BREASTFEEDING : A Neurobehavioral Approach

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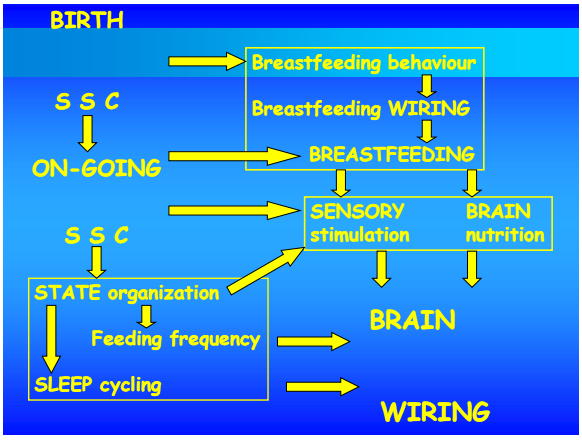
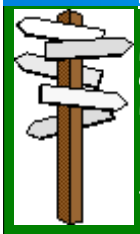


Presentation objectives



Birth Skin-to-Skin Contact
Ongoing SSC
Breastfeeding behaviour
- Breastfeeding wiring
- BREASTFEEDING

Sensory stimulation
- State organization
- Sleep cycling
- Feeding frequency
- Brain nutrition

BRAIN WIRING

Animal literature does not talk about mammalian lactation, it talks about mammalian birth.

Ruin the birth – and there is no lactation
With a good birth, lactation follows

Diane Weissinger

R Shore

Critical period concept :

"Windows of opportunity in early life when a child's brain is exquisitely primed to receive sensory input in order to develop more advanced neural systems."

BREASTFEEDING IS A BEHAVIOUR OF THE NEWBORN

Not the mother !!

"The newborn may appear helpless, but skin-to-skin contact
stimulates prolactin
ensures nutrition
stimulates oxytocin
ensures protection
stimulates cholecystokinin
ensures wellbeing bonding

FOLLOW-UP STUDY →

RCT of skin-to-skin contact from birth versus conventional incubator care for physiological stabilisation in 1200- and 2199-gram newborns.

Bergman NJ, Linley LL, Fawcus SR.
Acta Paediatrica 2004
Vol 93(6); 779-785

Bergman et al 2004

Reproduction-Induced Neuroplasticity: Natural Behavioural and Neuronal Alterations Associated with the Production and Care of Offspring

HORMONES (peaks & falls) → NEURONS PRIME (e.g. dendrification)

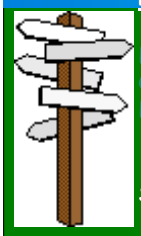
SALIENT stimulation Rich environment → New circuits = enhanced learning → Advanced behaviour

The first hours after birth are a CRITICAL PERIOD
mutual
psycho-neuro-physiological
caregivers

Centrally released oxytocin coordinates the onset of maternal nurturing behavior at parturition and plays a role in mother-infant bonding.

Ross 2009

Presentation objectives



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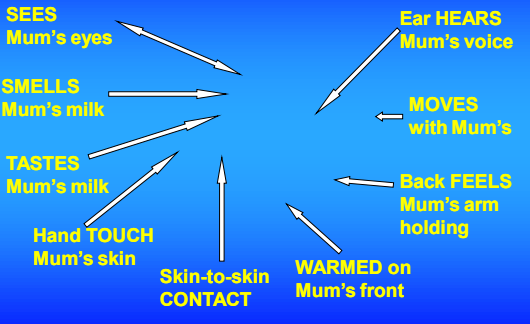
Brain nutrition
BRAIN WIRING

SENSATIONS THAT WIRE BRAIN



... the activity occurring during

neonatal REM sleep

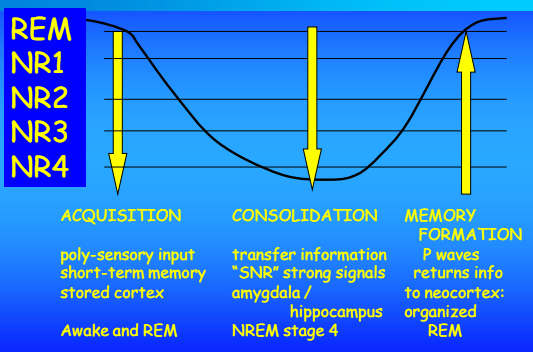
(or active sleep) seems to be

particularly important

to the developing organism

(Marks et al., 1995).

BRAIN WIRING



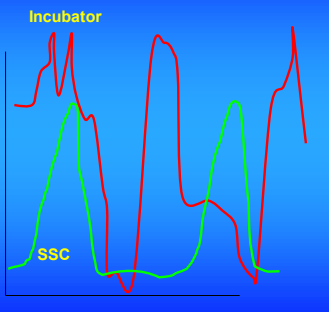
STATE ORGANISATION.

The ability to appropriately control the level of sleep and arousal.

STATE ORGANISATION.

Simplified scale -	
HARD CRYING	L to R shunting, IVH risk
CRYING	Stressful, wastes calories,
FUSSING	… build up to stress
ACTIVE AWAKE	This is feeding zone!
QUIET AWAKE	Time to connect - stimulation
ALERT INACTIVE	… transition zone
DROWSY	… transition zone
ACTIVE SLEEP	… activity consumes calories
IRREGULAR SLEEP	
QUIET SLEEP	Good sleep - digestion zone
DEEP SLEEP	Apnoea zone !!

Simplified scale -
HARD CRYING
CRYING
FUSSING
ACTIVE AWAKE
QUIET AWAKE
ALERT INACTIVE
DROWSY
ACTIVE SLEEP
IRREGULAR SLEEP
QUIET SLEEP
DEEP SLEEP



KMC babies oscillate slowly in safe zones

Separated babies oscillate erratically to danger zones

Simplified scale -
HARD CRYING
CRYING
FUSSING
ACTIVE AWAKE
QUIET AWAKE
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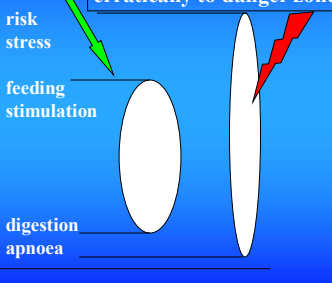


Compared to incubator babies, KMC babies have

less deep sleep	(when apnoea occurs)
more quiet sleep	(when growth occurs)
less active sleep	(wastes calories)
more alert periods	(promotes bonding)
much less crying	(which is harmful)

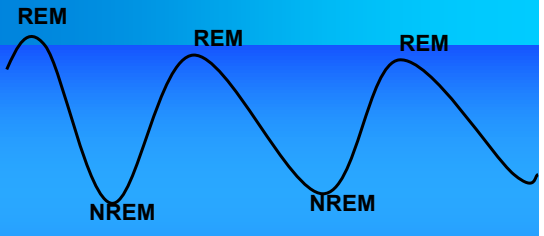
Not so much duration,
or density of any sleep stage,
or number of sleep stage episodes, but,

cycling between quiet sleep and active sleep

is what is important

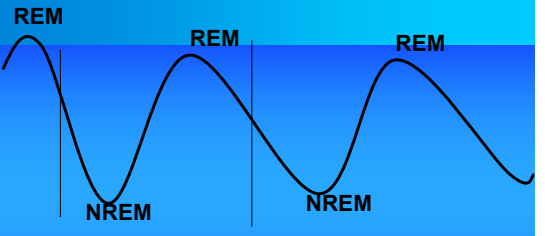
rest-activity cycle is 60-90 minutes long

(Ludington 2006)



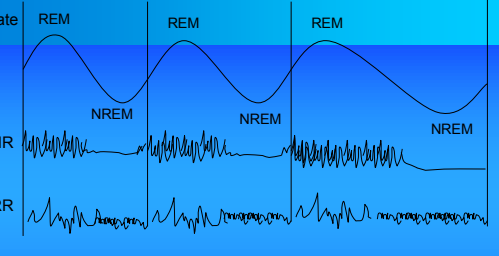
This is a healthy sleep pattern
This is a very good cycling pattern

(thanks to Susan Ludington-Hoe)



1st hour 2nd hour

So in every hour, you would like to see an EEG pattern that shows this



REM Sleep is supposed to be somewhat active, so
HR increases and RR is irregular

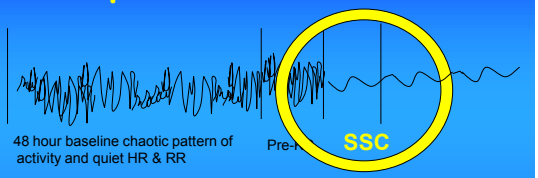
SLEEP CYCLING - Separation vs contact

48 hour baseline chaotic pattern of activity and quiet HR & RR

In separation:

- Dissociated state
- No cycling, chaotic pattern

SLEEP CYCLING – Separation vs contact



In SSC:

- Normal cycling
- Non-chaotic pattern

PREMATURE BREASTFEEDING

SELF ATTACHMENT.

The newborn should NOT be separated at birth, specially if premature !!

Sequence human newborn breast-feeding

Pre-requisite = habitat
hand to mouth
tongue moves
mouth moves
eye focuses nipple
crawls to nipple
latches to nipple
suckles

(Widstrom et al 1994)

"The newborn may appear helpless, but displays an impressive and purposeful motor activity which, without maternal assistance, brings the baby to the nipple.

(Michelson et al 1996)

BREASTFEEDING THE PREMATURE

The ABILITY to breastfeed is INNATE.
The physical CAPACITY to breastfeed may however be insufficient in prematures.

Full term babies need no help
Premature babies will need help.

KERSTIN HEDBERG-NYQVIST:
(Early Human Dev 55 (1999) 247 -264.)

PIBBS
Preterm Infant Breastfeeding Behaviour Scale

rooting	0 - 2
areolar grasp	0 - 3
latch (and fixation) time	0 - 3
sucking	0 - 4
longest sucking burst	1 - 6
swallowing	0 - 2

KERSTIN HEDBERG-NYQVIST:

PIBBS
Preterm Infant Breastfeeding Behaviour Scale

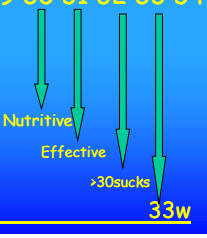
Nutritive sucking = >5ml swallowed

Full breastfeeding = exclusive Brf

KERSTIN HEDBERG-NYQVIST:
(Early Human Dev 55 (1999) 247 -264.)

PIBBS
Preterm Infant Breastfeeding Behaviour Scale
EARLIEST OBSERVATION:

(weeks PMA)	28	29	30	31	32	33	34	35	36
rooting	90%								
grasp	50%								
latch	95%								
sucking	90%								
swallow									
burst									
Full breastfeeding						33w			



Gut hormones.

(Uvnas-Moberg 1989)

20 different hormones
work in the gut –
regulated by the vagal nerve.

Each has a specific function.

Gut hormones.

"Bad guy" - SOMATOSTATIN:
(produced by fetus, rise 10-fold under stress)

inhibits gastrointestinal secretion,
inhibits motility ,
reduces blood flow to gut
and absorption,
causes gastric retention,
vomiting, constipation.

SOMATOSTATIN:

inhibits the good hormones,
contributes to
slow weight gain.
At high levels also
inhibits release of
growth hormone.

It takes 30 to 60 minutes
to lower somatostatin
and other stress hormones

SLEEP
VITAL !!!

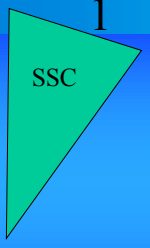
DISSOCIATED INFANT WILL NOT SHOW FEEDING CUES

BREASTFEEDING THE PREMATURE

Premature babies will need help.

BERLITH PERSSON has provided that help …

PERSSON'S WHEEL !



Step 1 SKIN-TO-SKIN

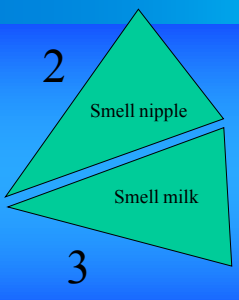
Continuous skin contact

The newborn must be in the right environment for the behaviours that it is capable of to be expressed. It requires protection from stress and provision of warmth.

KMC provides the "maternal nest"

Ideally this should be done on prematures AT BIRTH. However it can be done later, even with nasogastric tube providing expressed breast milk in the meantime

Step 2 and 3 Olfactory



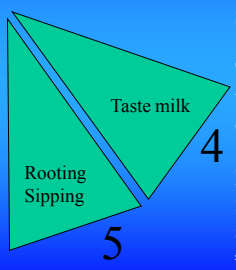
The first steps in sequence require smell of the nipple which may take longer in the premature,

and then the smelling of milk.

Babies can identify smells and tastes from their time in the uterus in the mother's milk!

Step 4 Taste

This is re-inforcing the smell.
Fullterm seems to skip this!



Step 5 Rooting

These are mouth movements the normal sequence described in the full-terms.

Here the premature requires help, with position and "sipping"
= feeling milk in mouth

Step 6 First suckling.

Key step, builds on steps 1 to 5.
Must be awake and alert.
Alert period is maximal at birth, and lasts 45 - 90 minutes.
If missed then, will require feeding, and several hours delay.

Step 6 First suckling.

Note difference suckling vs sucking!

" … myographically distinct"

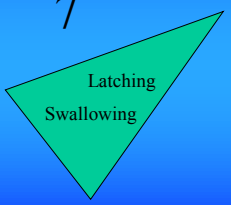
For late premature lactation, allow suckling to develop in successive alert periods, while feeding by tube.

Breastfeeding & Suckling

From 16 or 20 weeks gestation, the fetus is swallowing.
From 26 or 28 weeks gestation the fetus can SUCKLE
From 36 weeks gestation the fetus is able to SUCK

SUCKING and SUCKLING sound same, but VERY different

Step 7 Latching & swallowing



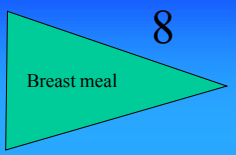
Premature is too physically weak to crawl to nipple, but if held to nipple will at this stage latch on.

Once latched, suckling follows.

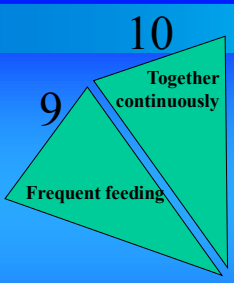
Suckling squirts a controlled dose of milk to the back of throat, which is safely swallowed without any interference of breathing

This is INNATE.

Step 8 First breast milk meal.



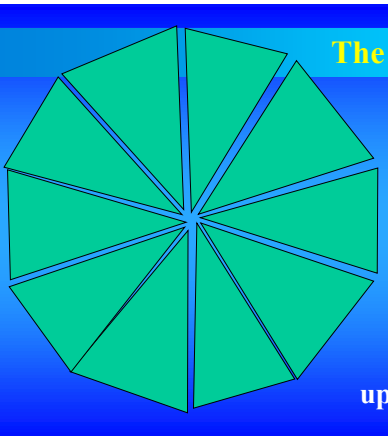
Steps 1 to 7 and on take place rapidly in the fullterm. They can occur in the first alert period after birth in a premature if allowed to,but may require a longer period of defined steps in successive alert periods. For late prem lactation, step 8 is the first time milk is swallowed Enough to feed the baby.



Step 9 Frequent feeding

In utero, baby is feeding Continuously.
Demand feeding is NOT SUITABLE f or prematures.
Feeds should be at most 2 hours apart.

Step 10
Together continuously



The wheel

is not round

Turns slow at first

but then picks up speed!

NUTRITION

BREASTFEEDING A PREMATURE

STEP 1	SSC
STEP 2	ALLOW TIME
STEP 3	State organisation: alert awake
STEP 4	SMELL
STEP 5	TASTE
STEP 6	LATCH
STEP 7	SUCKLE

STOHM PHOTOS ON WEBSITE:
www.kangaroomothercare.com

Babies need to have had a good sleep first.
They will only have a good sleep if given continuous skin-to-skin contact.
Baby should be allowed to get to a state of AWAKE and ALERT by itself.
ALLOW TIME → …

Position baby for eye to eye contact, and close the nipple for SMELLING …

"Feeding cues" are any movements that make up the global behaviour of breastfeeding.

In this ultrasound image, the fetus is practising hand to mouth movements: training for breastfeeding behaviour !

Emma's cat :
"Zig-Zag Thomas"

Ziggy
… is able to
eat and purr
(and breathe)
at
the same time !

Larynx meets uvula, separate
airway & foodway

THE NEWBORN

also has a larynx that meets the uvula, designed to separate the respiratory tract from the gastrointestinal tract , enabling the newborn to feed and breathe simultaneously.

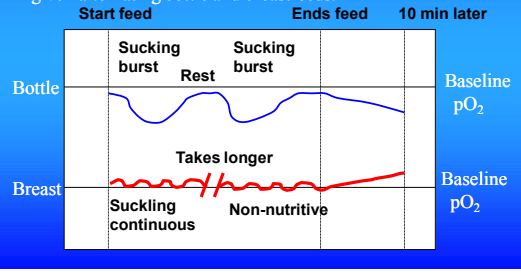
Apes (and all mammals) have a high larynx separates airway from "foodway"

Human newborn ALSO !!

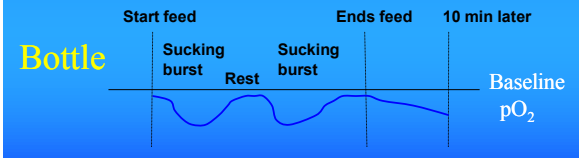
Only at 18 months does larynx start migrating, and ability to make more sounds develop → speech

From "Origins Reconsidered"
Richard Leakey.

Meier 1988
BOTTLE AND BREASTFEEDING IN PREMATURE
Prematures babies weighing 1300g and 34/40 PCA,
given alternating bottle and breastfeeds.



BOTTLEFEEDING IS STRESSFUL and DANGEROUS



Sucking and swallowing uncoordinated, baby gets hypoxic, so bad the heart slows.

SUCKLING uses the largest muscle in the baby's head, making the smallest movement

SUCKING requires lots of tiny and weak muscles, making maximum effort,

... also causes hypoxia,
... and is STRESSFUL !

Bottle feeding requires SUCKING, which requires completely different muscles, and does NOT allow co-ordination between swallowing and breathing. Bottle feeding causes STRESS in prematures, and relative post-prandial hypoxaemia.

SUCKLING - in and of itself, apart from nutrition intake - has beneficial effects on both mother and baby.
SENSORY STIMULATION ....

Suckling

induces simultaneous endocrine effects in the gut of both mother and child

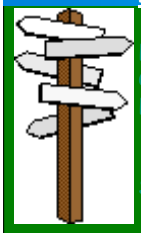
there is a physiological symbiosis between them.

Breast feeding also has psychic effects; CCK is produced, which induces sedation and sleep.

Sucking a pacifier while fed by nasogastric tube:

feed enters stomach faster,
stomach empties sooner,
somatostatin levels lowered.

Presentation objectives



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TRAWL for IQ genes in 7000 children

Article Preview
'Intelligence genes' reveal their complexity
29 November 2007 Andy Coghlan Magazine issue 2632

NewScientist

Six most powerful genes accounted for 1 % of variation in intelligence

So … n
jus… rm.
Alt… ual
effects are so small that for the most part they are barely detectable. This does not mean, however, that intelligence is not inherited.
The research, led by Robert Plomin of the Institute of Psychiatry in London, identified six genes that were strongly associated with high or low intelligence, but even the most powerful of these accounted for just 0.4 per cent of the variation in intelligence between individuals. The six together accounted for about 1 per cent of the variation in intelligence.

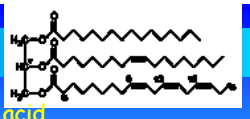
Alternatively:
there is no gene for intelligence !!!

Published online on November 5, 2007, 10.1073/pnas.0704292104
PNAS | **November 20, 2007** | vol. 104 | no. 47 | **18860-18865**

BUT:
there is a gene for breastfeeding to improve intelligence !!!
Caspi 2007

in response to breastfeeding. In Dunedin, breastfed children carrying the C allele showed a 6.4-IQ-point advantage relative to children not fed breast milk ($t = 6.35$, $P < 0.001$). In contrast, GG homozygotes neither gained an advantage from breastfeeding nor suffered a disadvantage from not being fed breast milk ($t = 0.50$, $P = 0.62$) (Fig. 1*A*). Turning to the E-risk cohort, we found that breastfed children carrying the C allele showed a 7.0-IQ-point advantage relative to children not fed breast milk ($t = 7.91$, $P < 0.001$), whereas GG homozygotes neither gained an advantage from breastfeeding nor suffered a disadvantage from not being fed breast milk ($t = 0.22$, $P = 0.83$) (Fig. 1*B*).

TRIGLYCERIDE
Left : glycerol,
Right: palmitic acid,
oleic acid, alpha-linolenic acid



In phosphoglycerides, glycerol molecule same: two fatty acids esterified

Phospholipids are a major component of all biological membranes,

Sphingomyelin particularly concentrated in BRAIN major part of MYELIN.

TRIGLYCERIDE

MYELIN.

FATTY ACIDS ARE SPECIES SPECIFIC

Dendirification and myelinisation peaks occur
at 2 and 6 months
is maximal at one year ....

At one year: human milk has less protein,
but MORE TRIGLYCERIDE !!!

Fat and Energy Contents of Expressed Human Breast Milk in Prolonged Lactation

Dror Mandel, Ronit Lubetzky, Shaul Dollberg, Shimon Barak and Francis B. Mimouni

Pediatrics 2005;116:e432-e435

DOI: 10.1542/peds.2005-0313

Up to 6 months,
milk is 7.4% fat,

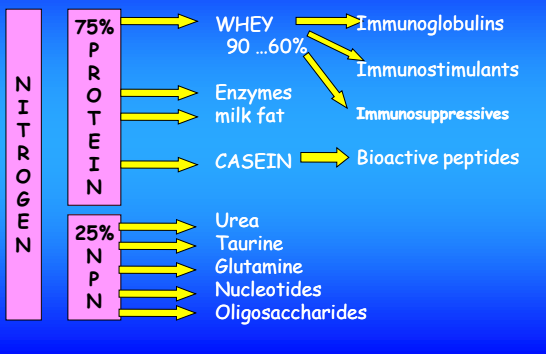
but after 12 months it is 10.7%

Be sure the wet nurse has plenty of milk ... because if she lacks it she may give the baby milk of a goat or sheep or some other animal, because the child ... nourished on animal milk does not have perfect wits like one fed on woman's milk and always looks stupid and vacant and not right in the head.

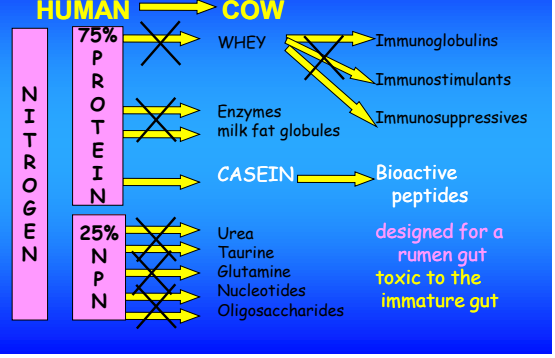
14th century Tuscan text

Caso-morphines
sedate for "cache" care

SCHEMA OF HUMAN MILK NITROGEN CONTENT ....



Nutrition & Protection



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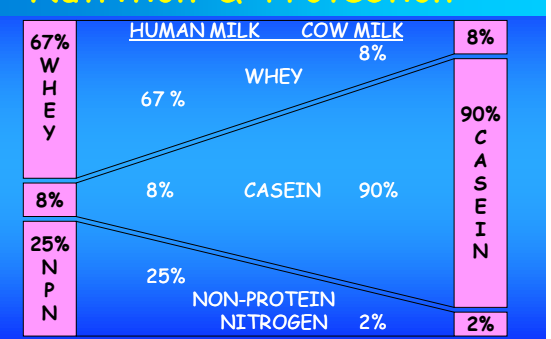
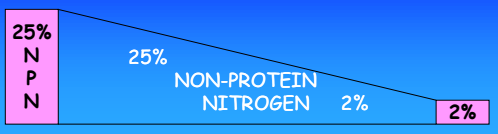


CASEINS → BIOACTIVE PEPTIDES

unique and essential effects:

Phosphopeptides	absorbing calcium and zinc
Opioid peptides	regulate gastric and intestinal motility
Milk mucins	against all pathogenic bacteria
Glycoproteins	against specific bacteria
Secretory IgA	against pathogenic bacteria
Cell adhesion molecules	prevent necrotising enterocolitis
Lactoferrin	growth factor, iron absorption
	anti-inflammatory factor
	immuno-modulating factor

Nutrition & Protection



NON - PROTEIN NITROGEN

In cows this is 2 - 4%.
In humans 20 - 25%

This is a critical component for the baby !!
Over 200 irreplaceable chemicals ...

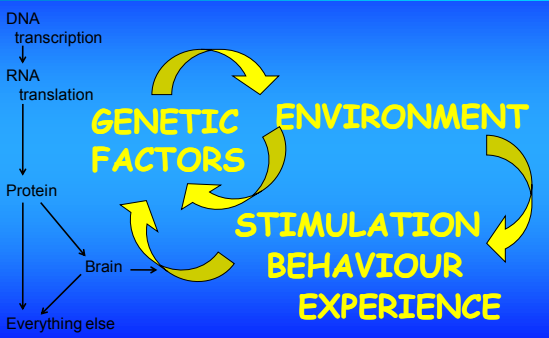
NON - PROTEIN NITROGEN

Urea conditionally essential nutrient
Taurine aminoacid required neonatal brain, eyes, kidney
Glutamine for stress and sepsis
Nucleotides repair of injury, specially gut
immunological processes
improve cellular immunity
Oligosaccharides
bacteria-specific interactions
anti-inflammatory effects

Results: The experimental intervention led to a large increase in exclusive breastfeeding at age 3 months (43.3% for the experimental group vs 6.4% for the control group; $P < .001$) and a significantly higher prevalence of any breastfeeding at all ages up to and including 12 months. The experimental group had higher means on all of the Wechsler Abbreviated Scales of Intelligence measures, with cluster-adjusted mean differences (95% confidence intervals) of +7.5 (+0.8 to +14.3) for verbal IQ, +2.9 (−3.3 to +9.1) for performance IQ, and +5.9 (−1.0 to +12.8) for full-scale IQ. Teachers' academic ratings were significantly higher in the experimental group for both reading and writing.

Arch Gen Psychiatry. 2008;65(5):578-584

NATURE VS NURTURE



POST - TEST .....

Georgetown University, Washington D.C.
212 babies <1500g, prospectively followed:
Infection rate for formula fed 47.2%
Infection rate for human milk fed 29.3%

Conclusion:
" being human milk fed
decreased the odds of infection by 57%."

OR

" being cow fed
increased the odds of infection by 61%."

POST - TEST ..... Example of paradigm

Conclusion:
" being human milk fed
decreased the odds of infection by 57%."

OR

" being cow fed
increased the odds of infection by 61%."

The first statement assumes that
being cow fed is the normal.
Would you introduce a new feed
which increases odds of infection?

HUMAN milk banking ASSOCIATION OF NORTH AMERICA

Human Milk Banking Association of North America

•Setting the Standards for Human Milk Banking
•Meeting the Milk Banking Needs for North America

•A Safe Alternative in the Absence of Infant's Own Mother's

This website is designed to provide information on milk banking and how to contact a milk bank to donate milk or to order donor human milk. This site is also a resource for health care providers and others who are looking for information on HMBANA's resources and services.

http://www.hmbana.org/

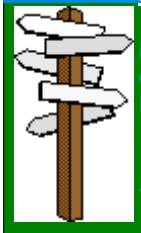
GIVE MILK®
International Breast Milk Project

"Where it is not possible for the biological mother to breastfeed, the first alternative, if available, should be the use of human breast milk from other sources. Human milk banks should be made available in appropriate situations."

World Health Organization/United Nations Children's Fund

http://www.breastmilkproject.org/

Presentation objectives



- Birth Skin-to-Skin Contact
- Ongoing SSC
- Breastfeeding behaviour
  - Breastfeeding wiring
  - BREASTFEEDING
- Sensory stimulation
  - State organization
  - Sleep cycling
  - **Feeding frequency**
  - Brain nutrition
- BRAIN WIRING

konklusion
that a good reliable set ov
bowels
iz worth more to a man
than enny quantity of brains."

http://www.vivo.colostate.edu/hbooks/pathphys/digestion/stomach/anatomy.html

Josh Billings

Mucus cells: protect lining from acid

Hydrochloric acid
important for activation of pepsinogen, inactivation of microorganisms such as bacteria.

Pepsinogen
activated by acid into active pepsin, responsible for the stomach's ability to initiate digestion of proteins.

Hormones: The principal hormone is gastrin
→ control of acid secretion and gastric motility.

STOMACH VOLUME

In adult human:

50 ml	when empty.
1000 ml	after ordinary meal... but can
4000 ml	of liquid

http://www.vivo.colostate.edu/hbooks/pathphys/digestion/stomach/anatomy.html

WHAT IS THE STOMACH VOLUME OF THE NEONATE ???

STOMACH VOLUME OF NEONATE ???

Generally accepted to be 75ml (60 – 80 ml)
(e.g. Zangen et al 2001)

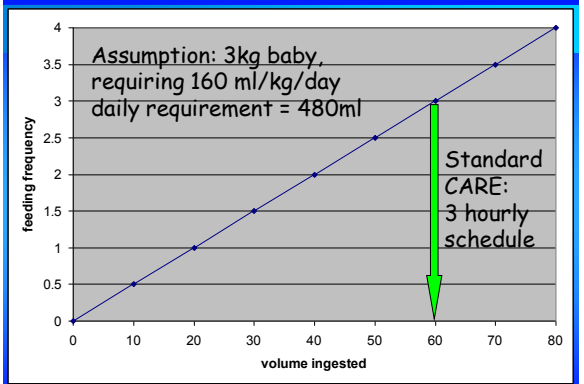
Popularly described as the size of ping-pong ball

Recently:
a ping-pong ball established to be 22-27 ml
an extra large chicken egg is 60-80ml

STOMACH VOLUME

FEEDING INTERVAL

$\frac{1}{\text{FEEDING INTERVAL}}$ = FEEDING FREQUENCY



Karen Edmond, MBBS, MSc (Epidemiology), PhD
London School of Hygiene and Tropical Medicine, London, U.K.

Rajiv Bahl, MD, PhD
Department of Child and Adolescent Health and Development, WHO, Geneva

EVIDENCE FOR FEEDING FREQUENCY ????

Findings of the review

What to feed

Choice of milk

Breastfeeding or mother's own expressed milk. There is strong and consistent evidence that feeding mother's own milk to pre-term infants of any gestation is associated with a lower incidence of infections and necrotising enterocolitis, and improved neurodevelopmental outcome as compared with formula feeding. Feeding unsupplemented mother's own milk to pre-term infants <1500 g resulted in slower weight and length gains, but the implications of this slower growth are unclear and there is not enough evidence to assess if it increased the risk of malnutrition. Long-term beneficial effects of breastfeeding on blood pressure, serum lipid profile or pro-insulin levels have also been reported for pre-term infants. There are limited data on most outcomes in term LBW infants; the available data suggest that improved infection and neurodevelopmental outcomes associated with feeding mother's milk in pre-term infants are also seen in this group.

Breastfeeding and mother's milk: Strong and consistent evidence

How to feed

Feeding methods

Cup feeding compared with bottle feeding. In pre-term infants, cup feeding leads to higher rates of full (exclusive or predominant) breastfeeding, compared with bottle feeding at the time of discharge from hospital. Cup feeding was also associated with greater physiological stability, e.g. lower risk of bradycardia or desaturation, than bottle feeding. No data are available for term LBW infants. When cup feeding is correctly done, i.e. with the infant upright and the milk is not poured into the mouth, there is no evidence that there is an increased risk of aspiration.

Cup feeding versus bottle feeding:
Cup feeding higher breastfeeding
greater stability

FEED FREQUENCIES AND INTERVALS

Results

Effects on mortality, serious morbidity, neurodevelopment or malnutrition

No RCTs or observational studies were located which examined the impact of feeding frequencies or intervals on mortality, serious

Effects on other important outcomes

Only case series and descriptive studies were located which examined outcomes such as *feed tolerance and biochemical measures* (Level IV evidence) (270, 283). These studies indicated

Conclusions and implications

Only case series and descriptive studies were located in this section. These describe the

about the safest or most effective regimens. No implications can be drawn for infants of particular gestational ages or birth weights.

Recommendations

No policy statements from international or national organizations were located which examined the frequency of feeding in LBW infants. Standard practice in many neonatal units is to commence feeding 4-hourly for infants >2000 g, 3-hourly for infants 1500–2000 g, 2-hourly for infants 1000–1500 g, and hourly in infants <1000 g. Feeding intervals are then extended on an individual basis depending on feed tolerance, gastric aspirates and physiological stability. It was not possible to provide additional recommendations due to insufficient evidence.

Only case series ...
Insufficient evidence

No mention of
stomach capacity

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London School of Hygiene and Tropical Medicine, London, U.K.

Rajiv Bahl, MD, PhD
Department of Child and Adolescent Health and Development, WHO, Geneva

EVIDENCE FOR STOMACH CAPACITY ????

WHAT IS THE STOMACH VOLUME OF THE NEONATE ???

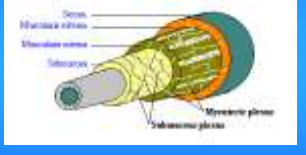
Naveed et al

Fetal stomach appears 4 weeks GA.
By 11 weeks, wall capable of muscular contraction.

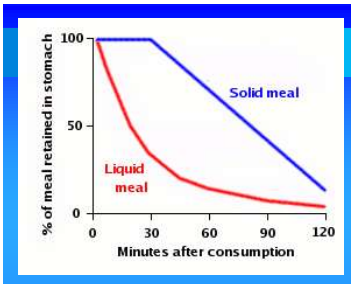
Hassan BB et al Patterns of antropyloric motility in fed healthy preterm infants
Arch Dis Child Fetal Neonatal Ed 2002 87(2):F95-9

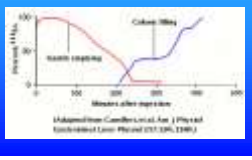
... the neuroregulatory mechanisms responsible for the coordination of antropyloric motility and gastric emptying are well developed by 30 weeks of PMA.

The digestive system is endowed with its own, local nervous system referred to as the enteric or intrinsic nervous system.



The magnitude and complexity of the enteric nervous system is immense - it contains as many neurons as the spinal cord.



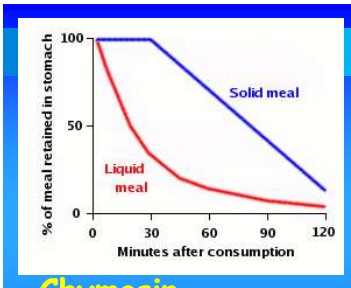


Chymosin

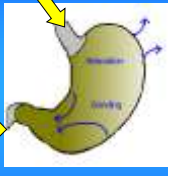
is an enzyme whose role is to curdle or coagulate milk in the stomach, a process of considerable importance in the very young animal.

If not coagulated, it would flow through stomach, & miss the opportunity for initial digestion of its proteins.

Chymosin efficiently converts liquid milk to a semisolid like cottage cheese, allowing it to be retained for longer periods in the stomach. Chymosin secretion is maximal during the first few days after birth, and declines thereafter, replaced in effect by secretion of pepsin as the major gastric protease.

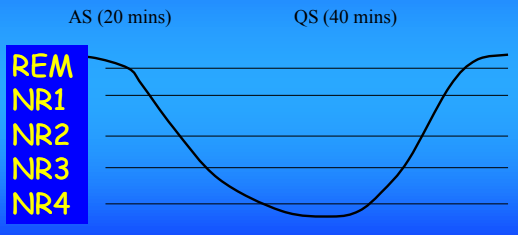


milk



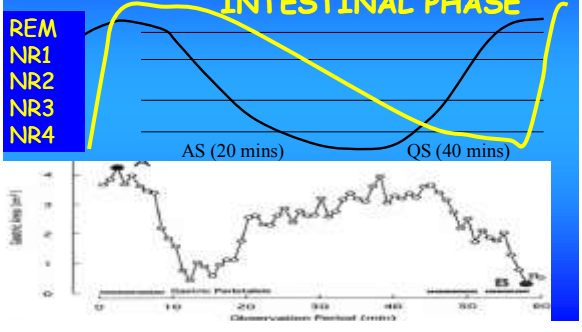
Chymosin
makes the milk into "cheese"
halfway between liquid and solid
stomach empties in 60 minutes

BRAIN CYCLING



Stanley Graven 2006

CEPHALIC PHASE
GASTRIC PHASE
INTESTINAL PHASE



Formula for calculation of stomach capacity (Charles Bradshaw, UCT)
Assumptions: the stomach can be approximated by dividing into three sections, namely a ellipsoidal hemisphere, an ellipsoidal cylinder, and a skewed ellipsoidal cone.
Variables: a = anteroposterior radius, t = transverse radius, l = length stomach
Relations: the height of the cone and the hemisphere are both the same as 'a'.

Ellipsoid = 4/3 * Pi* r1*r2*r3 = 4/3 *Pi * a * a * t;
therefore volume of hemisphere = 2/3 Pi * a *a * t
Cylinder = Area of base * height = (Pi * a * t) * (l - 2a)
Skewed cone = 1/3 * base *height = 1/3 * Pi * a * t * a
Total volume = 2/3 * Pi *a*a*t + Pi * a * t * (l- 2a) + 1/3 * Pi * a * t * a
=Pi a*t*l -Pi * a *a*t
= Pi * a * t*(l-a)

Goldstein and Sase data:
Stomach capacity at term 10 - 15 ml

Assumption: 2,5 kg baby 33wGA,
requiring 160 ml/kg/day = 400 ml

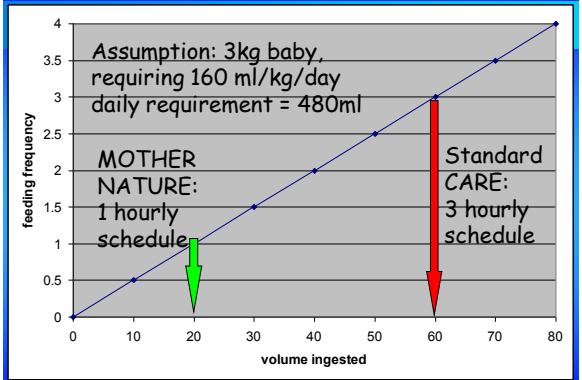
45 MIN CYCLES
12 ML PER CYCLE = 384 ml

The CAPACITY of a low birthweight prem from 20ml / 3000g
= 0.007 x BWt (g)

1kg x 0.007 = 7mls
2kg x 0.007 = 14mls

PROPOSAL:

The CAPACITY of a week old baby's stomach is approx 20 ml.



Known references with data:

Scammon and Doyle 1920
quoted in Silverman 1961

Scammon and Doyle:
14571 feeding records from 323 newborns
"physiologic capacity" → all breastfed
test weighing before and after feeding

Reviewed other investigators post-mortem studies

American Journal of Diseases of Children 1920 Vol 20 p516-538

Physiological capacity was determined by weighing before and after feeding

"infants were breastfed 5 times per day"

INFERENCE?? If fed 5 x per day
and daily requirement 160 ml x 3kg = 480
Required volume: 480 / 5 = 96 mls

Anatomic capacity was determined
in post-mortem studies

30 – 35 ml at birth –
almost regardless of birth weight
75 mls at two weeks

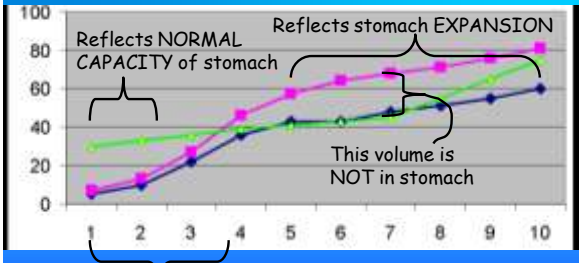
Note: postmortem allows for control at antrum and pylorus

Only recent study located:
"Autopsy" capacity was determined
in Indian post-mortem studies

Naveed et al
Indian J Gastroenterol 1992; 11(4):156-158

13 ml at birth = stillborns
16 ml "early neonatal death"
for plot: say 3 days = "mean ENND"

POSSIBLE INTERPRETATION



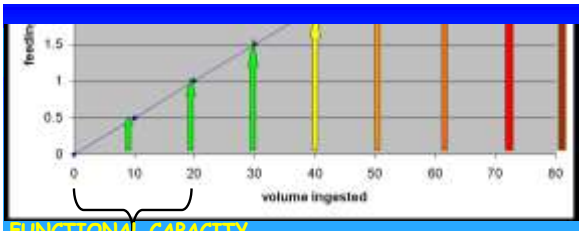
Reflects milk availability
from breasts,
NOT CAPACITY of stomach

TERMINOLOGY PROPOSALS

"Functional capacity"
= 10 – 15 ml at birth
stretches slowly to
= 20 at day 3 or 4

TERMINOLOGY PROPOSALS

"Functional capacity"
equivalent to "expectation volume",
for which optimal pepsin / acid is made,
does not cause distention
allows adequate time for curdle
allows protein breakdown
allows controlled pyloric passage



FUNCTIONAL CAPACITY

PHYSIOLOGICAL CAPACITY

RECEPTIVE CAPACITY of stomach

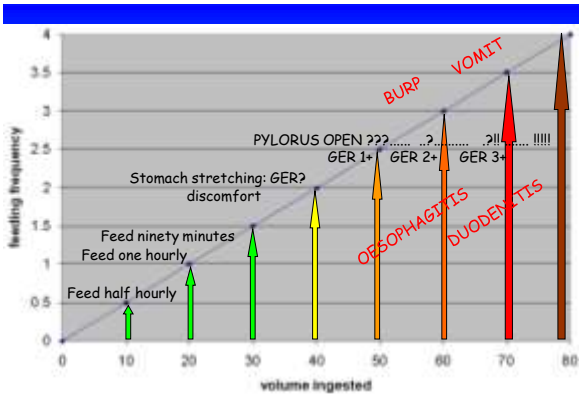
INGESTIVE CAPACITY of BABY

TERMINOLOGY PROPOSALS

Physiological capacity
Maximal amount stomach can handle without undue stress.

"Receptive capacity" of STOMACH
maximal amount stretched organ holds

"Ingestive capacity" of BABY
amount baby or infant swallowed,
(note, excess not in stomach)



Imagine a study !!

Let us measure the stomach capacity
with a balloon ... at end of NGT
Test the pressure on adults
must not be uncomfortable

Once the pressure starts to rise:
→ there is risk for reflux
→ to be avoided - expected physiology

THIS SHOULD BE THE STOMACH CAPACITY

Imagined study was done!!

Zangen S et al 2001
Rapid maturation of gastric relaxation in newborns

Tested the pressure on adults →

In healthy neonates, the volume of feedings in the first days of life is 60–100 mL/kg per day or about 20–40 mL per feeding. After a few days, the healthy neonate ingests approximately 150 mL/kg per day, or about 75 mL per feeding. The

No reference given ....

Imagined study was done!!

Zangen S et al 2001
Rapid maturation of gastric relaxation in newborns

Tested the pressure on adults →

Used two weeks of pressures that had been proven to cause pain !
"stopped at 30mmHg or when baby grimaced"

Zangen S et al
Rapid maturation of gastric relaxation in newborns

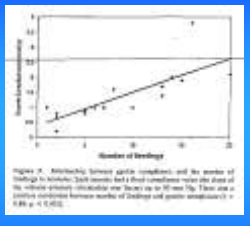
Pressures (mmHg)
Adult senses at 23
pain/discomfort 26

In study: Max
= 30 mmHg !!
(motivation:
200 mmHg when
vomiting ????)

17 healthy infants
"within the first week of life"
fed every 4 hours, swaddled,
breast or bottle fed (not factored in regression)

latex balloon in stomach

Zangen S et al
Rapid maturation of gastric relaxation in newborns



Number of feeds & gastric compliance
→ positive correlation

PRESUME: each feed approximately 75 mls

BUT ..... !!!

Hassan BB et al
Patterns of antropyloric motility in fed healthy preterm infants
Arch Dis Child Fetal Neonatal Ed 2002 87(2):F95-9

... the neuroregulatory mechanisms responsible for the coordination of antropyloric motility and gastric emptying are <u>well developed</u> by 30 weeks of postmenstrual age.

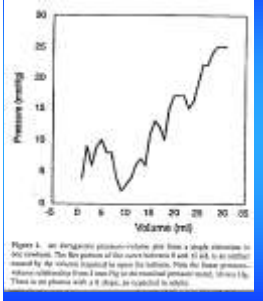
PARADIGM CONSTRUCT

Paradigm: "in the philosophy of science, a generally accepted model of how ideas relate to one another, forming a conceptual framework <u>within which scientific research is carried out</u>"
MSN Encarta

BASIC ASSUMPTION:
= INFANTS FEED 3 HOURLY

FOUNDATION / PLATFORM / BASE

Zangen S et al
Rapid maturation of gastric relaxation in newborns



Pressures (mmHg)

Balloon inflates to

15 ml no increase

functional capacity

Zangen S et al
Rapid maturation of gastric relaxation in newborns

Pressures (mmHg)

Balloon inflates to

15 ml no increase
20 ml pressure OK

physiological capacity ....

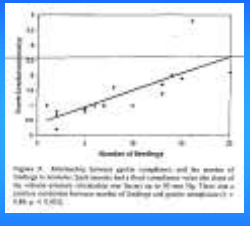
Zangen S et al
Rapid maturation of gastric relaxation in newborns

Pressures (mmHg)

Balloon inflates to

15 ml no increase
20 ml pressure OK
25 ml discomfort
30 ml "ethical" limit

Zangen S et al
Rapid maturation of gastric relaxation in newborns



Number of feeds & gastric compliance
→ positive correlation

PRESUME: each feed approximately 75 mls

receptive capacity

Zangen S et al
Rapid maturation of gastric relaxation in newborns

Number of feeds & gastric compliance
→ positive correlation

ALTERNATIVELY:
the more often you stretch the stomach, the bigger it soon becomes (76 mls)

PRESUME: each feed approximately 75 mls

75 ml per feeding ... ?? ASSUMPTION

IMMATURE ????
OR
OVERWHELMED !!!

immaturity of gastric function. Despite the appearance of anatomic features of the digestive tract early in fetal life (1, 2), many aspects of gastrointestinal motility are immature in the neonate (3–6). *In vitro* studies demonstrated rapid postnatal

.... many aspects of gastrointestinal motility are immature in the neonate

Adults interpret the actions, words and expressions of children through the distorting filter of their own beliefs.

In many cases these misinterpretations can be destructive.
The most dramatic example occurs when the impact of traumatic events on infants and young children is minimized.

Perry et al 1995

"It is an ultimate irony that
at the time when the human
is most vulnerable to
the effects of trauma –
during infancy and childhood –
- adults generally presume
the most resilience.

Perry et al 1995

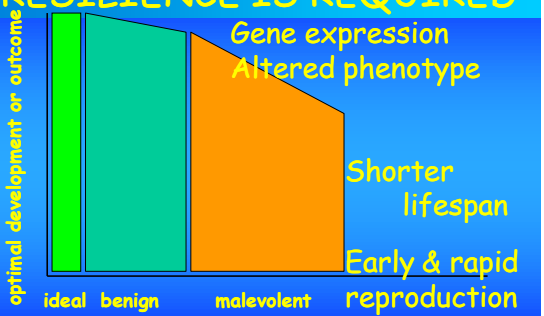
RESILIENCE !!

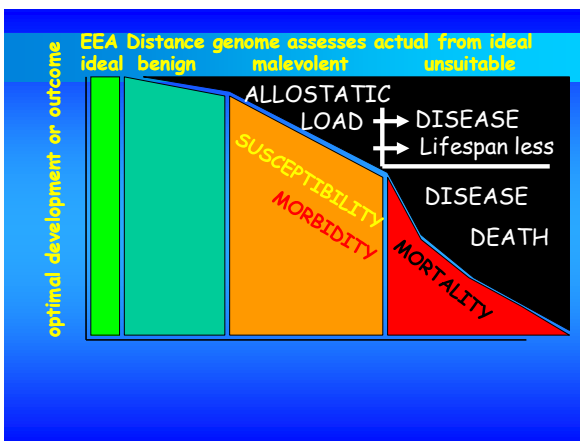
"EEA"
Environment of
Evolutionary
Adaptedness

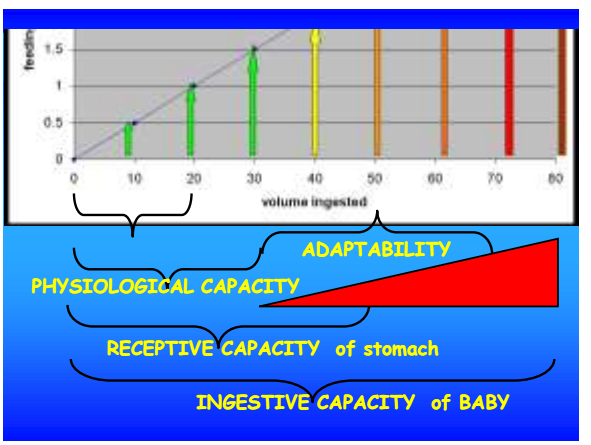
"Environment"
can be
BENIGN
MALEVOLENT
UNSUITABLE

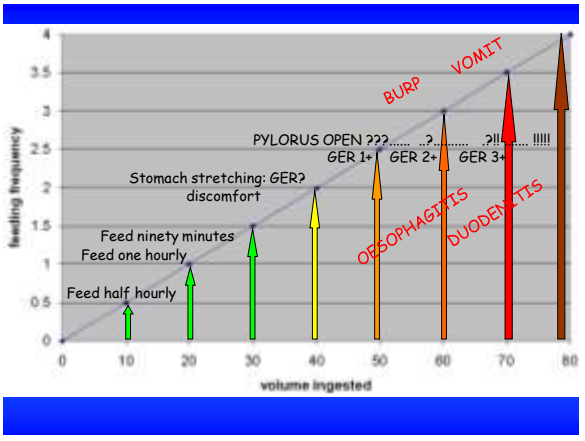
ideal benign malevolent unsuitable

RESILIENCE IS REQUIRED

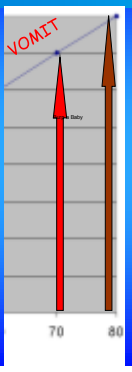








WHERE IS THE MILK?



Mother's shoulder

Oesophagus

Duodenum

Duodenum

Stomach

Stomach

Stomach

eHow

How To Do Just About Everything

How to Burp a Baby

Burping a baby can reduce spitting up and relieve bloating caused by swallowed air. Here are some tried-and-true methods.

WHERE IS THE MILK?

What happens when my baby spits up?

Babies spit up when they've eaten too much or when they're burped. It can also happen when your baby is drooling.

Spitting up is not vomiting.

Babies usually don't notice when they spit up, while vomiting is forceful and painful. Spitting up is a common occurrence for most babies.

http://familydoctor.org/online/famdocen/home/children/parents/infants/218.html

eHow

How To Do Just About Everything

How to Burp a Baby

Burping a baby can reduce spitting up and relieve bloating caused by swallowed air. Here are some tried-and-true methods.

Zangen S et al
Rapid maturation of gastric relaxation in newborns

A balloon in stomach can fill to 76 mls

What does the stomach – without a balloon – do to 76 mls?

PRESUME: each feed approximately 75 mls

Zangen S et al
Rapid maturation of gastric relaxation in newborns

A balloon in stomach can fill to 76 mls

What does the stomach – without a balloon – do to 76 mls?

PRESUME: each feed approximately 75 mls

REFLUX !!!

BMC Pediatrics

Research article

Open Access

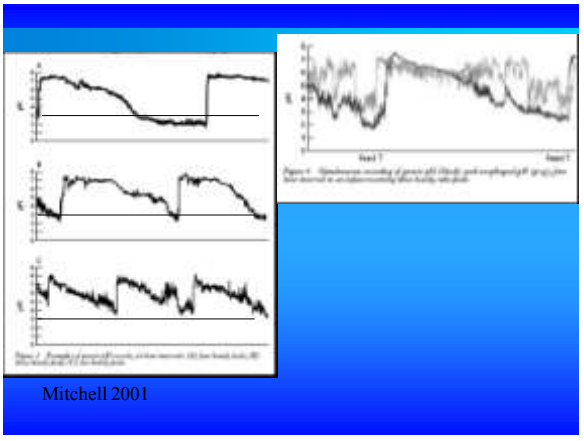
Infantile gastroesophageal reflux in a hospital setting

Susan S Baker*, Christine M Roach, Michael S Leonard and Robert D Baker

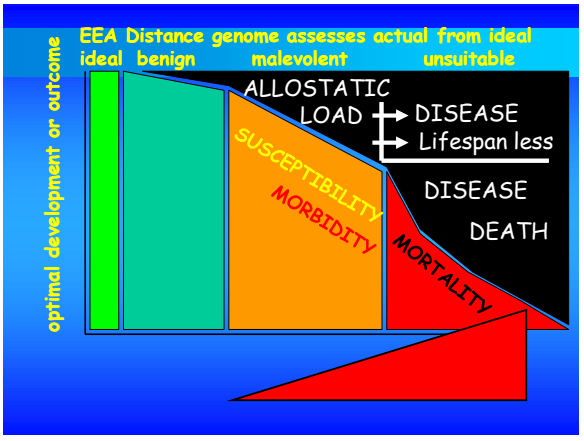
Methods: Retrospective chart review of children aged 0–2 years discharged between January 1, 1995 and December 31, 1999 with a diagnosis of reflux documented in their hospital chart prior to 12 months of age.

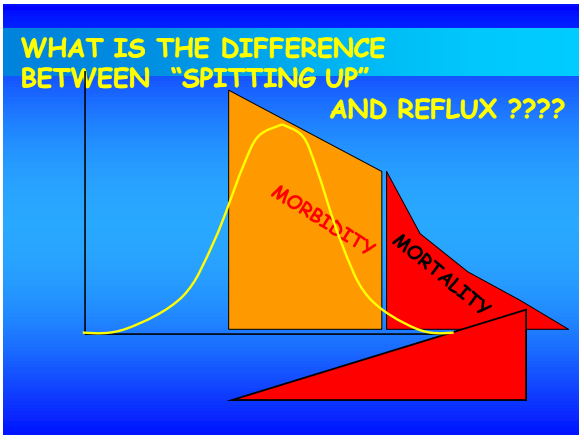
Results: Reflux was the seventh most common reason for hospitalization. About 50% of subjects with reflux had multiple hospitalizations. Of the 1,096 infants diagnosed with reflux about half were born prematurely. Reflux was the primary diagnosis for 21% of all infants, 18% of those born prematurely. The average length of stay for the subjects was longer than the hospital average. African Americans, 2.4% of the population, accounted for 29% of discharges. Caucasians, 86% of the population, were 66% of discharges. 21.8% of African Americans and 68.3% of Caucasians were diagnosed with reflux. 35% of mothers smoked, 27% worked and 48% had public insurance, compared to 22.2%, 57%, and 24% respectively of females in the general population.

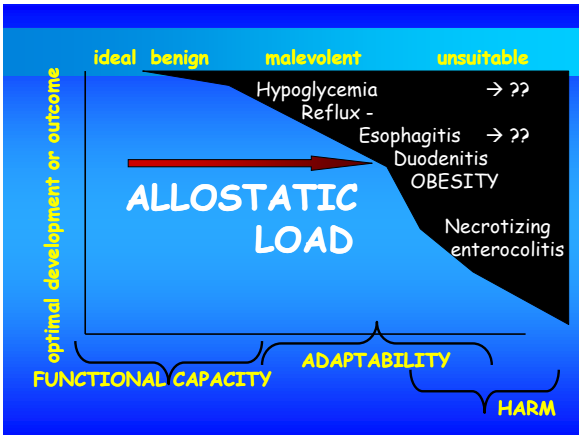
Conclusion: Reflux is a common discharge diagnosis. Children who have primary reflux have



Mitchell 2001







HYPOGLYCAEMIA

A babies stomach empties in **60 minutes.**
Blood sugar may fall …
after 90 minutes …
Options?

Blood sugar may fall …
after 90 minutes …

"There is a reason behind everything in nature" Aristotle

Would nature allow this?

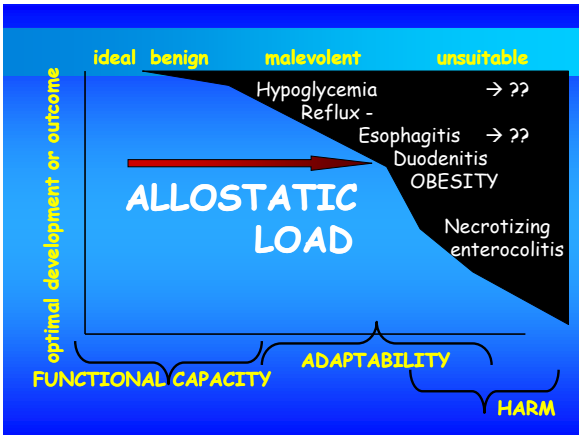
Sucking a pacifier while fed by nasogastric tube:

feed enters stomach faster,
stomach empties sooner,
somatostatin levels lowered.

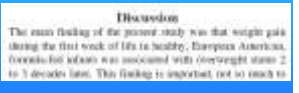
Sucking a pacifier while fed by nasogastric tube:

feed enters stomach faster,
stomach empties sooner,
somatostatin levels lowered.

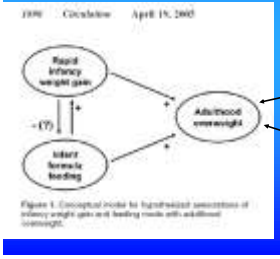
BUT: DO WE WANT THIS ??
Are we hastening hypoglycemia?



Weight gain 1st week:

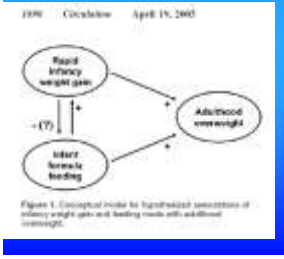


predicts OBESITY at 30 years

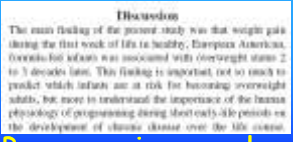


Large volume feeds stretched stomach=

doubled absorptive capacity as adult



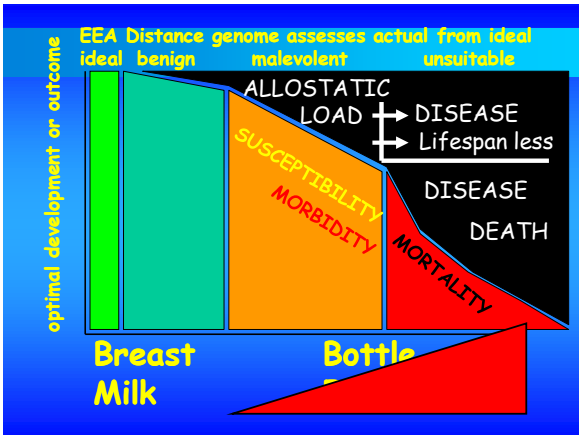
Importance →



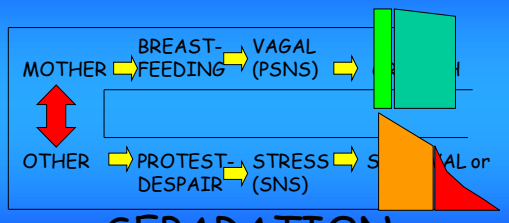
Programming – early life chronic disease

The Fetal Matrix:
Evolution, Development and Disease
Peter Gluckman, Mark Hanson

Genome and fetal programming
Predictive adaptive responses (PAR's)



BENIGN
SKIN-TO-SKIN CONTACT



SEPARATION
MALEVOLENT

WHAT IS THE
STOMACH VOLUME OF THE PREMATURE ??

Assume low resilience
(use functional capacity)
Assume proportionality →

The CAPACITY of a low birthweight prem from 20ml / 3000g
= **0.007 x BWt (g)**

1kg x 0.007 = 7mls
2kg x 0.007 = 14mls

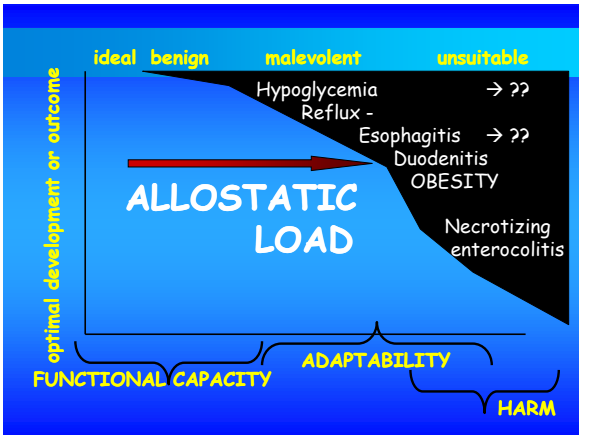
Standardised from 20ml capacity for 3kg baby (x 0.007)

Baby weight; freq; req'd size → actual

2kg baby: 4hrly
~ 320 ml/6 = 53ml → 14ml

1,5 baby: 3hrly
~ 240 ml/8 = 30ml → 10ml

1,0 baby: 2hrly
~ 160 ml/12 = 13ml → 7ml



Necrotizing enterocolitis?

Stomach has pH 2, 3 – 4 pylorus
(pancreatic/ biliary)
Jejenum pH 8

UNPREPARED BOLUS?
duodenitis ??
colic ???

RCT feeding tolerance bolus feed vs continuous

(Dollberg et al 2000)

Continuous compared to 2-3 hrly
NEC 2 (17) vs 3 (19)
(no difference, common)

Cochrane review: "continuous vs intermittent bolus ..."

(Premji & Chessell 2003)

"every 2 or 3 hours" used in all studies

"No evidence of a difference in the incidence of NEC"

Feeding strategies and necrotizing enterocolitis

(Berseth 2005)

"Overall incidence of NEC unchanged"

"Several studies ... safe to use small feeding volumes early in life" (Berseth 2003)

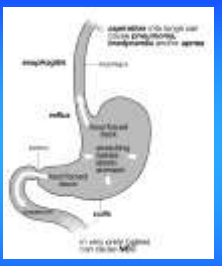
But "full enteral feedings" presumed to be as per Edmond (2 – 3 hourly)

Violence to the Neonatal Stomach:
Review of Stomach Capacity
and Infant Feeding Frequency

Necrotizing enterocolitis may be reduced by

ONE HOURLY FEEDS

Gastric overfilling syndrome?



Proposed Management →

Peter Hartmann

has measured the volume of milk in a single let down reflex.
Quite regardless
of breast-size …
amazingly constant:

a let down of milk is 20 - 30 ml.

The volume of a single milk ejection reflex is approx **20 ml.**

The volume of a week old baby's stomach is maximum **20 ml.**

A normal sleep cycle for a premature is **60 minutes**

A babies stomach empties in **60 minutes.**

One feed every 60 minutes
= 24 feeds/ day

24 feeds of 20 mls each
= 480 mls

480 mls per day for 3 kg baby
= 160 ml/kg/d

= requirement of baby.

Proposed Management →

All babies should be fed at least once an hour !!

FREQUENT FEEDS !!!!

In anthropological studies, where infants are carried constantly, and have free access to the breast, they will breastfeed every hour.

Surmise - Cholecystokinin, oxytocin
- Behavioural synchrony.

The first Milk Ejection Reflex (MER)

elicited in 2 minutes
works quickly
swallowed 1 minute

Feeding time 3 minutes

Repeat every 1 hour

The "normal" or usual and common breastfeed

takes 15 minutes
discomfort after
burping time 5 minutes

Feeding time 20 min

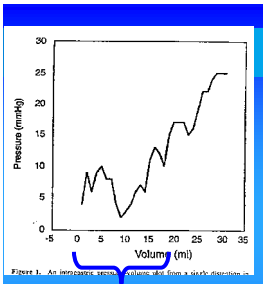
Repeat every 3 hours

3 minute 20ml feeds x 24/d = 72 minutes

20 minute 60ml feeds x 8/d = 160 minutes

SMALL AND FREQUENT FEEDS ARE EFFICIENT !!!!

FEWER NURSES NEEDED !!!



20 mls x 24 feeds
= 480mls / day

The calculated daily requirement for a 3kg baby can be given without increase in pressure ....
→ MINIMAL RISK

PARENTS CAN DO SAFELY !

FEEDING VOLUME

Alexis 1700g
daily requirement
160ml x 1.7 = 272 ml

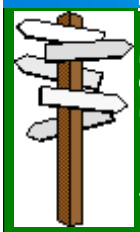
3 hrly feed = 34 ml

2 hrly feed = 22ml = ping pong ball

22 ml 11 ml 65 ml

1 hrly feed = 11ml
= stomach capacity

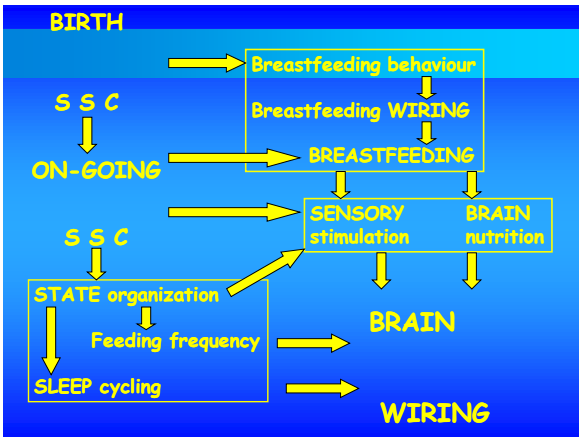
Presentation objectives



Birth Skin-to-Skin Contact
Ongoing SSC
Breastfeeding behaviour
Breastfeeding wiring
BREASTFEEDING
Sensory stimulation
State organization
Sleep cycling
Feeding frequency
Brain nutrition
BRAIN WIRING

The brain is a

SENSORY ORGAN
BREAST - FEEDING
=
BRAIN - WIRING
SOCIAL ORGAN



"the first three years are decisive"

PLAY
(=Sensory acquisition)
should be EVERY HOUR

BREASTFEEDING
(=BRAINWIRING)
should be EVERY HOUR

In the past, whether
to breastfeed or not
was a lifestyle choice.

Our new knowledge of the brain
makes breastfeeding
a public health issue.

(Gail Storr, Fredericton, NB)

Basic Biological Need

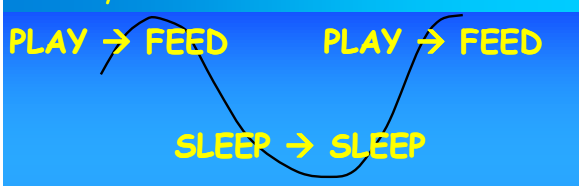
SLEEP

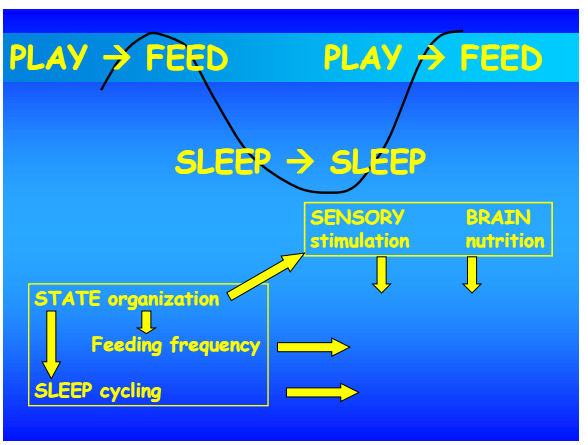
DEEP SLEEP
(= Emotional connection)
should be EVERY HOUR

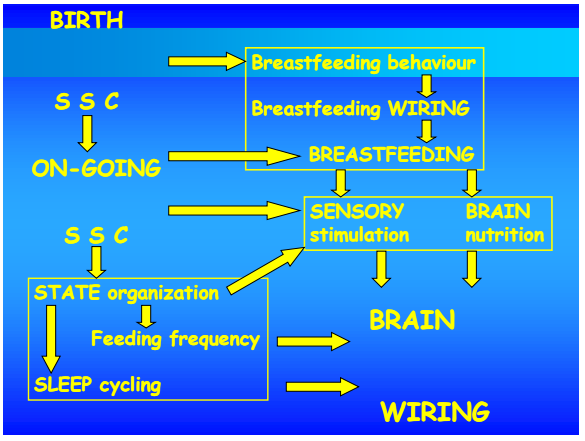
Co-sleeping ?
SAFE SLEEP !!

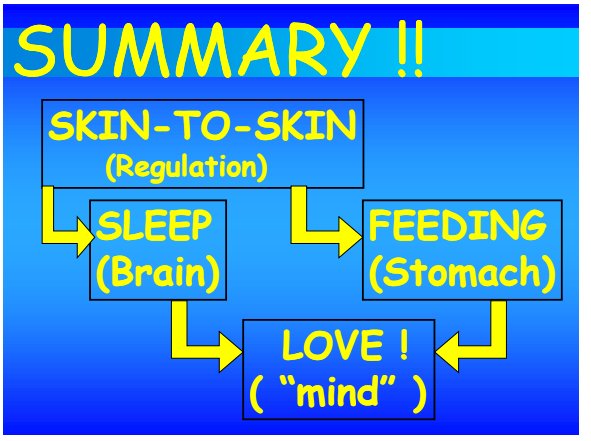
Gentle self-waking
(= REM memory formation)
should be EVERY HOUR

Sensory "hothouse"









MOTHER
is the
Only

Appropriate
ENVIRONMENT

KEEP
US
TOGETHER

SKIN-TO-
SKIN !

MOTHER'S
MILK is
the only

Appropriate
FOOD