In 1801 Eramus Darwin wrote:

“Another thing very injurious to the child is tying and cutting the navel-string too soon; which should always be left till the child has not only repeatedly breathed but till all pulsation in the cord ceases. As otherwise the child is much weaker than it ought to be, a part of the blood being left in the placenta, which ought to have been in the child.”

Before the mid 1950s, the term *early clamping* was defined as umbilical cord clamping within 1 minute of birth, and *late clamping* was defined as umbilical cord clamping more than 5 minutes after birth.

Given the benefits to most newborns and concordant with other professional organizations, the American College of Obstetricians and Gynecologists now recommends a delay in umbilical cord clamping in vigorous term and preterm infants for at least 30-60 seconds after birth.

**Early Observations**

In a series of small studies of blood volume changes after birth, it was reported that 80-100 mL of blood transfers from placenta to the newborn in the first 3 minutes after birth and up to 90%- of that blood volume transfer was achieved within the first few breaths in healthy term infants.

• What is the evidence that delayed cord clamping can increase red cell volume?
• What is the evidence that is improves health of the baby?
• What are the risks and costs for the infant and mother?
Distribution of blood infant placenta: term babies

- 110 normal full term births, no anesthesia to mom, oxytocics after clamp
- Birth times as buttocks delivered, 10 cm below introitus
- Blood volume of infant determined by Iodine 125-human serum albumin dilution
- Results: Distribution blood infant versus placenta by %
- Infant/placenta 67%/33% at birth
- 80%/20% at 1 minute
- 87%/13% by 6 minutes
- Almost complete by 3 minutes

Yao Ac et al. Lancet 1969 Finland and New York

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Red Cell Volume and Umbilical Cord Clamping in Preterm Babies

- 262 consecutively delivered babies 26 to 36 weeks
- Red Cell Volume (RCV) a direct correlate of time of cord clamping, oxytocics after placenta delivery, epidural
- Fatal cases had the lowest volumes
- 10.3% mortality from RDS among the 1/3 with smallest RCV versus 2.3% among the 1/3 with the largest RCV

Usher et al. Biol. Neonate 1975 Canada

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Resuscitation is More Than Airway and Breathing:

Circulation: Improved on EM, blinded, informed consent after delayed clamping in term babies 2 mm skin biopsy.

Pietra GG. Pediatrics 1968
“When medical progress apparently lags it is often due to neglect to honor the great physicians of the past, thus neglecting to call public attention to medical progress through those who have made great achievements.”

Dr. Charles H. Mayo

Recent Randomized Controlled Trials of Term and Preterm Infants

• As well as physiologic studies of blood volume, oxygenation, and arterial pressure have evaluated the effects of immediate versus delayed umbilical cord clamping (usually defined as cord clamping at least 30-60 seconds after birth).
• Delayed umbilical cord clamping appears to be beneficial for term and preterm infants.

What is the evidence that this improves health of the preterm baby?

• Prospective, randomized, 27 to 33 weeks
• 36 vaginal births, 20 cm below introitus for 30 seconds
• 17 babies, delay group
• Results: Mean initial packed red cell volume higher in delayed clamping
• 7 of 13 conventional need blood versus 1 of 13 in delayed

Kimmond, et al. BMJ 1993 Scotland

What is the evidence that it improves health of the preterm baby?
Cochrane Database 2004

• What is optimal timing for preterm?
• 7 studies, 297 infants, 24-33 weeks
• Vaginal (1/7) and C/S (1/7) births
• 30 to 120 seconds
• Results: Fewer transfusions RR 2.01, 111 infants, 3 trials
  Less low blood pressure RR 2.58, 2 trials, 58 infants
  Less intraventricular hemorrhage RR 1.74, 5 trials, 225 infants.

Cochrane Database 2004

• No clear differences in death, hyperbilirubinemia, RDS, surfactant or ventilation, Cord pH, Apgar at 5 minutes, temperature on admit
• Position of the baby to placenta and uterus varies
• No trials reported outcomes for the women
• Conclude: Delayed cord clamping by 30 to 120 seconds, rather than early clamping, seems to be associated with less need for transfusion and less IVH


Delayed clamping: NIRS Data, Preterm Babies

• 39 infants mean gestation 30 weeks, mostly c/s
• 60-90 second delay, 15cm below
• NIRS Data: Better cerebral oxygenation at 4 and 24 hours; 15 cm below, 60 to 90 seconds
• Less chance of HIE

Cochrane 2012 Preterm Babies

Delayed umbilical cord clamping was associated with few infants requiring transfusion for anemia (7 trials, 392 infants; relative risk [RR], 0.61; 95% confidence interval [CI], 0.46-0.81).

Cochrane 2012 Preterm

Peak bilirubin levels were higher in infants within the delayed umbilical cord clamping group, but there was no statistically significant difference in the need for phototherapy between the groups.

Cochrane 2012 Preterm

There was a lower incidence of necrotizing enterocolitis (5 trials, 241 infants RR, 0.62; 95% CI, 0.43-0.90) compared with immediate umbilical cord clamping.

Cochrane 2012 Preterm

There was a lower incidence of intraventricular hemorrhage (ultrasonographic diagnosis, all grades) (10 trials, 539 infants; RR, 0.59; 95% CI, 0.41-0.85).
Cochrane 2012 Preterm Babies

For outcomes of infant death, severe (grade 3-4) intraventricular hemorrhage, and periventricular leukomalacia, no clear differences were identified between groups; however, many trials were affected by incomplete reporting and wide confidence intervals.

Long Term Preterm

• Outcome after discharge from the hospital was reported in a small study in which no significant differences were reported between the groups in mean Bayley II scores at age 7 months (corrected for gestational age at birth and involved 58 children).
• In another study, delayed umbilical cord clamping among infants born before 32 weeks of gestation was associated with improved motor function at 18-22 months corrected age.

Cochrane 2013 Term Babies

• Clinical Trials in Term Infants
• A 2013 Cochrane review assessed the effect of timing of umbilical cord clamping on term neonatal outcomes in 15 clinical trials that involved 3,911 women and their singleton infants.
Cochrane 2013 Term Babies

This analysis defined early umbilical cord clamping at less than 1 minute after birth and late umbilical cord clamping as clamping at more than 1 minute or when cord pulsation ceased.

Cochrane 2013 Term Babies

The reviewers found that newborns in the early umbilical cord clamping group had significantly lower hemoglobin concentrations at birth (weighted mean difference, -2.17 g/dL; 95% CI, -4.06 to -0.28) as well as at 24 – 48 hours after birth (mean difference -1.49 g/dL; 95% CI, -1.78 to -1.21).

Cochrane 2013 Term Babies

In addition, at 3 – 6 months of age, infants exposed to early umbilical cord clamping were more likely to have iron deficiency compared with the late cord clamping group (RR, 2.65; 95% CI, 1.04 – 6.73).

Cochrane 2013 Term Babies

There was no difference in the rate of polycythemia between the two groups, nor were overall rates of jaundice different, but jaundice requiring phototherapy was less common among those newborns who had early umbilical cord clamping (2.74% of infants in the early cord clamping group compared with 4.36% in the late cord clamping group; RR, 0.62; 95% CI, 0.41 – 0.96).

Term Long Term

In a single cohort, assessed from 4 months to 4 years of age, scores of neurodevelopment did not differ by timing of umbilical cord clamping among patients at 4 and 12 months of age. At 4 years of age, children in the early umbilical cord clamping group had modestly lower scores in social and fine motor domains compared with the delayed umbilical cord clamping group.

What about the Mom?

In a review of five trials that included more than 2,200 women, delayed umbilical cord clamping was not associated with an increased risk of postpartum hemorrhage or increased blood loss at delivery, nor was it associated with a difference in postpartum hemoglobin level or need for blood transfusion.
However, when there is increased risk of hemorrhage (e.g., placenta previa or placental abruption) the benefits of delayed umbilical cord clamping need to be balanced with the need for timely hemodynamic stabilization of the woman.

**Delayed Cord Clamping ACOG 2017**

**Multiples**
- At this time, there is not sufficient evidence to recommend for or against delayed umbilical cord clamping in multiple gestations.

**Milking**
- Ongoing studies are evaluating the possible benefits/risks of umbilical cord milking compared with delayed umbilical cord clamping, especially in extremely preterm infants. Currently, there insufficient evidence to either support or refute umbilical cord milking in term or preterm infants.

**The Position of the Newborn During Delayed Umbilical Cord Clamping**

- Generally has been at or below the level of the placenta, based on the assumption that gravity facilitates the transfusion.
- A trial of healthy term infants born vaginally found that those newborns placed on the maternal abdomen or chest did not have a lower volume of transfusion compared with infants held at the level of the introitus.
- Immediate skin-to-skin care is appropriate while waiting umbilical cord clamping.

**Clamping Delay and Skin-to-Skin**

In the case of cesarean delivery, the newborn can be placed on the maternal abdomen or legs or held by the surgeon or assistant at close to the level of the placenta until the umbilical cord is clamped.

**Full Term Babies, 38 Seconds Before 1st Breath Boston Lancet 1965**

![Graph showing blood pressure changes during clamping and non-clamping of umbilical cord]
Cord Clamping after Onset of Spontaneous Respiration

**Objective:** Describe the relationship between time to cord clamping, onset of spontaneous respirations (SR) and 24 hour neonatal outcome.

**Subjects/Methods:** Rural Tanzanian hospital, trained research staff, observe every delivery (November 2009 – February 2013); 15,563 infants born, 11,967 were of birth weight (BW) > 2500g and 813 < 2500g; 12,780 (84.3%) initiated SR at 10.8 ± 16.7 seconds and CC occurred at 63 ± 45 seconds after birth; outcomes included 12,730 (99.7%) normal, 31 deaths, and 19 admitted.

Langli Ersdal H. Pediatrics 2014;134(2)265-272

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**Results:** The risk of death/admission was consistently higher if CC occurred before SR; infants of BW < 2500g were more likely to die or be admitted; the risk of death/admission decreased by 20% for every 10 second delay in CC after SR; this risk declined at the same rate in both BW groups.

**Conclusion:** Healthy self-breathing neonates are more likely to die or be admitted if CC occurs before or immediately after onset of SR.

Langli Ersdal H. Pediatrics 2014;134(2)265-272

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**Other Thoughts**

Effect on Umbilical Cord Blood Banking
- Delayed umbilical cord clamping significantly decreased the volume and total nucleated cell counts of cord blood donations.

Future Research
- The feasibility of resuscitation at the bedside with intact placental circulation.
- Value of enhanced stem cell and plasma transfusion associated with delayed umbilical cord clamping with respect to immediate and long-term immunity, host defense, and repair research.

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**American College of Nurse Midwives**

Recommends Delayed Umbilical Cord Clamping for Term and Preterm Infants for 2-5 Minutes after Birth

World Health Organization (WHO)
- WHO recommends that the umbilical cord not be clamped earlier than 1 minute after birth in term or preterm infants who do not require positive pressure ventilation.

Royal College of Obstetricians & Gynaecologists
- Recommends deferring umbilical cord clamping for healthy term and preterm infants for at least 2 minutes after birth.

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**American Academy of Pediatrics**

Recent Neonatal Resuscitation Program guidelines form the American Academy of Pediatrics recommend delayed umbilical cord clamping for at least 30 – 60 seconds for most vigorous term and preterm infants.

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**Questions**
Nutrition and the First 1000 Days

• Iron and the first 1000 days of life.

Preterm Babies

• Iron accretes in last 3 months of pregnancy.
• Despite iron containing formula, 14% of preterm babies are iron deficient by 4 to 8 months of age.
• AAP recommends 2 mg/kg/day until 12 month of age.
• Preterm babies fed breast milk should receive supplement 2 mg/kg/day by 1 month of age.

Full Term Formula Fed

• Full term formula fed babies: AAP indicates no additional iron needed, 12 mg iron/liter.
• A good quality marker would be to see if we can order in hospital (or directly advise) Ferrous sulfate 2 mg/kg/day for infants for preterm babies, SGA babies, and infants of diabetic Moms.

Nutrition and the First Thousand Days

Neurologic Processes | Cell Type | Function | Nutrient Examples | At Risk During Late Gestation and 0-3 y
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Anatomy
- Neuron
  - Neuron (proliferation; migration; axonogenesis; synaptogenesis)
  - Processes: carbohydrates, iron, copper, zinc, LC-ω, vitamin B6, vitamin D, vitamin C
  - Global, hippocampus, striatum, cortex, retina

- Oligodendrocyte
  - Myelination
  - Processes: carbohydrates, iron, copper, zinc, vitamin B6, vitamin B12
  - Global

Chemistry
- Neuron astrocyte
  - Neurotransmitter concentration, receptor, reuptake
  - Processes: proteins, iron, bile, storage, zinc, copper, iodine, vitamin B6, vitamin D
  - Global, hippocampus, nucleus, accumbens, VTA, cortex, cerebellum

Hygiene and Metabolism
- Neuron oligodendrocyte
  - Electrical efficiency
  - Processes: glucose, protein, bile, zinc, choline, copper
  - Global

Anemia is a Late Finding for Iron Deficiency

IUGR/SGA
• Fifty percent of infants with IUGR have low iron stores at birth; all have protein malnutrition.
• Seventy-five percent of the cases of IUGR in the US are owing to maternal hypertension.

Infant Diabetic
• ≤65% of infants of mothers with diabetes are born with iron stores below the fifth percentile.
• Ten percent of pregnancies are complicated by pregestational or gestational diabetes mellitus.

This practice of rapidly transferring umbilical cord blood to the infant is used when a delay in umbilical cord clamping after birth is not possible.

AAP News. February 2017:23