC surgical and SIP were diagnosed earlier in infants with a gestational age =<32 weeks. The bars represent the 10th to 90th percentiles for each group.

Gordon, P. (2017). *We have to redefine NEC*. Presented at, UC Davis

UCSF Benioff Children's Hospitals

NEC vs SIP

	NEC	SIP
Incidence < 1500 grams	7 – 10%	2 – 3%
Age of onset	2-6 weeks	0-14 days
Pneumatosis	Yes	No
Enteral feedings	Yes	No
Histologic evidence of villus necrosis	Yes	No
Mortality	10-30% above baseline	5-10% above baseline

SIP

- Can occur in the absence of NEC
- Compared to NEC: less hemodynamic instability, less metabolic acidosis, improved survival rate, lack of coagulation necrosis seen in NEC
- More common in patients with: UAC, administration of indomethacin or ibuprofen

Gordon, P. (2017). *We have to redefine NEC.* Presented at, UC Davis

23

UCSF Benioff Children's Hospitals

Early vs Late onset

- Early onset
  - Usually term
  - First 7 days
  - Critically ill
  - Never fed
  - Vascular cause of intestinal injury
- Late onset
  - > 7 days
  - Growing preemie
  - Has been fed
  - Luminal cause of intestinal injury

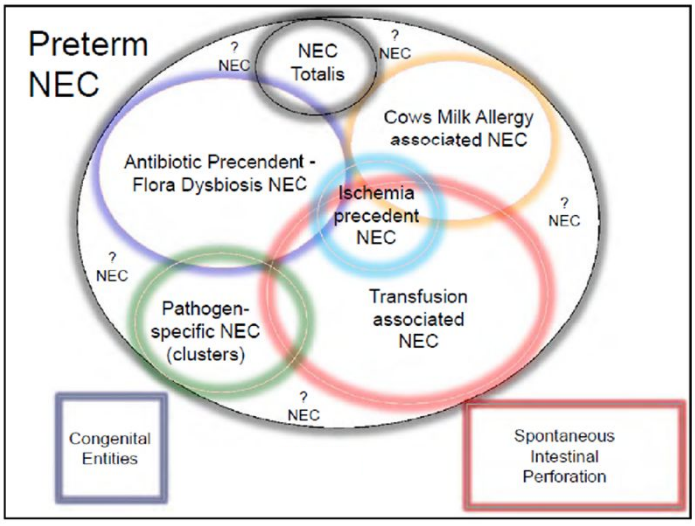
UCSF Benioff Children's Hospitals

NEC in Term Infants

- Gut vs gut immaturity
- Early onset – perinatal events plausible
- Cannot rely on metabolic acidosis, hemodynamic instability. May have few systemic symptoms due to greater reserve
- Improved survival – probably related to lack of associated problems of prematurity
- May be that NEC results from two different disease processes in premature and term infants
- Most have some risk factor

UCSF Benioff Children's Hospitals

What is or isn't NEC?



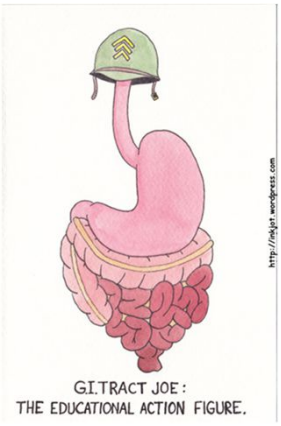
Gordon, P. (2017). *We have to redefine NEC.* Presented at, UC Davis

26

UCSF Benioff Children's Hospitals

NEC Pathogenesis

- **Prematurity**
  - Propensity towards gut inflammation
  - Impaired intestinal barrier function
  - Decreased intestinal motility
  - Deficient mucosal enzymes, hormones, pepsin, and gastric acid
  - Immature autoregulation of microcirculation
  - Lack of amniotic fluid
  - Immature mucin layer

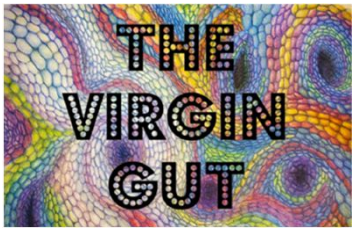


27

UCSF Benioff Children's Hospitals

NEC Pathogenesis

- **Enteral Feeds**
  - Formula feeding
  - Fortification



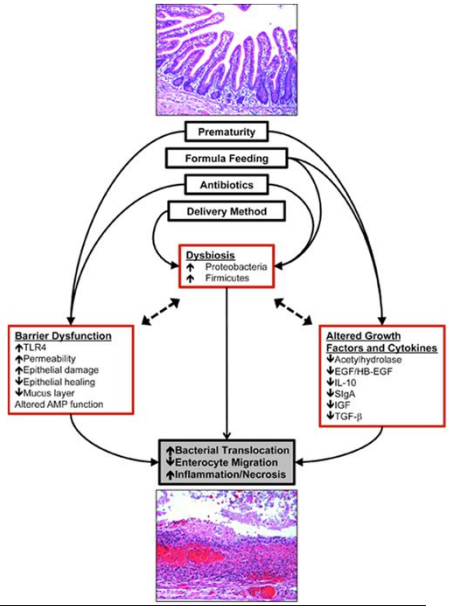
- **Abnormal intestinal microbiota**
  - Decreased commensal flora
  - Increased pathogenic bacteria
  - Prolonged antibiotic therapy
  - Acid suppression medications

28

UCSF Benioff Children's Hospitals

NEC Pathogenesis

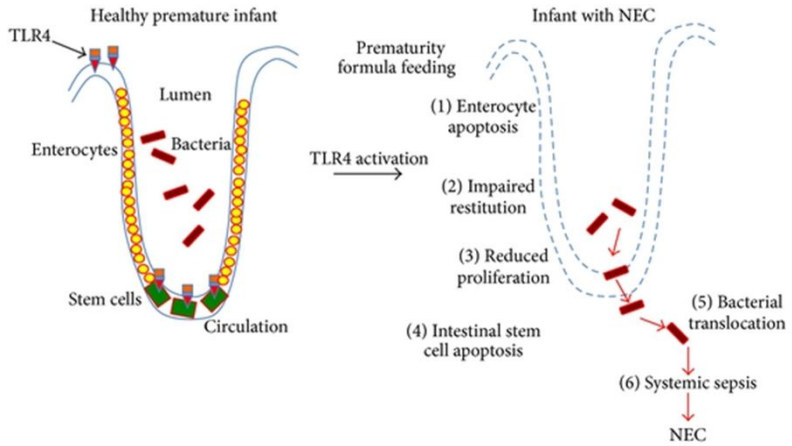
- **Gut Ischemia**
  - Abnormal gut vascular regulation
  - More prone to hypoxic events
- **Inflammatory response**
  - Genetic factors?
  - TLR4?



UCSF Benioff Children's Hospitals

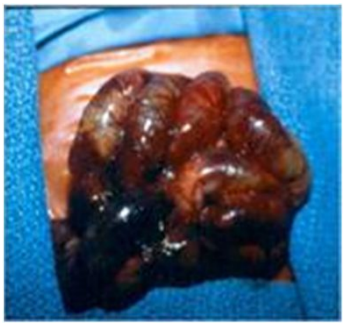
NEC Pathogenesis

- **TLR4**
  - Toll-like receptor



Etiology

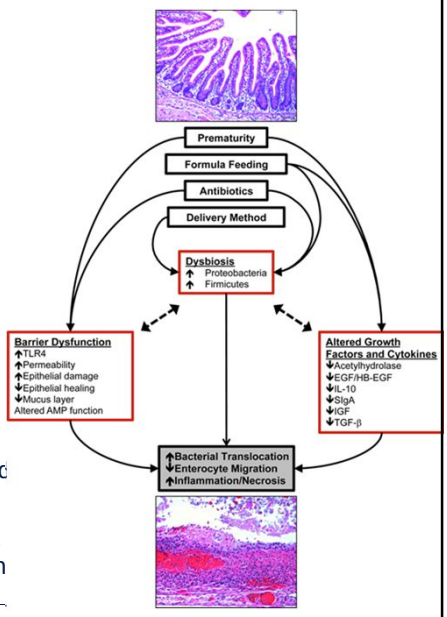
Common final pathway – the endogenous production of inflammatory mediators that precipitate intestinal injury



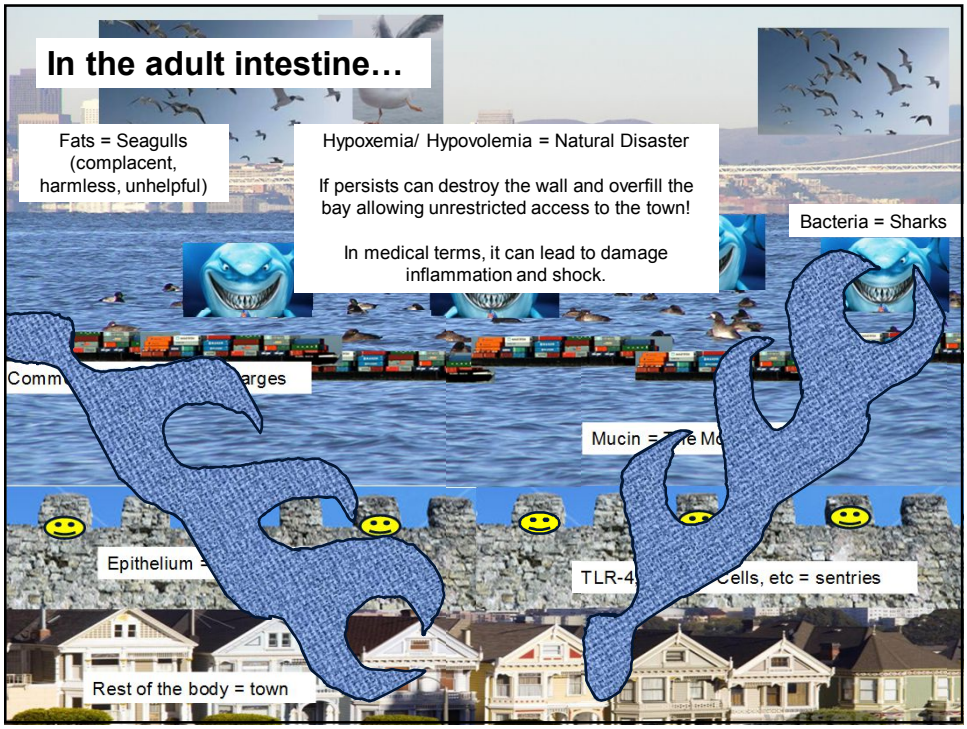
UCSF Benioff Children's Hospitals

Model of Pathogenesis

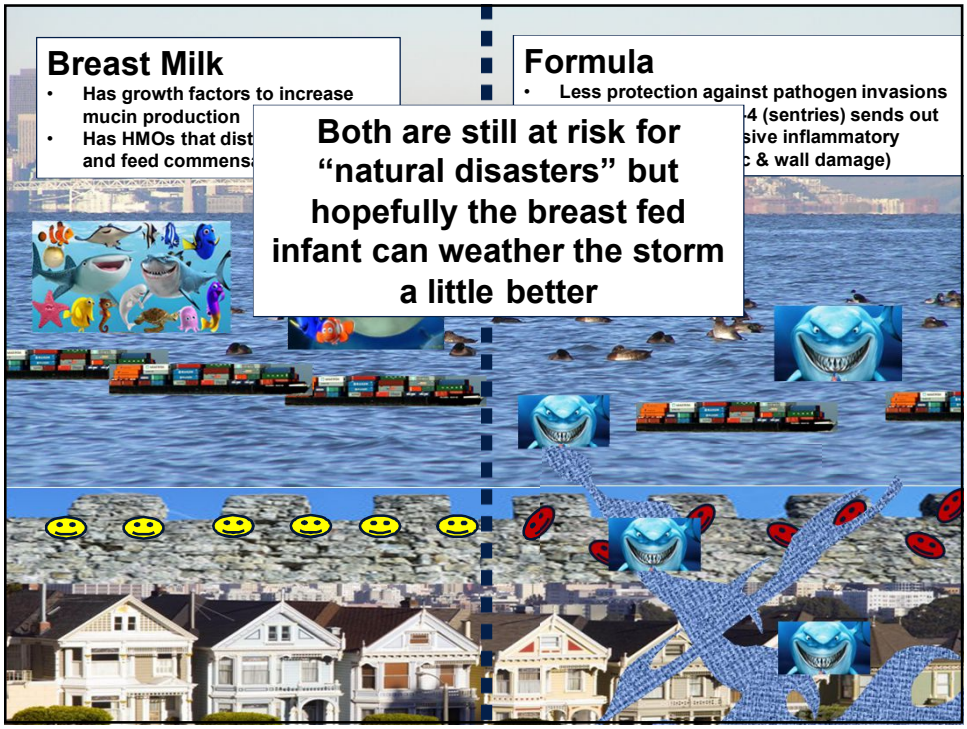
- Subclinical event (hypoxia, ischemia)
- Intestines become colonized
- Bacteria bind to injured mucosa
- Inflammatory response
- Increased permeability of mucosa
- Translocation of bacteria
- Inflammatory response accelerates
- Inflammatory mediators, reactive oxygen species further injure mucosa
- Maladaptive vasoconstrictive response leac to ongoing ischemia/reperfusion injury
- End result – cycle of feedback mechanisms ultimately causing necrosis and perforation



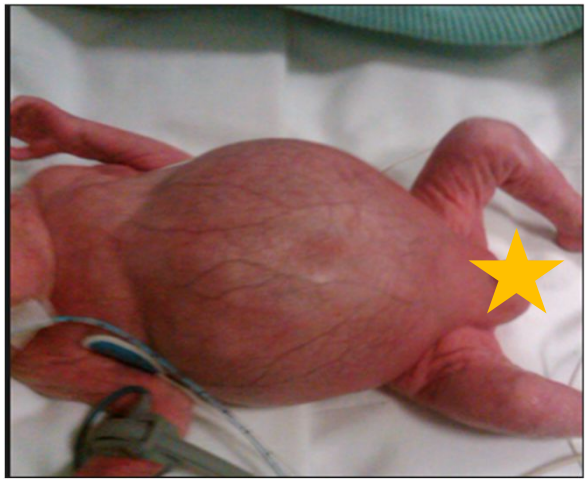
UCSF Benioff Children's Hospitals


In the adult intestine…
Fats = Seagulls (complacent, harmless, unhelpful)
Hypoxemia/ Hypovolemia = Natural Disaster
If persists can destroy the wall and overfill the bay allowing unrestricted access to the town!
In medical terms, it can lead to damage inflammation and shock.
Bacteria = Sharks
Epithelium =
TLR-4
Cells, etc = sentries
Rest of the body = town


In the premature intestine…
• Walls aren't as strong
• Moat isn't as wide
• Lots more sentries
• Not as many barges



Diagnosing NEC



UCSF Benioff Children's Hospitals

Bell's Staging for NEC

- Most commonly used in practice
- Staging based on severity of systemic, intestinal, and radiographic findings
- Treatment is directed at the clinical signs rather than the particular stage of NEC
- Each advancing stage includes the characteristics of the previous stage plus additional findings due to increasing severity of the disease

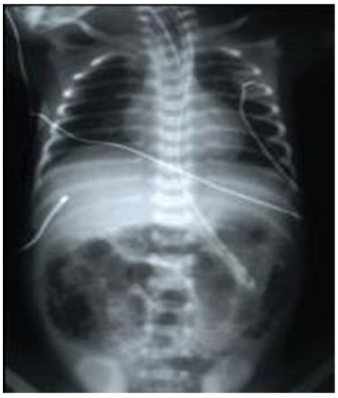
UCSF Benioff Children's Hospitals

Stage 1-Suspected NEC

- Gastric residuals
- Abdominal distension
- Heme positive stools
- X-ray normal to mild distension
- Temp instability
- A's and B's

UCSF Benioff Children's Hospitals

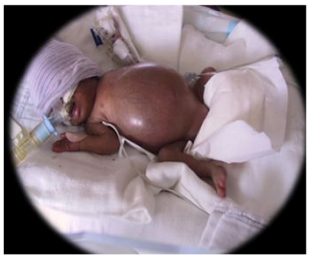
Stage 2- Proven NEC



- Absent bowel sounds
- Abdominal tenderness
- Pneumatosis intestinalis
- Portal venous gas
- Mild metabolic acidosis
- ↓ Platelets
- Radiograph findings include intestinal dilation, ileus, pneumatosis intestinalis, and ascites
- Stage IIA “mildly ill”, stage IIB “moderately ill”

UCSF Benioff Children's Hospitals

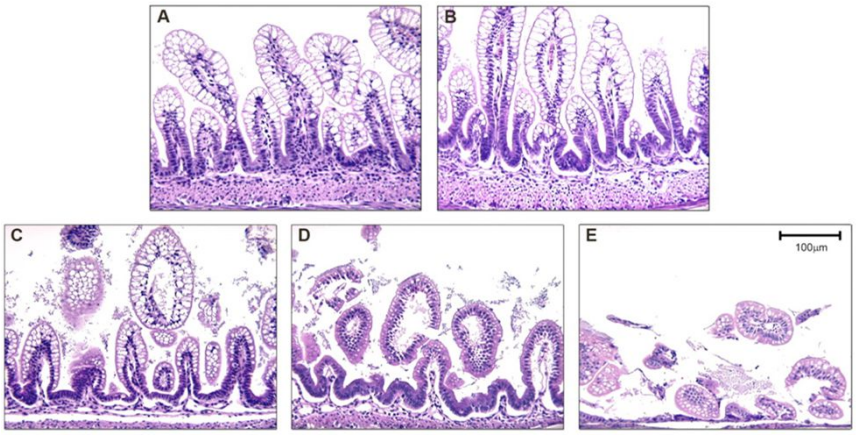
Stage 3-Advanced NEC



- Severely ill
- Marked distension
- Signs of peritonitis
- Hypotension
- Bradycardia
- Severe apnea
- Metabolic and respiratory acidosis
- Disseminated intravascular coagulation (DIC)
- Stage IIIA intact bowel, stage IIIB perforated bowel visualized as a pneumoperitoneum

UCSF Benioff Children's Hospitals

Diagnosing NEC



Khailova, L., Dvorak, K., Arganbright, K., Halpern, M., Kinouchi, T., Yajima, M., & Dvorak, B. (2017). Bifidobacterium bifidum improves intestinal integrity in a rat model of necrotizing enterocolitis. Retrieved 16 April 2017, from

UCSF Benioff Children's Hospitals

Diagnosing NEC

- Based on the presence of the characteristic clinical features of:
  - Abdominal distention
  - Rectal bleeding
  - Abdominal radiographic finding of pneumatosis intestinalis.
- Assessment of infants with suspected NEC includes:
  - abdominal imaging, blood studies, stool analysis, and sepsis evaluation
- Future Biomarkers? iFABP? PAF?

UCSF Benioff Children's Hospitals

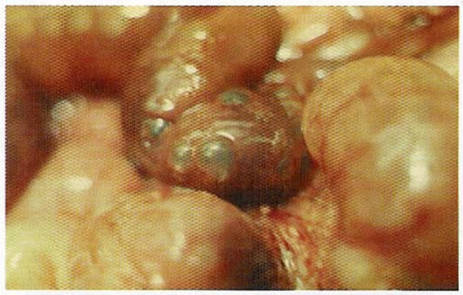


FIGURE 8–61. Pneumatosis intestinalis

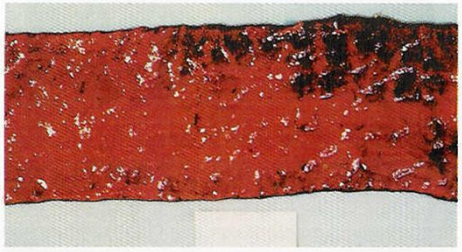
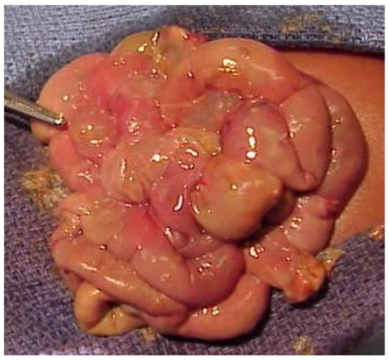


FIGURE 8–62. Hemorrhagic intestine



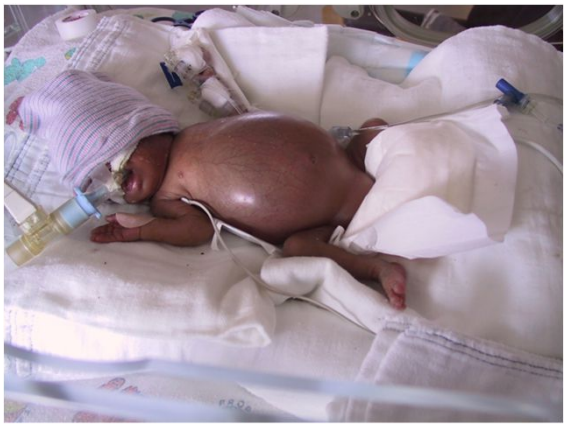
UCSF Benioff Children's Hospitals

Presentation – clinical findings

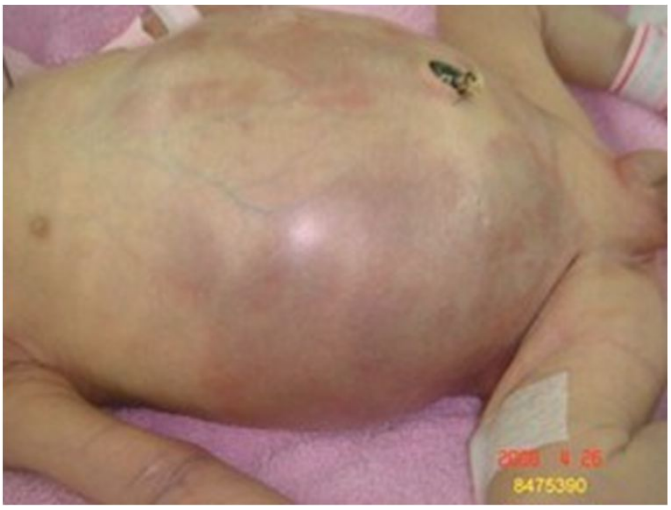
- Abdominal distension
- Feeding residuals, often bilious
- Gross or occult blood in stool
- Abdominal tenderness
- Erythema or bluish discoloration of abdominal wall
- Absent bowel sounds
- Non-specific signs (temp. instability, glucose instability, lethargy, apnea/bradycardia, hypotension)

UCSF Benioff Children's Hospitals

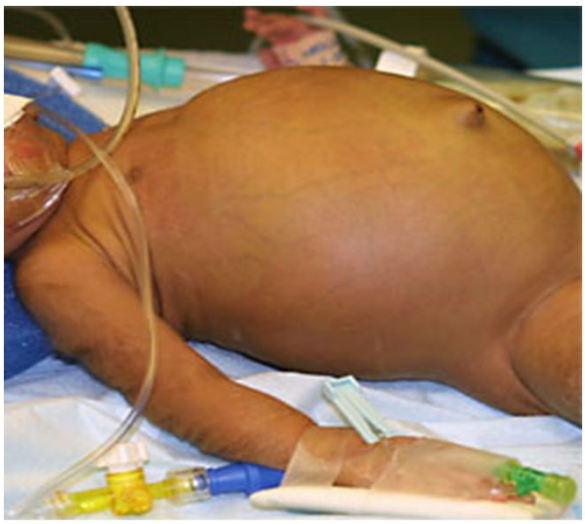
Visual Exam



UCSF Benioff Children's Hospitals



UCSF Benioff Children's Hospitals



UCSF Benioff Children's Hospitals

Abdominal Distension/ Increased AG

- What is the distension from?
- What has been the baseline abdominal exam
- Last stool
- Is he on CPAP or been recently bag/mask ventilated? Does he have an OGT in place and vented?
- Are there any other concerning signs? – glucose instability, lethargy, temp. instability, apnea, etc.
- Is the infant hungry and eager to nipple feed?

UCSF Benioff Children's Hospitals

Residuals

- Is the residual bilious?
- Is the baby stooling at least q12h, moderate amounts?
- Has the infant been recently bag/mask ventilated?
- What position has the baby been in?
- Has the last few hours been stressful for the infant? (blood draws, lots of handling, procedures)
- Is the physical exam benign?
- Could there be an ileus? – morphine, infection, post-op
- Refeed residual if non-bilious, partially digested milk.

UCSF Benioff Children's Hospitals

Heme Positive Stools

- Is the stool meconium?
- Is the infant receiving glycerin suppositories?
- Does the infant have a fissure?
- Has the infant had abdominal surgery?

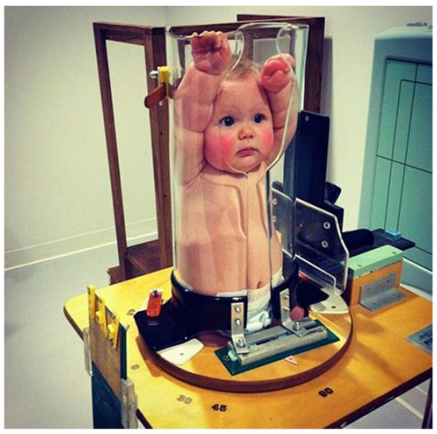
UCSF Benioff Children's Hospitals

Presentation – Laboratory Findings

- Glucose instability
- Abnormally high or low WBC
- Left shift of WBC
- Thrombocytopenia
- Metabolic acidosis
- DIC
- CRP

UCSF Benioff Children's Hospitals

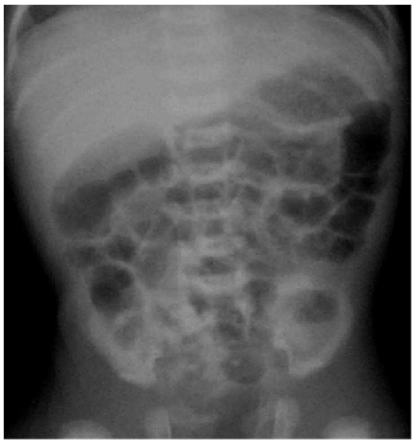
Radiologic Findings



UCSF Benioff Children's Hospitals

Normal Abdominal Xray

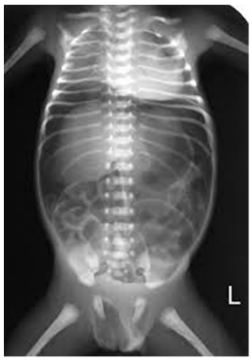
- Uniform size and shape of loops
- Diameter approximates vertebra
- Gas throughout entire bowel tract
- Gas pattern should vary on subsequent x rays
- No free air in abdomen and liver is opaque



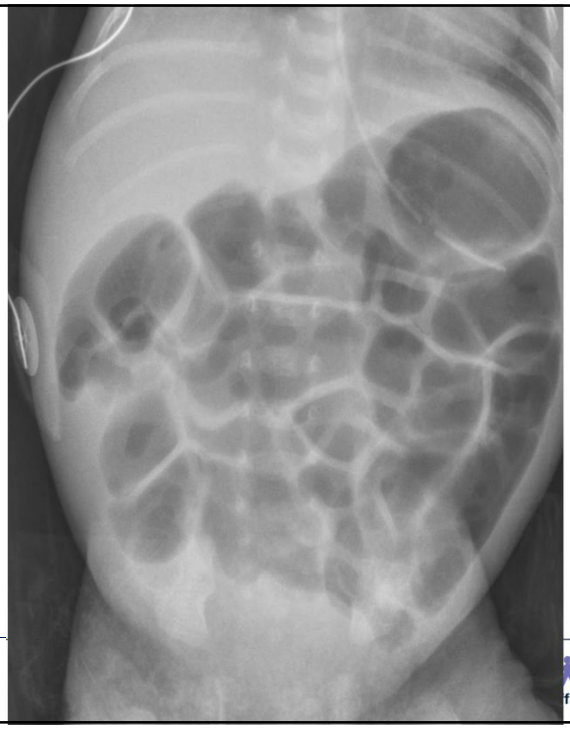
UCSF Benioff Children's Hospitals

Presentation – Radiographic Findings

- Non-specific bowel dilatation
- Thickening of bowel wall
- Fixed, dilated loop unchanged on >1 radiograph
- Pneumatosis intestinalis
- Portal venous gas
- Pneumoperitoneum
- Falciform ligament may be outlined
- Football sign

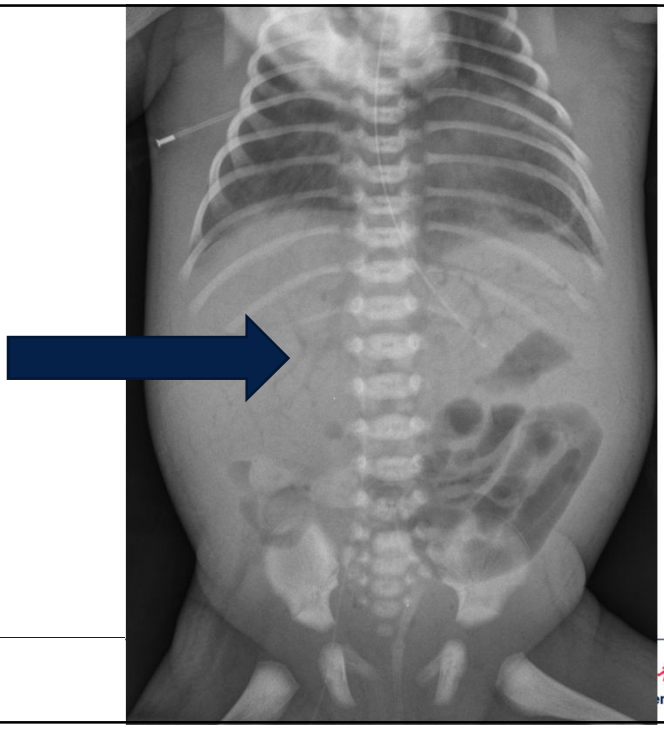


UCSF Benioff Children's Hospitals

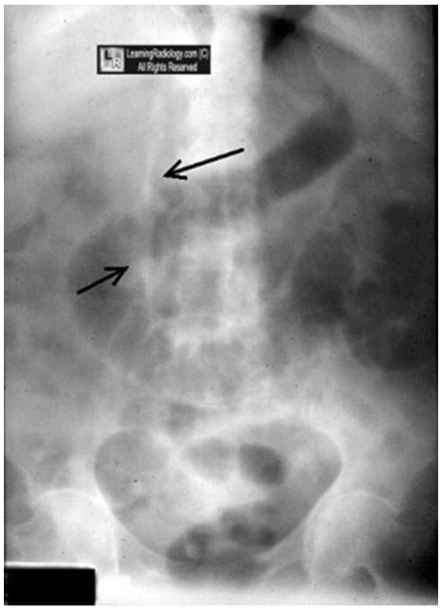


f Children's Hospitals

Benioff Children's Hospitals

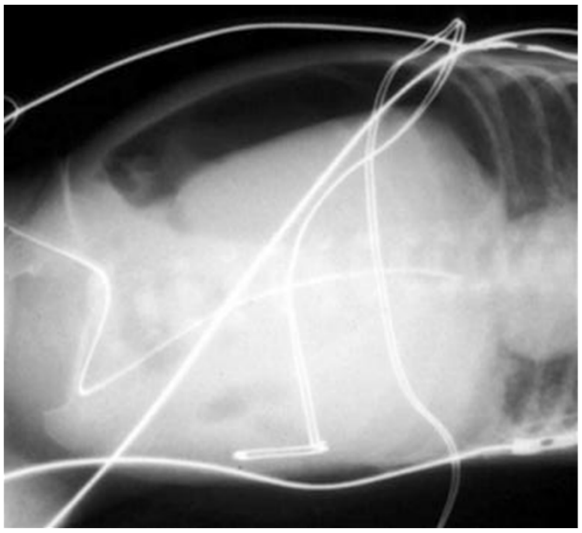


nioff Children's Hospitals


LearningRadiology.com (C)
All Rights Reserved

58

UCSF Benioff Children's Hospitals

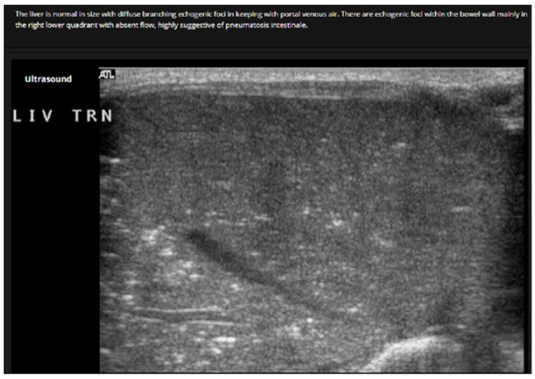


59

UCSF Benioff Children's Hospitals

Ultrasound

- Used to look for bowel wall thickening
- Free air
- Portal Venous gas



UCSF Benioff Children's Hospitals

Management- Suspected NEC

- NPO
- Fluid/electrolyte and parenteral nutrition management
- Gastric decompression
- Labs
- Antibiotics (Ampicillin and Gentamicin, Vancomycin, Cefotaxime, Flagyl?)
- Correct metabolic acidosis
- Serial xrays
- Respiratory & Circulatory support
- Rule out other causes of distension
- Transfusions?
- Close monitoring

UCSF Benioff Children's Hospitals

Management – Definite NEC

- Obtain consult with surgical team
- Serial KUB's
- NPO 7-10 days
- Careful I/O's – maintain bowel perfusion, may require fluid resuscitation
- Circulatory support
- Respiratory support
- PT, PTT, fibrinogen, platelets
- Frequent abg's, electrolytes
- Antibiotics 7-14 days

UCSF Benioff Children's Hospitals

Surgical Treatment

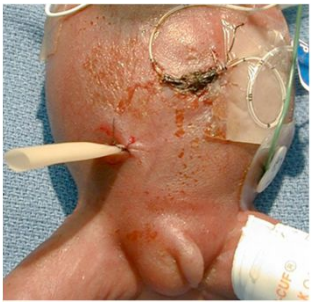
Medical management is appropriate in most cases

- Operative intervention indications:
  - Perforation, evidence of necrotic bowel (fixed loop, metabolic acidosis, DIC, shock), or progressively worsening clinical condition despite intensive medical management
- Surgical Options:
  - Peritoneal drain
  - Exploratory laparotomy for resection of necrotic bowel

UCSF Benioff Children's Hospitals

Surgical Considerations

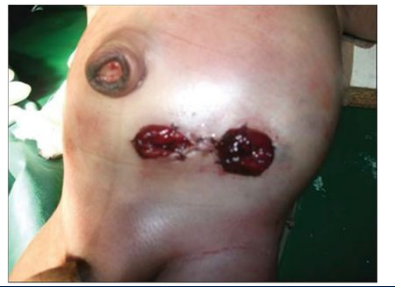
- Peritoneal drain +/- irrigation
  - Allows time for baby to stabilize
  - Better able to delineate viable gut when do operate
  - Borderline bowel segments may recover
  - Intestinal perforation may be definitively treated
  - Laparotomy indicated if not improving in 24-48 hrs



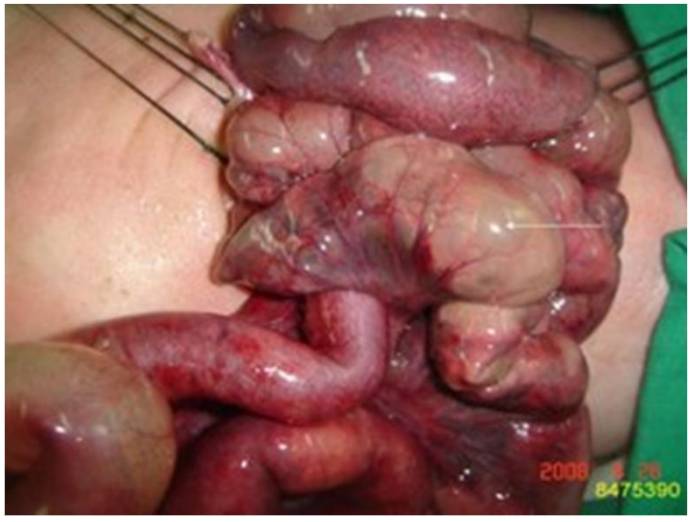
UCSF Benioff Children's Hospitals

Surgical Considerations

- Exploratory laparotomy for resection of necrotic bowel
  - Primary Anastomoses
  - Ostomy & Mucous Fistula
  - Clip & Drop



UCSF Benioff Children's Hospitals



UCSF Benioff Children's Hospitals

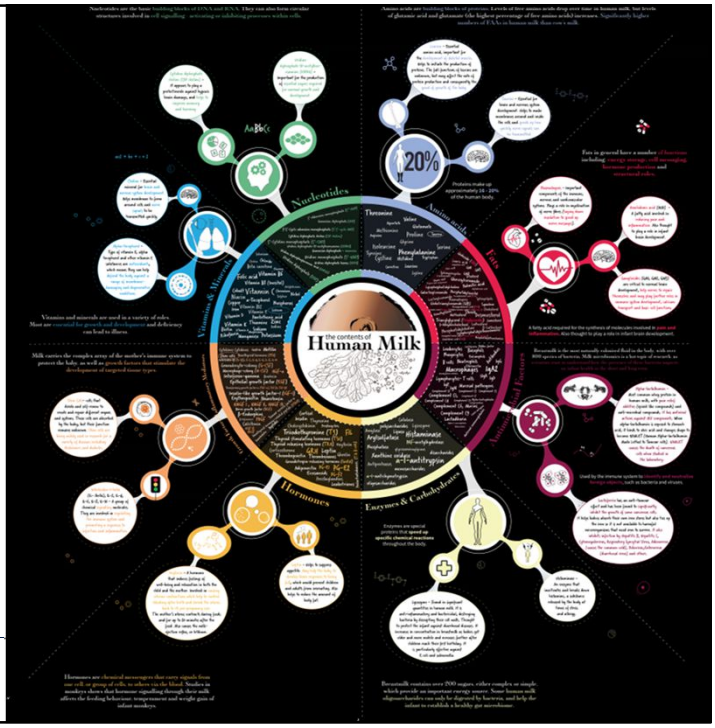
UCSF Benioff Children's Hospitals

Prevention

- Human milk
  - pasteurized MBM is not as protective
- Intestinal priming (gut stimulation feedings)
  - Promotes structural and functional maturation
  - Promotes acquisition of normal flora
  - Stimulate release of gastric hormones
- Slow, but not too slow, feed advance
- Minimize prolonged antibiotic use
- Antenatal glucocorticoids for lung maturation also accelerate intestinal maturation
- Prebiotics, probiotics, postbiotics

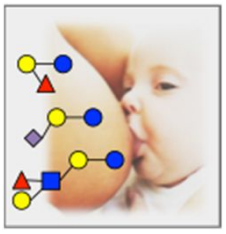
UCSF Benioff Children's Hospitals

How can Human Milk Prevent NEC?



http://www.human-milk.com/infographic/leaflet.html

Oligosaccharides & the Gut



- Human Milk Oligosaccharides
  - 3rd most abundant biomolecule in human milk
  - Un-digestible by humans

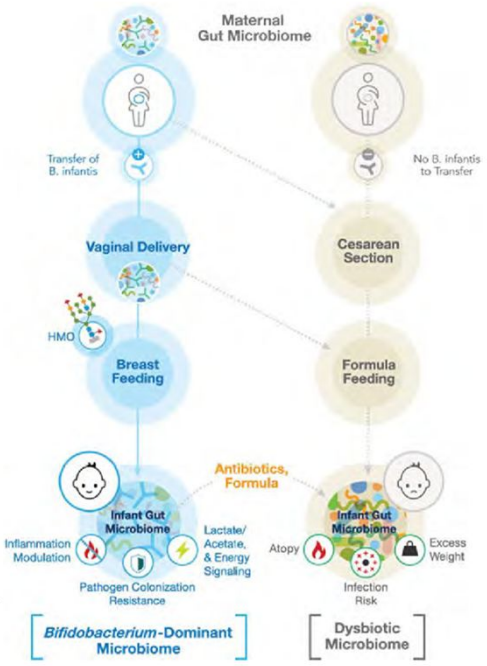
"It's All About the Breast Milk Sugars, Baby"

German, B. (2017). *The Evolution of Lactation as a Guide to Understanding Nourishment and Prevention in the 21st Century*. Presentation, UC Davis.

UCSF Benioff Children's Hospitals

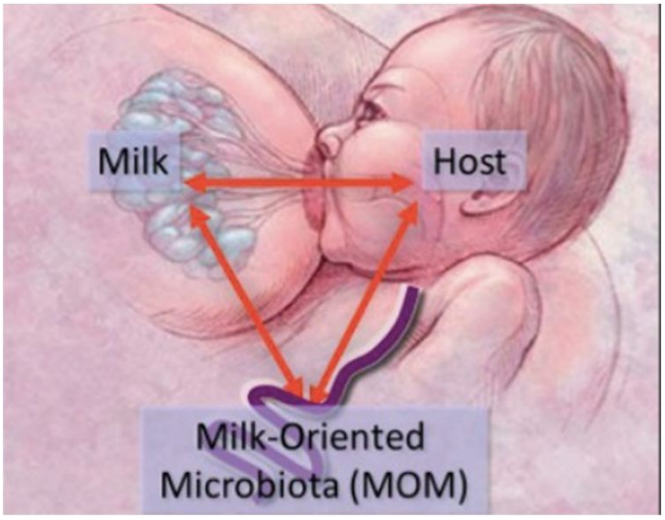
Microbiota

- Modern life has stopped microbial transfer…
- So what are we left with?
- Microbial Dysbiosis…
- Long term consequences



71

Milk-Oriented Microbiota



72

UCSF Benioff Children's Hospitals

Probiotics…

The "Golden Age" of Probiotics: A Systematic Review and Meta-Analysis of Randomized and Observational Studies in Preterm Infants

- Probiotics potentially prevent severe NEC and late-onset sepsis, and reduce mortality in preterm infants

Prophylactic Probiotics for Preterm Infants: A Systematic Review and Meta-Analysis of Observational Studies.

- Probiotic supplementation reduces the risk of NEC and mortality in preterm infants. The effect sizes are similar to findings in meta-analyses of RCTs. However, the optimal strain, dose and timing need further investigation.

73

UCSF Benioff Children's Hospitals

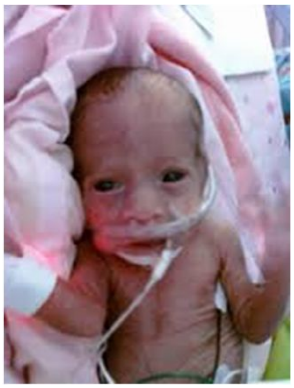
Colostrum Care

- Oropharyngeal administration
  - Use syringe to place directly onto the
  - oral mucosa in the buccal cavity for
  - absorption via the mucosa
- Allows for systemic absorption of the cytokines and pancreatic secretory trypsin inhibitor (PSTI)
- Rich source of Oligosaccharides
- May reduce time to full feeds

74

UCSF Benioff Children's Hospitals

Trophic feeds



- Improved feeding tolerance
- More rapid advancement to full feeds
- Improved weight gain
- Shortened duration of TPN
- Less phototherapy
- Reduction in direct bilirubin
- Decreased length of stay
- Does not increase risk of NEC!
- May be considered for an infant who is hemodynamically stable on a low dose of dopamine and/or with an Umbilical Arterial Line in place

UCSF Benioff Children's Hospitals

Feeding Protocol for Preterm Infants

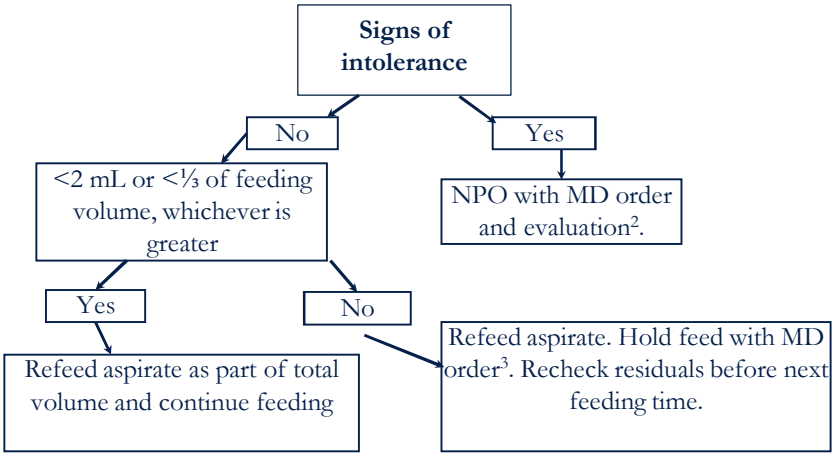
- Goal
  - Preterm: 150-160 ml/kg/day of 24cal/oz; fortify when feed volume is 60ml/kg/day
  - Term: 150-165 ml/kg/day of 20cal/oz
- Consider increasing concentration of feeds if poor weight gain, volume intolerance or fluid restriction, or increased energy requirements.
  - Preterm infants should receive 24cal/oz for at least one week before increasing to 27cal/oz
  - Consider hind milk

UCSF Benioff Children's Hospitals

UCSF BCH Feeding Protocol

Birth GA (wks)	1st day (ml/kg/d)	Advance on Day #	Amount (ml/kg/d)	>60 ml/kg/d Advance by	Achieve Goal Feeds by
< 26	15	6	15	20	Day 13
26 to 27-6/7	15	4	15	20	Day 11
28 to 29-6/7	15	3	15	20	Day 10
30 to 31-6/7	20	Daily	20	20	Day 8
32 to 34-6/7	20	Daily	20-40	20-40	Day 5-8
>35	50 or ad lib	Daily	>20-40 or ad lib	>20-40 or ad lib	Day 4-6

UCSF Benioff Children's Hospitals



1.Signs of Feeding Intolerance:	dark bile or blood stained aspirate; vomiting >1/3 feed; abd. distension, discoloration or tenderness; visible bowel loops; bloody stool; abnl KUB; metab. acidosis or ↓pHs; apnea (new onset/↑ frequency or severity), resp. distress, lethargy, poor perfusion, temp instability, etc
2.Evaluation:	physical exam, KUB, CBC, blood culture, etc.
3.Recommendations	check fdg tube placement; prone position, right side down; ? glycerin if no stool X18-24 hours; if recurrent episode s/p fdg ↑, return to tolerated fdg vol. or conc.

78

UCSF Benioff Children's Hospital San Francisco

Prevention - Disadvantages of NPO

- "The wisdom of stopping all enteral intake is counter-intuitive to the ontologic processes that started in utero"
  Edmund Gamma, Lyle Browne, State Univ. NV
- Has not uniformly provided protection, may simply delay the onset of NEC
- Predisposes to injury when finally fed
  - Gut atrophy
  - Decreased mucin production and enzyme activity
  - Decreased secretion of IgA
  - Increased transmural penetration of bacteria, and antigens
  - Increased susceptibility to infection
  - Autodigestion

UCSF Benioff Children's Hospitals

Enteral Nutrition

- Breast milk is best
- Donor breast when MBM not available
- Use of standardized feeding guideline
  - Reduced risk of NEC
  - Less variability
  - Achieve full feeds earlier

80

UCSF Benioff Children's Hospitals

Prevention – experimental approaches

- Enteral IgG/IgA
- Formula acidification to prevent bacterial overgrowth
- Probiotics supplementation (bifidobacteria)
- L-arginine supplementation: precursor of NO
- Oral antibiotics
- PAF-acetylhydrolase: degrades the inflammatory mediator PAF
- Glutathione (GSH): an antioxidant
- Epidermal Growth Factor (EGF): matures intestinal mucosa

UCSF Benioff Children's Hospitals

Gut Check NEC (Gephart et al, 2014)

GutCheck^{NEC}, a Neonatal NEC Risk Index for infants born weighing < 1500 grams © Gephart, 2012					Points
Gestational age (weeks) (9 max.) Calculate GA in weeks at birth based preferably on due date determined by 1st trimester ultrasound. If that is unavailable, use the gestational age assessment at delivery (Ballard or Dubowitz)		<28 9 points	28-31 6/7 8 points	≥ 32 0 points	
Race (2 max) If the infant is either Black or Hispanic race assign 2 points. If both, assign only 2 points. If not Black or Hispanic, assign 0 points.		Black 2 points	Hispanic 2 points	Other races 0 points	
Outborn (3 max) If the infant is transferred into this center from another hospital at any time after birth, assign 3 points.			Yes 3 points	No 0 points	
NICU NEC rate (23 max.) This is the annual calculated NEC rate for infants weighing less than 1500 grams at delivery. If < 2%, assign 0 points.	2-4.99% 9 points	5-7.99% 16 points	8-11.99% 19 points	> 12 % 23 points	
Exclusive human milk feeding (0 max) Defined as human milk fed at both day 7 and day 14 of life. Volume of human milk fed is not defined. If *any* milk is fed at *both* day 7 and day 14, subtract 3 points from the total score. Points cannot be subtracted until day of life 14.			Yes -3 points	No 0 points	
Probiotics (0 max) If any probiotic preparation has been given at any dose or any vol			Yes -5 points	No 0 points	
Ho **of**					

Gut Check NEC (Gephart et al, 2014)

How many culture-proven infections has the infant had since day 3 of life? (6 points max)	One 4 points	Two 6 points	None 0 points
Packed Red Blood Cell transfusion history (8 max) If any PRBC transfusion has been given, regardless of feeding status or volume given. Once the infant receives a transfusion, from that time on it is scored "yes."		Yes 8 points	No 0 points
Hypotension treated with Inotropic Medication (4 max) If hypotension is severe and medications such as dopamine, dobutamine or milrinone are given to treat it, regardless of dose, frequency or duration of treatment.		Yes 4 points	No 0 points
Metabolic Acidosis (3 max) If the infant experiences metabolic acidosis, defined as low pH associated with low serum bicarbonate (HCO_3 < 17) but normal or near normal pCO2 (pH< 7.30) or lactate > 6.1 mmol/L. If ordering clinician (physician, NNP, PA-C) documents "metabolic acidosis" code as "yes."		Yes 3 points	No 0 points
TOTAL Score > 32 At Risk; 58 points maximum **Do Not Reproduce without Permission Contact: gepharts@arizona.edu**			

UCSF Benioff Children's Hospitals

"You are a better monitor than Hewlett Packard ever made" (NICU nurse)

- Educate yourself in the signs/symptoms of NEC.
- Know your infant's history. Is this infant at risk?
- Know your infant's baseline exam.
- Be alert to subtle changes.
- Watch for patterns/clusters of concerning symptoms.
- Respect your intuition. It is grounded in expertise.
- If you are worried, assess, obtain a KUB, blood gas, CBC. Remember that these can be normal in the early phase of NEC.
- Nurses by their vigilance and expertise can substantially influence the incidence and outcome of NEC.

UCSF Benioff Children's Hospitals

Neonatal nurses go beyond the numbers to take in the entire baby. Their nursing is particular, contextual, and holistic. It is an art. Xrays and lab values pale in comparison with the vigilance and commitment of an expert nurse.

UCSF Benioff Children's Hospitals

UCSF Benioff Children's Hospitals

References

- American Academy of Pediatrics, Section on Breastfeeding. (2005). Breastfeeding and the use of human milk. Pediatrics, 115(2), 496-506.
- Bisquera JA, Cooper TR, Berseth CL. Impact of necrotizing enterocolitis on length of stay and hospital charges in very low birth weight infants. *Pediatrics.*2002;109(3):423-428.
- Cochrane Library 2001, CPQCC/CAN; McClure, 2000; Peter, et al, 2002; Ziegler, 2002; Kuzman O'Reily, 2003; Berseth Yu, et al, 2005; Tyson & Kennedy Cochrane review, 2005

▪Dasgupta, S., Arya, S., Choudhary, S., & Jain, S. K. (2016). Amniotic fluid: Source of trophic factors for the developing intestine. *World journal of gastrointestinal pathophysiology*, *7*(1), 38.

▪Dermyshi, E., Wang, Y., Yan, C., Hong, W., Qiu, G., Gong, X., & Zhang, T. (2017). The "Golden Age" of Probiotics: A Systematic Review and Meta-Analysis of Randomized and Observational Studies in Preterm Infants. *Neonatology*, 9-23. http://dx.doi.org/10.1159/000454668

▪Gephart, S., Spitzer, A., Effken, J., Dodd, E., Halpern, M., & McGrath, J. (2014). Discrimination of GutCheckNEC: a clinical risk index for necrotizing enterocolitis. Journal Of Perinatology, 34(6), 468-475. http://dx.doi.org/10.1038/jp.2014.37

UCSF Benioff Children's Hospital San Francisco

References

▪Morgan, J., Young, L., & McGuire, W. (2014). Delayed introduction of progressive enteral feeds to prevent necrotising enterocolitis in very low birth weight infants. Cochrane Database Of Systematic Reviews. http://dx.doi.org/10.1002/14651858.cd001970.pub5

▪Mulvihill, S. J., Stone, M. M., Debas, H. T., & Fonkalsrud, E. W. (1985). The role of amniotic fluid in fetal nutrition. *Journal of pediatric surgery*, *20*(6), 668-672.

- Rodriguez, N., Meier, P., Groer, M., Zeller, J., Engstrom, J., & Fogg, L. (2010). A Pilot Study to Determine the Safety and Feasibility of Oropharyngeal Administration of Own Mother's Colostrum to Extremely Low-Birth-Weight Infants. Advances In Neonatal Care, 10(4), 206-212. http://dx.doi.org/10.1097/anc.0b013e3181e9413

▪Underwood, M. (2017). *Probiotics and the Prevention of Necrotizing Enterocolitis.* Presentation, UC Davis.

▪Vohr, B., Poindexter, B., Dusick, A., McKinley, L., Wright, L., Langer, J., & Poole, W. (2006). Beneficial Effects of Breast Milk in the Neonatal Intensive Care Unit on the Developmental Outcome of Extremely Low Birth Weight Infants at 18 Months of Age. PEDIATRICS, 118(1), e115-e123. http://dx.doi.org/10.1542/peds.2005-2382

UCSF Benioff Children's Hospitals

Questions?

Thank you!!

Tanya.Kamka@ucsf.edu

UCSF Benioff Children's Hospitals

UCSF Benioff Children's Hospitals