Cord Management of the Term Newborn

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KEYWORDS

• Placental transfusion • Umbilical cord clamping • Term • Resuscitation • Delivery

KEY POINTS

- Keeping the umbilical cord intact by delaying cord clamping for at least 3 minutes improves iron stores during infancy and supports health and development for the growing child. In preterm infants, delayed cord clamping reduces mortality by approximately 30%.
- Many midwives prefer to delay cord clamping until pulsations cease or until the placenta is ready to deliver and experience good results.
- To warn for risk of jaundice and need for phototherapy after delayed cord clamping is not evidence based.
- A multidisciplinary approach is critical to implement guidelines, training, and education with scheduled audits to increase compliance with delayed cord clamping.
- Intact cord resuscitation has been practiced for centuries at midwifery births, and has shown physiologic improvements in animal and human trials.

INTRODUCTION

Leaving the umbilical cord intact after birth has ensured our survival for millennia. Early cord clamping (CC) has emerged in modern society as a concern in the past century. Recent research has reestablished the value of delayed CC, which many regard as common sense and most midwives experience in their practice.

In the mid twentieth century, with the advance of modern medicine, delayed CC was replaced with the efficiency and expedieny of immediate CC without testing for its safety. Practice was guided by expert opinion and delayed CC at birth was discarded from mainstream practice.[1] For term infants, the focus of this article, early CC decreases hematocrit, blood pressure, blood volume, and iron stores, increases anemia,

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and seems to result in less brain myelin and poorer neurodevelopmental skills compared with keeping the cord intact for at least 3 minutes (Fig. 1).[2–7]

This article focuses on the physiologic effects of placental transfusion on term neonates; the current evidence; benefits and potential risks from immediate and delayed CC; practice recommendations, including special cases such as shoulder dystocia and nuchal cord; and a discussion of further needed research.

PHYSIOLOGY OF PLACENTAL TRANSFUSION

Fetal and Neonatal Blood Volume

Throughout pregnancy, the fetal-placental blood volume is approximately 110 to 115 mL/kg of fetal weight.[8] Waiting to clamp the cord results in a net transfer of blood from the placenta to the neonate.[8,9] The volume of the transfusion can be estimated by comparing birth weight,[10] by measurement of the residual placental blood volume (RPBV),[11,12] and by serial weights on individuals directly after birth.[13] In the Cochrane analysis in 2013, including 12 trials and 3139 infants, birth weight was ~100 g higher in the delayed CC group, compared with early CC.[2] In a study on serial measurements on individual neonates, weight after delayed CC increased by ~87 g.[13]

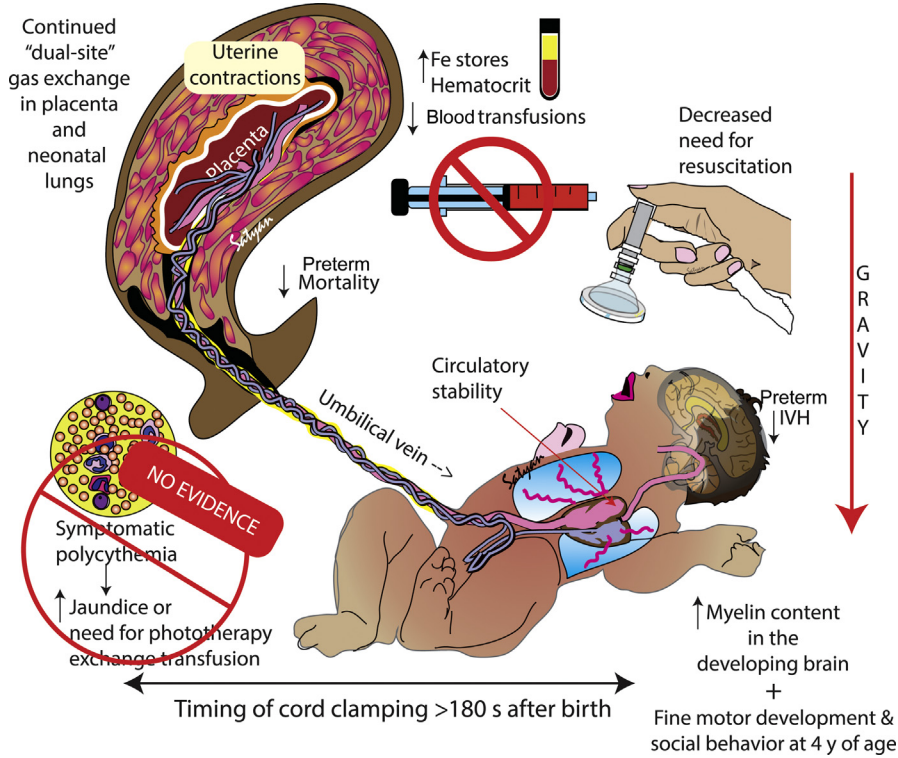

Fig. 1. Factors influencing placental transfusion with delayed CC. Timing of CC, uterine contractions, spontaneous respirations and gravity influence the magnitude of transfusion. Reported long-term benefits are shown. IVH, intraventricular hemorrhage. (*Courtesy of* Satyan Lakshminrusimha; with permission.)

Circulation

After receiving only 8% of the cardiac output during pregnancy, the pulmonary circulation must increase at birth to 40% to 55% of the cardiac output. An unclamped umbilical cord allows the newborn to equilibrate blood volume, oxygen levels, and pH through ongoing placental exchange.[14,15] Closure of the umbilical arteries occurs later than previously thought,[16] whereas the remaining uterine contractions may help to squeeze additional blood through the umbilical vein.[17,18]

Timing of cord clamping

Extending the time of CC after birth results in an increase in placental transfusion (**Fig. 2**).[11,18]

Farrar and colleagues[13] estimated placental transfusion by measuring infant weight gain while the cord was left intact. The mean amount of placental transfusion was 81 mL or 25 mL/kg. In a randomized control trial (RCT), Chen and colleagues[19] compared 720 term neonates after CC within 15 seconds, by delayed CC of 30, 60, 90, 120, 150, 180 seconds, and when umbilical cord pulsations ceased (n = 90 in each group). With the increase in the timing of CC, neonatal hematocrit at 24 hours was gradually increased.[19]

Gravity and positioning of the infant immediately after birth

Gravity affects the amount of placental transfusion that an infant receives and is interrelated with time of CC.[20,21] Holding the infant above the level of the placenta (>10 cm) slows the placental transfusion, and lowering the infant accelerates it (**Fig. 3**).[20] Clamping the cord at 1 minute with the infant on the maternal abdomen may reduce the placental transfusion by 50%.

Mercer and Erickson-Owens[21] measured the RPBV after infants were placed skin to skin and showed that a 5-minute delay in CC allowed the infant who is skin to skin to receive significantly more placental transfusion than a 2-minute delay (**Fig. 4**).

In contrast, a recent study reported no difference in weight in infants weighed quickly at birth, then placed on the maternal abdomen or lowered, and then weighed again after a 2-minute delay in CC. Weight gain was only half of what was expected after delayed CC.[22] An interpretation of these results is that a full placental transfusion was not completed after 2 minutes in either position.

Cord pulsations

Two recent studies on midwifery practices in the Netherlands and Italy report that umbilical artery flow and pulsations continue longer than the previously thought 1 to 3 minutes after birth.[23,24] Boere and colleagues[16] used Doppler to measure the blood flow

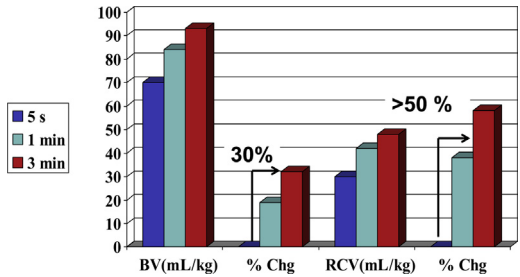

Fig. 2. Percentage change (% Chg) in blood volume (BV) and red cell volume (RCV) caused by delayed CC. *From* Yao, Lind, et al, "Distribution of Blood between Infant and Placental after Birth," Lancet, Oct 25, 1969. Used with permission of Elsevier, Inc.

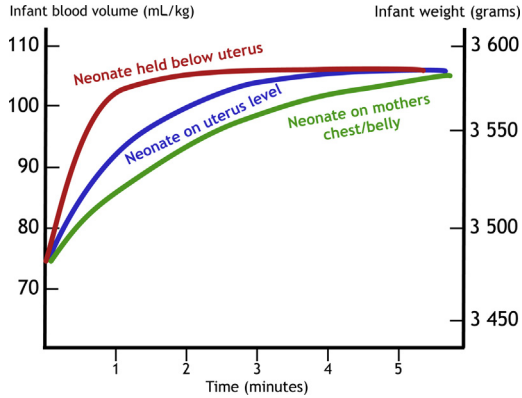

Fig. 3. The speed and volume of placental transfusion in relation to time and relative position of neonate in relation to the placenta. Conceptual model.

and pulsations in the umbilical cord after birth and before CC. Umbilical artery flow was registered for a mean of 4.22 minutes after birth. When cord was clamped at 6 minutes (Dutch midwifery practice), 43% still had umbilical artery flow that was pulsatile, from the infant to the placenta, and similar to the infant's heartbeat.[16,23] The conclusion was that umbilical blood flow is likely unrelated to cessation of pulsations and that using pulsations as a time point for CC should be reconsidered.

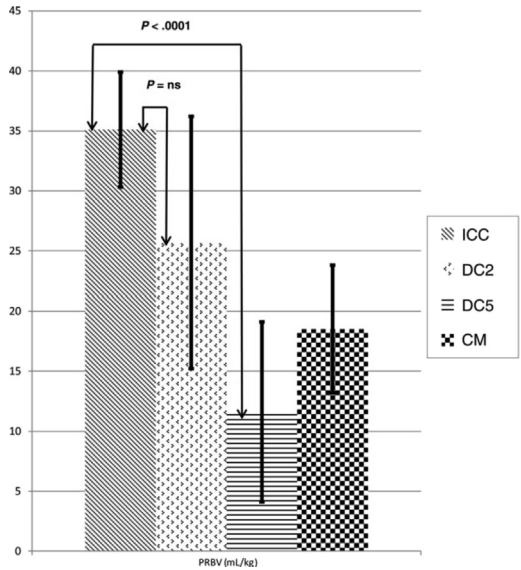

Fig. 4. The amount of blood left behind in the placenta (placental residual blood volume [PRBV]) when term infants are held skin to skin after birth. CM, umbilical cord milking 5 times; DC2, delayed cord clamping for 2 minutes; DC5, delayed cord clamping for 5 minutes; ICC, immediate CC. (*From* Mercer JS, Erickson-Owens DA. Rethinking placental transfusion and cord clamping issues. J Perinat Neonatal Nurs. Jul-Sep 2012;26(3):202-17; with permission.)

Di Tommaso and colleagues[24] reported that the median duration of palpated pulsation was 3.5 minutes (213 seconds). These 2 studies show that, for term infants, the ideal time of CC remains unknown but extends long after 1 minute. The end of palpable pulsations is likely not to be interpreted as cessation of placental transfusion.

What Cord Blood Contains

The residual placenta blood is body temperature and oxygenated with about 15 to 20 mL/kg of red blood cells, several million to a billion stem cells, and 10 to 15 mL/kg of plasma. The amount of iron provided by the placental transfusions is enough for a 3 to 8 months' supply for a term infant.[25] The large amount of stem cells represents an autologous transplant, which may reduce the infant's susceptibility to both neonatal and age-related diseases.[26]

Progesterone levels in term infants at birth are higher than the mothers' levels, and this high level may support the incorporation of the large volume of placental transfusion.[27] In addition, there are numerous cytokines, growth factors, and important messengers in cord blood that most likely support and drive the process of transition.[26–29] Recent research has shown associations between delayed CC and fewer oxidation reactions[30] as well as a decrease in cord blood lipids and an augmented antioxidant activity, which may moderate inflammatory-mediated effects induced during delivery.[31–33]

OBSTETRIC CONSIDERATIONS

Uterotonics and Uterine Contractions

Some investigators have raised concerns about giving uterotonics before CC. In a randomized controlled trial by Andersson and colleagues,[34] oxytocin was administered after 3 minutes and no negative effects were noticed. Vain and colleagues[35] recently reported that administration of intravenous oxytocin immediately after birth or after a 3-minute delay in CC did not alter the amount of placental transfusion received by term neonates born vigorous.

Cesarean Section

In planned/elective cesarean sections, 2 recent RCTs found increased hemoglobin level and hematocrit in the neonates after 60 seconds' delayed CC, without affecting maternal hemoglobin or blood losses.[36,37] In an observational study, Andersson and colleagues[38] found elective cesarean section combined with CC at 30 seconds resulted in higher iron stores at 4 months of age compared with early CC after vaginal birth. After a pilot trial, Chantry and colleagues[39] suggested CC can be delayed to 120 seconds during elective cesarean section without increased risk of excessive maternal blood loss. The authors conclude that it is safe and beneficial for neonates to clamp the umbilical cord after at 60 seconds in planned/elective cesarean sections.

CORD MILKING

Umbilical cord milking (UCM) at birth speeds up the process of providing a partial placental transfusion to a newborn and, although not physiologic, may provide a placental transfusion in infants that require immediate resuscitation.[40] McAdams and colleagues[41] reported a smaller blood volume with UCM compared with what is reported with a 3-minute delay (**Fig. 5**).

UCM is usually done by stripping the cord from placental end to the neonate over 2 seconds, releasing to allow refill and repeating 3 to 5 times. Studies on term infants show effects on short-term hematological outcomes from UCM comparable with

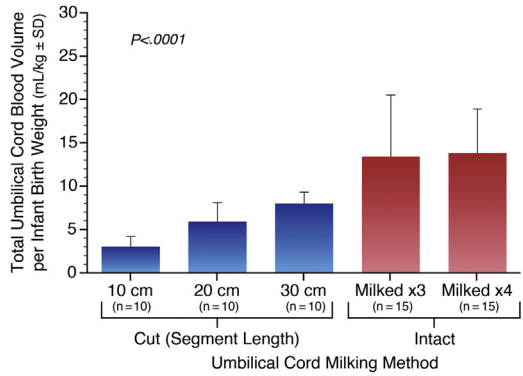

Fig. 5. Total milked cord blood volume per newborn birth weight. Total umbilical cord milked blood volume in relation to infant birth weight is compared between milked cord segments cut at different lengths (10, 20, and 30 cm) and intact cords milked either 3 or 4 times. (*From* McAdams RM, Fay E, Delaney S. Whole blood volumes associated with milking intact and cut umbilical cords in term newborns. J Perinatol. 2018;38(3):245-250; with permission.)

delayed CC without any apparent harm.[42] In contrast, in the more susceptible population of preterm infants, 1 large RCT and registry studies find increased intraventricular hemorrhage after UCM compared with delayed CC.[43–45]

MAJOR BENEFITS OF DELAYED CORD CLAMPING FOR TERM INFANTS

The major effects of delayed CC/placental transfusion on term infants are outlined in Fig. 6. Briefly, the placental transfusion increases hemoglobin level and hematocrit

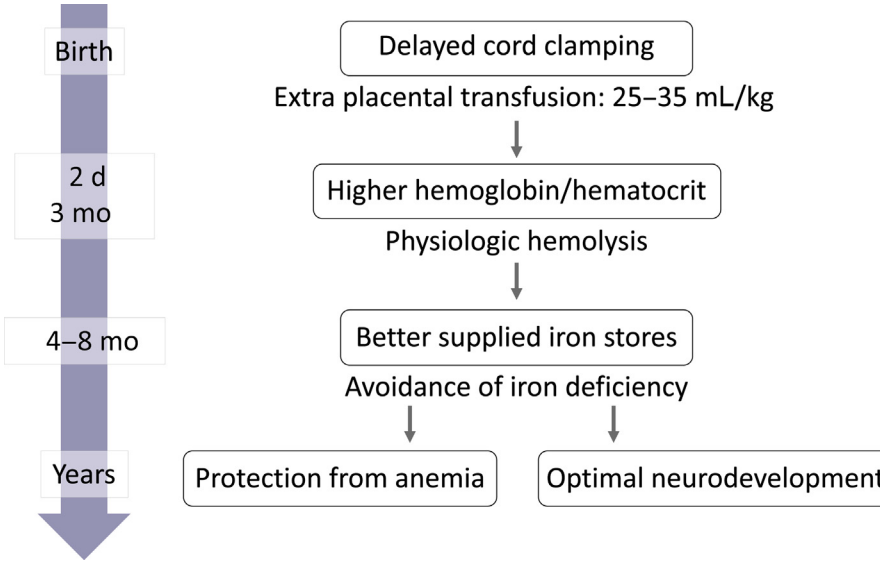

Fig. 6. The placental transfusion model.

within hours after delivery. Although physiologic hemolysis diminishes this effect on hemoglobin/hematocrit, iron stores are higher in infants with delayed CC.[2] A full placental transfusion increases iron stores for up to 8 months when CC is performed after 3 minutes.[46] This higher availability of iron helps to protect against anemia later in infancy.[3] Iron also provides substrate for an optimized neurodevelopment, including increased myelin content in the early developing brain up to 12 months of age and improved fine motor development and social behavior at 4 years of age.[5,6,47]

Ferritin and Iron Deficiency

Iron is mainly stored as ferritin in the body. Serum ferritin is considered an accurate indicator of body iron stores and is the most commonly used biomarker for identifying iron deficiency (ID).[46] In CC studies, ferritin level has been shown to be significantly higher at 3 to 8 months after birth, comparing CC before 1 minute with after 3 minutes.[2,3,10,48]

A higher ferritin level reduces the numbers of infants with ID, shown at 4 months in Sweden (from 6% to 0.6% of infants having ID), at 6 months in Mexico (from 7% to 1%), and at 8 months in Nepal (from 38% to 22%).[2,3,10,48]

Anemia

Anemia, or low hemoglobin content, leads to impaired oxygen delivery to the body's tissues, which in turn is associated with affected growth and cognitive development in children. Infant hemoglobin levels improved by 0.9 g/dL and anemia was significantly reduced at 8 months postpartum after introduction of a delayed-CC policy in a Peruvian hospital, resulting in an increase in CC timing from 57 seconds to 170 seconds.[49] In an RCT in Nepal, comparing early CC at less than 60 seconds with delayed CC after 180 seconds, anemia was reduced by 11% at 8 months, and by 9% at 12 months.[3]

Optimized Neurodevelopment

The late fetal period and postnatal period through the first 3 years of life are critical periods of rapid development for the brain.[47] Despite its high iron demand, the brain is not the highest-priority organ system for iron distribution because the red blood cells receive priority.[50] Neurodevelopmental studies in nonanemic term neonates as well as infants and toddlers show that ID causes neurodevelopmental abnormalities in brain circuits with high iron requirements. These abnormalities include reduced recognition memory, affect, and motor movements.[47]

Myelin

Iron also contributes to the maturation and functioning of the oligodendrocytes responsible for brain myelination. Myelination progresses rapidly during infancy and is essential for establishing brain connectivity and cognitive function.[47,51]

Mercer and colleagues[4,5] examined brain myelinization by MRI at 4 and 12 months of age in a study on 73 healthy term neonates randomized to either delayed CC (>5 minutes) or immediate CC (<20 seconds). At 4 and 12 months, infants with delayed CC had higher ferritin levels and greater myelin content in brain regions associated with motor, visual, and sensory processing/function. Developmental testing was not significantly different between the 2 groups.[5]

Development

Andersson and colleagues[52] also did not find any differences in neurodevelopment at 12 months of age after 3 minutes or immediate CC assessed by Ages and Stages Questionnaire (ASQ), second edition. However, they performed a longer-term follow-up at 4 years of age.[6] Delayed CC improved the ASQ personal-social and

fine motor domains, and the Strengths and Difficulties Questionnaire prosocial subscale. Fewer children in the delayed-CC group had results below the cutoff in the Movement ABC bicycle-trail task. The effect of delayed CC seemed to be more evident in boys, who also showed significantly improved processing-speed quotient in the Wechsler Preschool and Primary Scale of Intelligence test.[6]

Rana used the ASQ third edition to assess development in 332 out of originally 540 infants randomized to either delayed (>3 minutes) or early CC (<60 seconds) and found delayed CC to be associated with an improvement of the overall neurodevelopment, with the most pronounced effects in the communication and personal-social domains.[7]

A summary of the research on delayed CC in term infants is shown in **Fig. 6**.

ARE THERE RISKS ASSOCIATED WITH PLACENTAL TRANSFUSION?

The theoretic risks associated with placental transfusion are a potential increase in hyperbilirubinemia, symptomatic polycythemia, hypothermia, and delayed resuscitation. None of these risks have been shown to be substantial in current RCTs and observational studies (**Table 1**).

There is a widespread misconception that placental transfusion increases an infant's risk for hyperbilirubinemia, repeatedly reiterated in official guidelines,[53,54] mainly referencing a 2013 Cochrane Review, the results of which may be questioned (discussed later).[2]

Systematic Reviews

Two systematic reviews have evaluated jaundice, hyperbilirubinemia, and use of phototherapy in term infants with regard to CC.[2,55] Hutton and Hassan[55] could not find a significant difference between early and late CC. A pooled analysis of data from 8 trials (1009 infants) did not show an increased risk of developing neonatal jaundice associated with late CC.

In 2013, the latest Cochrane Systematic Review reported a significant increase of 1.7% for jaundice requiring phototherapy but no significant difference in clinical jaundice. Neither term is defined in the report. Seven trials with data for 2324 infants.[2]

Recent Studies on Cord Clamping

A summary of findings from recent studies regarding possible risks associated with delayed CC is presented in **Table 1**.[12,19,56–65] No study reported any differences in hypothermia or respiratory distress between delayed and early CC groups.

Mercer and colleagues[12] reported more infants in the delayed-CC group needing phototherapy by intention-to-treat analysis, whereas analysis by actual treatment revealed that there were 2 infants in each group who received phototherapy during hospital stay without differences in peak total serum bilirubin levels or symptomatic polycythemia between the groups.[12]

Rincón and colleagues[60] observed an increase in the number of cases of blood hematocrit greater than 65% in the group with delayed CC after 3 minutes, but no symptomatic polycythemia was reported.

In the light of recent studies, our conclusion is that the risk of jaundice, hyperbilirubinemia, and need of phototherapy is much exaggerated, and rests on invalid conclusions mainly from an unpublished study performed more than 20 years ago. It has become a habit to refer to this risk in recent guidelines, but the authors implore future writers of guidelines to evaluate the evidence before repeating this warning. As for polycythemia, it may be unavoidable to detect an increased occurrence of this as

Table 1
Findings on possible risks of delayed cord clamping in the most recent meta-analyses and studies published after those

	Hyperbilirubinemia	Phototherapy	Hematocrit>65%	Symptomatic Polycythemia
Systematic Review/Meta-analyses				
Hutton & Hassan,[55] 2007	0	0	+	0
McDonald et al,[2] 2013	—	+	0	—
Randomized Trials				
Salari et al,[56] 2014 (n = 56, 180 s vs <10 s)	—	—	0	—
Nesheli et al,[57] 2014 (n = 60, 50–60 s vs ICC)	0	—	0	—
Mercer et al,[12] 2016 (n = 73, ≥5 min vs <20 s)	0	+	+	0
Chen et al,[19] 2018 (n = 720, within 15 s, by 30, 60, 90, 120, 150, or 180 s, or pulsation ceased)	0	0	—	—
Rana et al,[7] 2019 (n = 524, >60 s vs 180 s)	0	0	—	—
Mohammad et al,[59] 2021 (n = 128, 90 s vs <30 s)	0	—	—	—
Nonrandomized Studies				
Rincón et al,[60] 2014 (n = 80, <1 min; n = 31, 1–2 min; and n = 131, 2–3 min)	0	0	+	—
Ertekin et al,[61] 2016 (n = 150, at 90–120 s vs <30 s)	0	0	—	—
Yang et al,[62] 2019 (n = 424, >60 s vs early CC)	+[a], 0[b]	0	—	—

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Table 1
(continued)

	Hyperbilirubinemia	Phototherapy	Hematocrit>65%	Symptomatic Polycythemia
Qian et al,[63] 2020 (n = 949, 30–120 s: 3 subgroups [30–60 s, 61–90 s, 91–120 s] vs n = 1005, <15 s)	0	—	+[c], 0[d]	—
Shinohara & Kataoka,[64] 2020 (n = 1211, DCC unspecified)	0	0	—	—
Carvalho et al,[65] 2019 (n = 117, <1 min; n = 228, between 1 and 3 min; and n = 53, >3 min)	0	0	0	—

Abbreviations: DCC, delayed CC; ICC, immediate CC.
[a] Serum.
[b] Transcutaneous.
[c] First day.
[d] Second and third day.

defined, because the placental transfusion increases hemoglobin content and hematocrit in the blood of neonates after birth. To date, no "symptomatic" polycythemia or hyperviscosity syndrome has been reported in the literature to our knowledge.

Conditions Associated with Risk

Small for gestational age and large for gestational age

Although polycythemia is more prevalent in small-for-gestational-age (SGA) as well as large-for-gestational-age (LGA) neonates, in the latter group especially with diabetic mothers,[66] current studies on delayed CC do not report concern for symptomatic polycythemia. In a South African cohort of 104 term newborns with a subnormal distribution of birth weight (39% had a birth weight <2500 g), neither hyperbilirubinemia nor hyperviscosity was observed.[67] In an RCT, Chopra and colleagues[68] reported that delayed CC improved iron stores in SGA infants greater than or equal to 35 weeks at 3 months of age without increasing the risk of symptomatic polycythemia at birth, the need for partial exchange transfusions or morbidities associated with polycythemia. A prospective randomized study on 51 term LGA infants, with 13 (25%) having a mother with diabetes mellitus, found similar rates of polycythemia and levels of bilirubin.[69]

Alloimmunization

An increased rate of hemolysis, as is present in blood group incompatibility (alloimmunization) between the mother and fetus, is associated with higher prevalence of

hyperbilirubinemia and jaundice. A few studies have examined the effects of delayed CC in patients with alloimmunization. Garabedian and colleagues[70] studied 72 neonates with fetal anemia caused by Rh incompatibility and reported decreased exchange transfusion needs, improved hemoglobin level at birth, and longer delay between birth and first transfusion, with no severe hyperbilirubinemia after delayed CC. In a retrospective study on 336 cesarean-delivered term and late preterm neonates with ABO alloimmunization, Ghirardello and colleagues[71] reported that delayed and immediate CC had similar bilirubin levels at newborn screening, but immediate CC received a mean of 28 hours of phototherapy compared with 19 hours in the delayed-CC group, whereas delayed CC was associated with more phototherapy and longer time to discharge. Sahoo and colleagues[72] studied 70 Rh-alloimmunized infants after delayed or early CC in an RCT. Hematocrit was higher after 2 hours in the delayed-CC group, whereas there were no differences in the incidence of exchange transfusion or phototherapy.

Human immunodeficiency virus

The risk of virus transmission when the mother is infected with human immunodeficiency virus (HIV) has been studied on 64 mothers and their infants. Delayed CC 2 minutes after birth was not associated with any virus transmission and reduced the risk of neonatal anemia without any differences in polycythemia or need of phototherapy.[73]

INTACT CORD RESUSCITATION

As studies have shown improved outcomes on preterm as well as vigorous term infants after delayed CC, the concept of performing resuscitation with an intact cord has gained scientific interest. The rational is simple and is shown in **Fig. 7**. In addition to the placental transfusion, there is a possibility for the neonate to exchange carbon dioxide and oxygen while the placenta is still attached to the uterus.[17]

Midwives have used this approach for centuries and are inclined to practice intact cord resuscitation (ICR) at birth centers and planned home births.[74] Experience-derived knowledge is that neonates continue to receive placental support during the immediate transition, including when resuscitation is needed.[75]

Since 2013, animal studies have shown loss of preload and decrease in cardiac output producing bradycardia and disturbances in blood flow to the cerebral, visceral, and pulmonary circulation if CC is performed before ventilation.[76–78] Recently, a prolonged CC (10 minutes) in lambs after hypoxia-induced asystole was shown to significantly reduce postasphyxial rebound hypertension while normalizing cerebral blood flow and cerebral oxygenation.[15]

The concept of ICR to reduce further injury in term infants has been explored in a few pilot and/or feasibility trials. Katheria and colleagues[79] compared pregnancies at risk for resuscitation (n = 30 per group) in an RCT comparing 1 minute and 5 minutes of CC. The need for resuscitation was 63% in the 1-minute group and 43% in the 5-minute group. The 5-minute group had greater cerebral oxygenation and blood pressure at 12 hours of life.[79]

In a before-and-after design (n = 20 in each group), effects of ICR in neonates with congenital diaphragmatic hernia was studied. ICR resulted in higher pH and significantly lower plasma lactate concentration. Mean blood pressure was significantly higher 1, 6, and 12 hours after birth in the ICR group.[80] In another study on ICR and congenital diaphragmatic hernia, hemoglobin level and mean blood pressure at 1 hour of life were significantly higher in trial participants (n = 19, CC at 3 minutes) than historical controls.[81]

In an Australian feasibility trial, 44 vigorous infants ($\geq$32 weeks) were enrolled and received greater than or equal to 2 minutes of delayed CC. It was feasible to provide

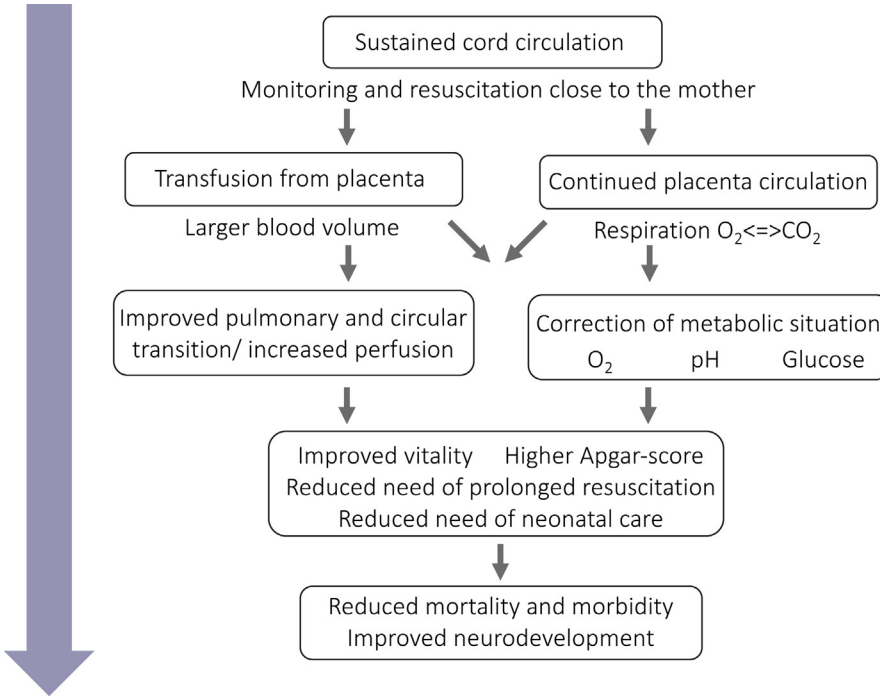

Fig. 7. Effects of intact cord resuscitation with sustained cord circulation.

resuscitation to term and near-term infants during delayed CC, after both vaginal and cesarean births.[82]

The largest RCT to date on ICR, Nepcord III, was performed on neonates born vaginally at 35 weeks' gestational age or more randomized before delivery to ICR for 3 minutes (n = 134) or immediate CC (n = 97) and resuscitation.[83] Oxygen saturation and Apgar score were significantly higher in the ICR group at 1, 5, and 10 minutes. Newborn infants in the ICR group started to breathe and established regular breathing earlier than in the early-CC group.[83]

These studies provide new and important information on the effects of resuscitation with an intact cord. Newborns had improved oxygenation and higher Apgar score, and negative consequences were not recorded, similar to findings in preterm infants.[84] The model of ICR is very simple, cost neutral, and likely easily implemented, although with the possibility of almost surprisingly high impact on neonatal outcome.[85]

Nuchal Cord, Shoulder Dystocia, and the Cardiac Asystole Theory

During labor, and especially the second stage, the umbilical venous flow may be impeded by compression either because of a nuchal cord or pressure on the infant's body (occult cord), especially those infants at risk for shoulder dystocia. This condition causes blood to be sequestered in the placenta and can lead to severe hypovolemia at birth if the cord is clamped and cut immediately. The cardiac asystole theory suggests that, when this occurs, the pressure on the fetus in the birth canal functions like an antishock garment and helps to maintain central perfusion, keeping a normal pulse and blood pressure even when the blood volume is low.[86,87] At birth, the sudden

release of pressure acts like a fast removal of the antishock garment, and the central blood volume flows rapidly into the peripheral circulation. This sudden and severe lack of central perfusion can result in hypovolemic shock and even asystole.[87–90]

Nuchal cord

Cutting a tight nuchal cord before birth can result in reduction in blood volume (60 mL of blood), resulting in hypovolemia and neonatal anemia.[91,92]

To restore blood volume after a nuchal cord, the Somersault maneuver is recommended (**Fig. 8**).[91] It involves somersaulting the body so that the infant's feet end up toward the mother's feet. The cord can then be unwrapped from the neck to preserve the integrity of the cord to allow for care at the perineum to avert hypovolemia from the blood sequestered in the placenta.[91,93]

Shoulder dystocia

Shoulder dystocia also places an infant at risk for hypovolemia, which may account for the poor condition of these infants at birth: worse than would be anticipated from shoulder dystocia alone.[94] Several cases, with and without nuchal cord, are found in the literature. Cases report head-to-shoulder birth times of 3 to 7 minutes, no prior evidence of fetal distress, asystole immediately after birth, poor Apgar scores, brain damage, and death. Iffy and Varadi[95] reported on 9 cases of shoulder dystocia with a nuchal cord cut before the birth, with 76% developing cerebral palsy. Five recently reported cases confirm these findings. Menticoglou and Schneider[89] present 2 fatal cases of asystole after shoulder dystocia. Heartbeats returned only after volume was administered, but the infants had profound brain damage and the babies did not survive. Cesari and colleagues[90] present a fatal case (after 35 minutes of resuscitation) where labor was uneventful, fetal heart rate tracing was normal until delivery, and resolution of the shoulder dystocia took less than 5 minutes. Two other cases were recently published by Ancora and colleagues,[88] of infants asystolic after delivery,

Somersault maneuver. The summersault maneuver involves holding the infant's head flexed and guiding it upward or sideways toward the pubic bone or thigh, so the baby does a "somersault," ending with the infant's feet toward the mother's knees and the head still at the perineum.

1. Once the nuchal cord is discovered, the anterior and posterior shoulders are slowly delivered under control without manipulating the cord.
2. As the shoulders are delivered, the head is flexed so that the face of the baby is pushed toward the maternal thigh
3. The baby's head is kept next to the perineum while the body is delivered and "somersaults" out.
4. The umbilical cord is then unwrapped, and the usual management ensues.

Fig. 8. Somersault maneuver. (*From* Mercer JS, Skovgaard RL, Peareara-Eaves J, Bowman TA. Nuchal cord management and nurse-midwifery practice. J Midwifery Womens Health. Sep-Oct 2005;50(5):373-9; with permission.)

with near-normal cord pH but very low pH on blood gas analysis obtained within 1 hour of life. The practice of immediate CC in such infants is harmful because it puts the newborn at risk for hypovolemic sequelae and death.[87]

Stem Cells

Cord blood is particularly rich in hematopoietic as well as nonhematopoietic stem cells, such as mesenchymal, unrestricted somatic, multilineage progenitor, embryoniclike, and oligodendrocyte progenitor cells.[28] Stem cells secrete neurotropic factors, growth factors, and cytokines, prevent cell death, decrease microglial activation, engraft and differentiate, and promote endogenous stem cell self-renewal.[96] They are part of the body's innate healing system.[26] Damaged tissue releases cytokines, which signal stem cells to travel to the damaged area and begin the healing process. Animal studies have shown that human umbilical cord blood stem cells help to heal almost any inflicted damage no matter how they are administered.

When infants receive the placental blood at the time of birth, they receive stem cells that are in the perfect medium along with the many cytokines, proangiogenic and anti-apoptotic messengers, and growth-stimulating factors. Tolosa and colleaues[97] argue that "artificial loss of stem cells at birth could … predispose infants to diseases such as chronic lung disease, asthma, diabetes, cerebral palsy, infection, and neoplasm." When stem cells are given at later times, finding the appropriate medium is a major obstacle confronting stem cell therapies, especially when attempting proliferation of stem cells and translation of successful animal studies to humans.[98]

Cord Blood Banking

Cord blood banking involves collecting and storing umbilical cord blood after birth either in public banks or private banks. Stem cell therapy derived from cord blood can benefit individuals with selective genetic conditions, blood disorders, and cancers. However, as more studies show significant benefits to infants from placental transfusion and professional statements recommend delayed CC, ethical issues around cord blood banking become more prescient. The initial autologous autotransfusion that occurs with placental transfusion preserves all components of the residual placental and cord blood for the infant. Clinical trials examining administration of autologous stem cells to children for such conditions as autism, type 1 diabetes, hypoxic-ischemic encephalopathy, and cerebral palsy have not shown the expected improvements.[99,100]

The American College of Obstetricians and Gynecologists states that routine use of private cord blood banking is not supported by available evidence and should not alter routine practice of delayed umbilical CC, with the rare exception of medical indications for directed donation.[101] Parents should be fully informed before consenting to cord blood banking or donation.[102]

PRACTICE

At a normal birth, the provider can place the infant skin to skin, dry and cover the infant with a warm blanket, and leave the umbilical cord intact until the placenta is ready to deliver. Because blood flow continues after pulsations are palpable,[16] it is better to wait until the cord becomes pale, white, and flat and looks obviously emptied. This stage may or may not happen in 3 minutes and, if not, waiting longer is advised. Avoid tension on the cord because this is thought to cause the vessels to spasm and obstruct blood flow.

One caveat is that only infants with good tone should go immediately onto the maternal abdomen. When an infant has poor tone or is slow to start, the infant can

be placed on a clean pad at the perineum if the bed is intact, held below the level of the placenta or placed on a cart or trolley placed close to the mother. Preliminary studies suggest that resuscitation can proceed but at the perineum (with an intact cord), rather than on the warmer.[79,83,103] Once the infant is breathing and tone is regained, the infant can be placed skin to skin.[104] It should not be assumed that, because the infant is now breathing, the blood volume has returned to normal: leave the cord intact a longer time for these infants. This method of resuscitation has been practiced for many years in out-of-hospital settings.[74,105,106]

As mentioned previously, if a baby has a nuchal cord or shoulder dystocia and looks floppy and pale and is not breathing, do not cut the cord but instead allow the baby to reperfuse with any resuscitation methods as needed. In the recently published American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, it is recommended that it may be reasonable to delay CC for longer than 30 seconds in term infants who do not require resuscitation at birth.[107] The authors find this recommendation surprisingly unaware of the body of evidence on long-term positive effects of delayed CC, predominantly based on a CC after 180 seconds. For term infants in need of resuscitation, the statement has not changed from the 2015 recommendations.[108]

Cord Gas Collection

Cord gases provide a method to measure the metabolic status of the neonate at birth. It is suggested that the sample be drawn from a double-clamped segment of the umbilical cord and implies immediate CC.[109] The practice of placental transfusion and the collection of umbilical cord blood gases are not necessarily mutually exclusive. Nudelman and colleagues[110] performed a systematic review on 5 studies where blood gases were acquired after delayed CC up to 120 seconds. This delay had either no or only a small and not clinically significant effect on cord blood gas values. In Sweden, blood gases are drawn routinely from the intact, pulsating cord (**Fig. 9**). Andersson and colleagues[34] report this practice in an RCT, showing a preserved placental transfusion and comparable blood gas values.

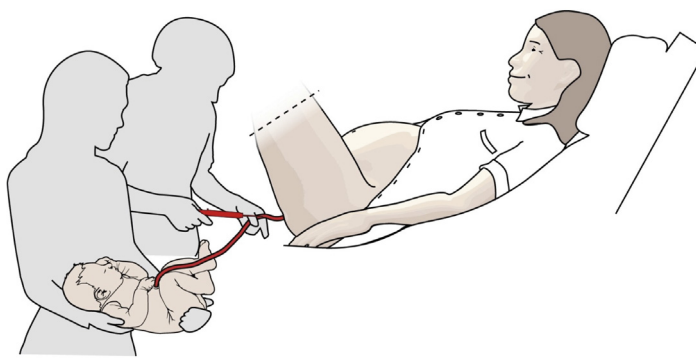

Fig. 9. Blood gas sampling from an unclamped umbilical cord. (*From* Andersson O, Hellstrom-Westas L, Andersson D, Clausen J, Domellof M. Effects of delayed compared with early umbilical cord clamping on maternal postpartum hemorrhage and cord blood gas sampling: a randomized trial. Acta Obstet Gynecol Scand. May 2013;92(5):567-74; with permission.)

CURRENT AND FUTURE RESEARCH ON PLACENTAL TRANSFUSION

Term infants gain ~80 to 100 mL of blood by delayed CC after at least 3 minutes when held at the level of the perineum or placed on the mother's abdomen.[11,13] However, the normal mechanisms of birth, including how umbilical cord circulation is regulated and ended after delivery, are not fully known or understood.

Trials on ICR in term infants are important, to ensure safety, as well as to establish possible long-term effects. Because term infants needing resuscitation are often not identifiable before birth, research involves enrolling large numbers of women before or during labor is an expensive, difficult, and ethically challenging task. A full-scale study in Sweden is expected to include at least 8000 deliveries to yield 600 neonates in need of resuscitation (NCT04070560). Alternatives, such as obtaining a waiver for randomization before enrollment, would make these trials more cost-effective to run. However, waivers for randomization before enrollment are difficult to obtain from institutional research boards because ethics are questioned by some for this method.[111] One trial on cord milking times 4 compared with immediate CC for infants needing resuscitation has been successful in obtaining waivers (NCT03631940).

For the study of rare events such as resuscitation of term infants, case, cohort, and epidemiologic studies, and quality improvement projects are essential and need consideration and the best level of evidence. Preplanning and careful coordination of staff are essential for success.[103,112] A few studies have evaluated parents and staff perceptions of ICR, whereas more research in different contexts and on broader outcomes is needed.[113–115]

For future studies, the authors urge researchers to use bilirubin levels rather than the subjective designation of jaundice or use of phototherapy. Use of a risk tool such as the Bhutani Nomogram for designation of hyperbilirubinemia allows a more objective quantification of levels of risk in comparing 2 groups of infants over time.[116,117] Because intention-to-treat analyses are designed to show the compliance with the protocol, we recommend that results also be analyzed by sensitivity analyses to allow the reader to see the actual effect of delayed CC on hyperbilirubinemia.

Best practices

What is the current practice?

Umbilical CC in term infants

Best practice/guideline/care path objectives

- Vaginal deliveries
  - In vigorous infants, clamp the umbilical cord after 30 to 60 seconds or later
  - In neonates requiring resuscitation, clamp the umbilical cord as soon as possible and transport the neonate to a warmer for resuscitation measures
- Cesarean deliveries
  - Clamp the umbilical cord as soon as possible

What changes in current practice are likely to improve outcomes?

- Allowing for a full placental transfusion by waiting to clamp the umbilical cord until it turns pale (>180 seconds)
- Initiating ventilation during resuscitation while there is an intact umbilical cord circulation
- Providing placental transfusion and smooth transition also to neonates born by cesarean section

Major recommendations

- Vaginal deliveries

- In vigorous infants, clamp the umbilical cord after the umbilical cord turns pale (at least 180 seconds)
- In neonates requiring resuscitation, perform resuscitation measures with an intact umbilical cord (in a research setting)

- Cesarean deliveries
  - Clamp the umbilical cord after 60 seconds or perform resuscitation measures with an intact umbilical cord (in a research setting)

Summary statement

Allowing for an intact cord circulation and full placental transfusion provides a facilitated transition, reduces ID early in infancy, and is associated with improved myelinization and neurodevelopment up to 4 years of age.

Data from Mercer JS, Erickson-Owens DA, Deoni SCL, et al. The Effects of Delayed Cord Clamping on 12-Month Brain Myelin Content and Neurodevelopment: A Randomized Controlled Trial. Am J Perinatol. Jul 21 2020;(EFirst)https://doi.org/10.1055/s-0040-1714258; Andersson O, Lindquist B, Lindgren M, Stjernqvist K, Domellof M, Hellstrom-Westas L. Effect of Delayed Cord Clamping on Neurodevelopment at 4 Years of Age: A Randomized Clinical Trial. JAMA Pediatr. Jul 2015;169(7):631-8. https://doi.org/10.1001/jamapediatrics.2015.0358; Katheria AC, Lakshminrusimha S, Rabe H, McAdams R, Mercer JS. Placental transfusion: a review. J Perinatol. Feb 2017;37(2):105-111. https://doi.org/10.1038/jp.2016.151.

SUMMARY

Placental transfusion is an essential part of the birthing process. The enhanced blood volume provided by an intact cord circulation is involved in interactions with all organ systems to help postdelivery adaption and support the complexity of internal stability during transition.[118] Considering the many interactions in the infant's attempt to regain and maintain homeostasis during transition and placing an emphasis on the effects of an intact cord circulation may help clinicians make further advancements in the prevention and treatment of conditions such as hypoxic-ischemic encephalopathy, bronchopulmonary dysplasia, and neurodevelopmental injury for infants of all gestational ages.

CLINICS CARE POINTS

- Keep the umbilical cord intact for at least 3 minutes or until the cord is flat and white.
- Placental transfusion allows for transfer of the infant's blood volume from the placenta to the infant's body, lungs, and other vital organs.
- Uterotonics may be used at the provider's discretion before, during, or after cord clamping.
- Avoid cutting a nuchal cord before birth - allow infants with nuchal cord and/or shoulder dystocia time to reperfuse via an intact cord after birth.
- Keep infants with poor tone at the level of the perineum.
- Learn how to collect cord blood gases from an intact cord when necessary.
- Resuscitation with an intact cord offers an infant continued placental circulation and oxygenation, improved transition, higher Apgar scores and oxygen saturation at 10 minutes of life but requires a conscious paradigm shift.
- Providing a placental transfusion is an interdisciplinary issue: therefore midwifery, obstetrics, neonatology/pediatrics, and nursing need to collaborate on education and quality improvements to increase utilization of optimal cord management.

DISCLOSURE

The authors have nothing to disclose.

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