Delayed umbilical cord clamping; what’s the physiology?

Stuart Hooper
What happens during delayed umbilical cord clamping?

1. Stablises the cardiovascular transition at birth
2. Results in placental transfusion?
Physiology of Umbilical cord clamping at birth

Cord clamping reduces Right Ventricular output

Ventilation onset

Pre-ductal arteries

Ductus arteriosus

Foramen Ovale

Right Heart

Left Heart

Lungs

Upper body

Lower body

Placenta
Ventilating before cord clamping

![Graph showing carotid arterial pressure and blood flow](image)

- Placenta
- Lower body
- Ductus arteriosus
- Right Heart
- Left Heart
- Foramen Ovale
- Lungs
- Upper body

50% Venous Return

Lungs aerate
Ventilation before cord clamping

Clamp: Carotid arterial pressure (% of control)
Vent: Carotid arterial flow (mL/min/kg)

Clamp: Heart rate (bpm)
Vent: Right ventricular output (mL/min/kg)
What happens during delayed umbilical cord clamping?

1. Stabilises the cardiovascular transition at birth

2. Results in placental transfusion?
DISTRIBUTION OF BLOOD BETWEEN INFANT AND PLACENTA AFTER BIRTH

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Placental blood transfusion = Fetal blood volume restoration?

The Lancet, 1969
Fetal/Placental transfusion

- Infant
- Placenta
- Umbilical Vein
- Umbilical Artery
- Chest
- Abdomen
- Lungs

Thoracic pressure – inspiration
Thoracic/abdominal pressure – iPPV, crying
Pulmonary or systemic vascular resistance
Oxytocin & Uterine contractions
Gravity: Infant height above/below the placenta

William Harvey in 1628
Doppler US of umbilical vessels

• Measured UA & UV flow using Doppler US in 15 infants

• Umbilical Vein
  – 10% no flow
  – 57% flow ceased at ~4 mins
  – 33% flow continued until clamping at ~5 mins

• Umbilical Artery
  – 17% no flow
  – 40% flow ceased at ~4 mins
  – 43% flow continued until clamping at ~5 mins

• Flow ceased in UV before UA in 8 infants
UV blood flow patterns
Hemodynamics of fetal breathing movements: the inferior vena cava

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UV blood flow

Ceases during crying & can reverse (25% infants)
UA Blood flow

Can be bi-directional
**Fetal/Placental transfusion**

- **Infant**
  - Chest
  - Abdomen
  - Lungs

- **Placenta**
  - Umbilical Vein
  - Umbilical Artery

- **Indications**
  - Thoracic pressure – inspiration (X)
  - Thoracic/abdominal pressure – iPPV, crying (✔)
  - Pulmonary or systemic vascular resistance
  - Oxytocin & Uterine contractions
  - Gravity: Infant height above/below the placenta
Effect of ventilation on UA and UV blood flow
Increase in pulmonary blood volume with increased flow

Increased PBF accounts for ~2% increase in blood volume

Volume \approx r^2
Flow \approx r^4

Walker et al J. Appl. Physiol. 1975
Fetal/Placental transfusion

- Thoracic pressure – inspiration
- Thoracic/abdominal pressure – iPPV, crying
- Pulmonary or systemic vascular resistance
  - Oxytocin & Uterine contractions
- Gravity: Infant height above/below the placenta
Effect of oxytocin

Blood Flow (mL/min)
Fetal/Placental transfusion

- Chest
- Abdomen
- Umbilical Vein
- Umbilical Artery

- Thoracic pressure – inspiration
- Thoracic/abdominal pressure – iPPV, crying
- Pulmonary or systemic vascular resistance
- Oxytocin & Uterine contractions
  - Gravity: Infant height above/below the placenta
Effect of gravity on UA & UV blood flow

Vent 1 = 1 min
Vent 2 = 3 min
Position of the newborn baby before cord clamping does not seem to affect volume of placental transfusion. Mothers could safely be allowed to hold their baby on their abdomen or chest. This change in practice might increase obstetric compliance with the procedure, enhance maternal-infant bonding, and decrease iron deficiency in infancy.
Fetal/Placental transfusion

- Infant
- Placenta

- Chest
- Abdomen
- Umbilical Vein
- Umbilical Artery

- Lungs

- Infants:
  - Thoracic pressure – inspiration
  - Thoracic/abdominal pressure – iPPV, crying
  - Pulmonary or systemic vascular resistance
  - Oxytocin & Uterine contractions
  - Gravity: Infant height above/below the placenta

- If the infant becomes progressively hypoxic?

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DCC during birth asphyxia
DISTRIBUTION OF BLOOD BETWEEN INFANT AND PLACENTA AFTER BIRTH

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Placental blood transfusion = Fetal blood volume restoration?

The Lancet, 1969
Effect of birth order & mode of delivery on Hb levels at birth

What about umbilical cord milking??

Is it the same as delayed umbilical cord clamping??
Umbilical cord milking

Is this a good thing?
UCM without placental refilling

Fetus

Umbilical flow probes

Placenta
UCM without placental refilling

- Net Umbilical Blood Flow (UV-UA)
- Carotid Artery Blood Pressure
- Carotid Artery Blood Flow
UCM with placental refilling

Fetus

Placenta

Umbilical flow

probes
UCM with placental refilling

Net Umbilical Blood Flow (UV-UA)

Carotid Artery Blood Pressure

Carotid Artery Blood Flow
UCM without placental refill versus UCM with placental refill

Net blood umbilical blood flow (Umbilical vein - umbilical artery)

- Milk 1
- Milk 2
- Milk 3
- Milk 4
- Milk 5
- Milk 6
- Milk 7
- Milk 8

Umbilical cord milking
- with placental refill
  Net: 8.8 ml/kg (IQR 8-10)
- without placental refill
  Net: 0 ml/kg (IQR -2.8-1.7)
Umbilical blood flow (UV-UA), group comparison

- **UCM without placental refill**
  - Median: 0 ml/kg (IQR -2.8-1.7)

- **UCM with placental refill**
  - Median: 8.8 ml/kg (IQR 8-10)

- **Ventilation 1st**
  - Median: 1.1 ml/kg (IQR -1.3-4.3)

N=6  N=7  N=7
Take home message

The neonatologists mantra

“Do no harm”

Lets fully understand the science first before we implement treatments

• Ensure that it is not harmful
• Understand what the treatment is supposed to achieve
• Optimize the treatment to get “full value for money”
Thank you!

Team
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-Domenic LaRosa
-Valeria Zahra
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-Corinna Binder-Heschl
-Euan Wallace
Effect of timing of umbilical cord clamping of term infants on maternal and neonatal outcomes (Review)

McDonald SJ, Middleton P, Dowswell T, Morris PS

- No decrease in mortality
- No decrease in NICU admission
- Increased in Hb concentrations 24-48h after birth
- Increased ferritin levels at 6 months
- Tendency for reduction in IVH – all grades
- Increase in birth weight by on average 101g
- Increased risk of polycythemia & jaundice