Evidence-Based Practices for the Fetal to Newborn Transition

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Many common care practices during labor, birth, and the immediate postpartum period impact the fetal to neonatal transition, including medication used during labor, suctioning protocols, strategies to prevent heat loss, umbilical cord clamping, and use of 100% oxygen for resuscitation. Many of the care practices used to assess and manage a newborn immediately after birth have not proven efficacious. No definitive outcomes have been obtained from studies on maternal analgesia effects on the newborn. Although immediate cord clamping is common practice, recent evidence from large randomized, controlled trials suggests that delayed cord clamping may protect the infant against anemia. Skin-to-skin care of the newborn after birth is recommended as the mainstay of newborn thermoregulation and care. Routine suctioning of infants at birth was not been found to be beneficial. Neither amnioinfusion, suctioning of meconium-stained babies after the birth of the head, nor intubation and suctioning of vigorous infants prevents meconium aspiration syndrome. The use of 100% oxygen at birth to resuscitate a newborn causes increased oxidative stress and does not appear to offer benefits over room air. This review of evidence on newborn care practices reveals that more often than not, less intervention is better. The recommendations support a gentle, physiologic birth and family-centered care of the newborn. J Midwifery Womens Health 2007;52:262–272 © 2007 by the American College of Nurse-Midwives.

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INTRODUCTION

The transition from fetus to newborn is a normal physiologic and developmental process—one that has occurred since the beginning of the human race. Many hospital routines that are used to assess and manage newborns immediately after birth developed because of convenience, expediency, or habit, and have never been validated. Some practices are so ingrained that older traditional practices, such as providing skin-to-skin care or delaying cord clamping, must be considered "experimental" in current studies.[1] However, recent research is beginning to identify some older practices that should not have been abandoned and some current practices that should be stopped. In order to achieve a gentle, physiologic birth and family-centered care of the newborn, practices that might interfere with maternal and newborn bonding need to be closely scrutinized. This article examines the evidence about practices related to the newborn transition, including the effects of various drugs used labor, umbilical cord clamping, thermoregulation, suctioning, and resuscitation of the newborn.

EFFECT OF MATERNAL ANALGESIA ON NEWBORN TRANSITION

Most analgesic agents commonly used to alleviate labor pain readily transfer to the fetus via the placenta. Usually, the effects of the analgesic agents are subtle, as most full term infants transition easily from fetus to newborn. However, some specific medications have the potential to disturb normal neonatal transition.[2]

Although there is a large body of literature on the various effects of analgesic agents, the reports of neonatal outcomes are often incomplete or inconclusive. The ethical and practical implications of assigning women to various pain management modalities make randomized control trials (RCTs) on pharmacologic management of labor pain and its effect on the neonatal transition difficult to conduct.

A comprehensive literature review (English only) using a combination of search terms (maternal analgesia, effects on newborn, newborn transition, labor drugs, newborn, epidural, first 4 hours, and neonatal outcomes) resulted in three Cochrane Reviews,[3–5] nine systematic reviews (includes RCTs and other types of studies),[6–14] six RCTs,[15–20] a case control study,[21] a retrospective cohort study,[22] and three observational studies.[23–25] These studies compared types of parenteral opioids (dosages, route of administration, and co-drugs), epidural versus parenteral opioids, epidural versus combined spinal–epidural analgesia, epidural dosing (traditional vs. light), and parenteral opioids versus epidural analgesia versus no analgesia. Neonatal outcomes in these studies include Apgar scores, umbilical cord pH, respiratory depression, neonatal sepsis evaluation, breastfeeding success, neurobehavioral effects, and admission to a neonatal special care unit.

Apgar Scores and Umbilical Cord pH

Most studies report no effect of analgesic agents (parenteral opioids or epidurals with local anesthetics, with or without opioids) on Apgar scores or umbilical cord pH values.[6,11,13,14,17,20] One systematic review[9] of RCTs

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and well designed prospective cohort studies found that newborns exposed to parenteral opioids (5 trials, N = 2015 infants) had a higher incidence of 1-minute Apgar score < 7 compared to newborns exposed to epidural analgesia. However, at 5 minutes, the Apgar scores did not differ significantly (6 trials, N = 2545).

In a Cochrane review by Anim-Somuah et al.,[4] newborns exposed to epidural analgesia had a decreased risk of having an umbilical cord pH < 7.2 compared to newborns whose mothers had nonepidural analgesia. However, there was no significant difference between groups in 5-minute Apgar scores. Findings from the PEOPLE study, a multicenter RCT (N = 1862), which examined delayed pushing and prolonged second stage of labor in primigravidas with continuous epidural analgesia, found lower umbilical cord pH (<7.15 venous or <7.10 arterial; RR, 2.45; 95% CI, 1.35–4.43) in the newborns whose mothers delayed the start of pushing as compared to the control group who began pushing at the start of second stage.[26] Yet, no newborns in the delayed pushing group had any sign of perinatal asphyxia as measured by the Neonatal Morbidity Index. These data suggest that Apgar scores and umbilical cord pH are common gross measures of newborn well-being that may not adequately assess the subtle effects of maternal analgesic agents on the newborn.

Respiratory Depression

Morphine, meperidine (Demerol; Sanofi-Aventis, Bridgewater, NJ), and fentanyl are the opioids that have been studied the most in labor analgesia research. These opioids, as well as newer alternatives, such as nalbuphine (Nubain; Endo Pharmaceuticals, Chadds Ford, PA) and butorphanol (Stadol; Bristol-Meyers Squibb, New York, NY), have been associated with newborn respiratory depression. However, there is insufficient evidence to clarify the relationship between medication dosage and respiratory depression at birth. Opioids are known for their high lipid solubility, which allows rapid transfer of the drug through the placenta and into the fetus. The risk of respiratory depression is highest if birth occurs at the time of peak fetal uptake—between 1 and 4 hours after administration of drug to the mother.[27]

Naloxone (Narcan; Endo Pharmaceuticals) is currently used in clinical practice to reverse respiratory depression following administration of opioids. One systematic review reported that naloxone administration to the newborn is more common when parenteral opioids and patient-controlled opioid analgesia is used, compared to epidural analgesia.[9,18,19] Another review found no differences in naloxone use between types of analgesia.[6] Many of the studies included were too small to draw conclusions for clinical practice recommendations. Naloxone should not be given routinely at the time of birth.[8]

Neonatal Sepsis Evaluation

Lieberman and O'Donoghue[11] found that epidural use was associated with a higher incidence of maternal fever and subsequent neonatal sepsis evaluation. However, Capogna[7] suggested that, while the number of neonates receiving sepsis evaluations varies between institutions, there is no evidence that epidural exposure increases the incidence of neonatal sepsis.

Breastfeeding

There has been a longstanding concern about the negative impact of labor analgesic agents on breastfeeding success. Analgesic effects are known to include suckling inhibition, delay in the establishment of breastfeeding, decreased neonatal alertness, and diminished neurobehavioral function.[6,12] However, most of these effects were noted in observational studies that were published more than 30 years ago.

In a review[10] of two prospective cohort studies done more recently (N = 2364), there was no correlation between breastfeeding success and use of either parenteral opioids or epidural/spinal analgesia during labor. Capogna[7] reports that "theoretically," the types and amount of epidural analgesia may affect breastfeeding success, but suggests early maternal infant bonding may have a greater effect on breastfeeding than does the type of maternal analgesic agent used during labor. The results of a small observational study (N = 28) revealed that neonates not exposed to pain medication exhibited an important prebreastfeeding behavior (spontaneously moving towards the breast and massaging the mother's nipple), which is believed to contribute to suckling.[23] Newborns (n = 12) in the first 120 minutes after birth, exposed to either intravenous (IV) meperidine, epidural with local anesthetic, or a combination of both had increased amounts of crying and a delay in developing breastfeeding behaviors.[23] In a study of 129 infants, Riordan[24] found that fetal exposure to labor analgesia agents (IV opioids or epidural or IV opioids plus epidural) diminished early suckling but did not effect duration of breastfeeding through 6 weeks.

Radzyminski[25] observed no difference in breastfeeding behaviors when comparing neonates exposed to ultra–low dose anesthetics via labor epidurals (n = 28) to neonates with no exposure to pain medication (n = 28).

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Beilin[16] reported that women (n = 58) who received an epidural with high dose fentanyl (>150 mcg) had more difficulty breastfeeding in the first 24 hours compared to women (n = 59) with either an intermediate dose (1–150 mcg) or no fentanyl (n = 60), although the difference did not reach statistical significance. Yet, at 6 weeks postpartum, a greater number of the women in Beilin's high-dose fentanyl group were no longer breastfeeding. In a retrospective cohort study (N = 99), Volmanen[22] found that more women who had an epidural in labor described not having enough milk when compared to women without an epidural (15 vs. 6, P = .006) in the first 12 weeks postpartum. Lieberman and O'Donoghue[11] caution in their systematic review that further study is needed to evaluate breastfeeding success rates with the use of epidural analgesia.

Early Neurobehavioral Effects

Studies of the effect of maternal analgesic agents on early neonatal neurobehavior showed minimal differences in the neurobehavioral scores of newborns exposed to epidural opioids versus newborns exposed to parenteral opioids.[11] Even results comparing epidural-exposed newborns to newborns with little or no medication exposure did not show a clear difference between groups. Beilin found lower neurobehavioral scores in newborns exposed to high versus low (or none) dose fentanyl (>150 mcg) epidurals.[16] Intravenous fentanyl just before spinal anesthesia for elective cesarean birth had no impact on neurobehavioral scores.[15]

Admission to a Neonatal Intensive Care Unit

No differences were found in neonatal intensive care unit (NICU) admissions of infants exposed to epidural versus nonepidural or no analgesia in labor[4] or in comparing epidural and combined spinal–epidural analgesia.[3] Exposure to maternal analgesia does not appear to increase an infant's risk for admission to the NICU.

In summary, the current evidence on the safety of maternal analgesia (parenteral opioids or epidural or combined epidural/spinal) and the effects on the neonate are limited, and at times confusing, making it difficult to draw conclusions for clinical practice. Newborns not exposed to any labor analgesic agents appear to exhibit important prebreastfeeding behaviors necessary for successful suckling sooner than analgesia-exposed newborns, but the effects of labor analgesic agents on early suckling and breastfeeding duration is unclear. The long-term impact of neurobehavioral effects from maternal analgesia is uncertain. Future studies must look beyond gross measures, such as Apgar scores and umbilical cord pH, and focus on long-term neonatal outcomes, such as attachment, breastfeeding duration, and neurobehavioral effects.

THE TIMING OF UMBILICAL CORD CLAMPING

Currently, no formal guidelines about the best timing for umbilical cord clamping exist. Clamping the cord immediately after birth results in a 20% reduction in blood volume for the neonate and up to a 50% reduction in red cell volume.[28] Several RCTs have indicated that more infants who experience immediate clamping have anemia of infancy compared to infants who had delayed clamping (Table 1). A number of studies have related anemia of infancy, even when treated with iron, with less favorable neurodevelopmental and behavioral outcomes up to age 10.[29] There are no studies of immediate or delayed cord clamping that follow children beyond 6 months of age.

Immediate Cord Clamping and Anemia

Since the publication of the last review of the literature on umbilical cord clamping,[30] one systematic review[31] and four additional RCTs involving term infants[32–35] have been published. The four studies, whose subjects included 827 mother–infant pairs, were all conducted in resource-poor countries over the last 4 years. All included women at term with no medical or obstetric complications. Although the findings of each study are slightly different, they all found higher newborn hematocrit and hemoglobin levels within the first 24 hours after birth without adverse outcomes in the infants who experienced delayed cord clamping. Two of the studies found significantly fewer signs of anemia at 3 and 6 months in infants with delayed cord clamping. Synopses of the four studies can be found in Table 1. The systematic review is discussed below.

Van Rheenen and Brabin[31] conducted a systematic review of two randomized controlled trials[34,36] that compared immediate versus delayed cord clamping in term infants to determine the effect on anemia status after 2 months of age. Their secondary objective was to assess the incidence of polycythemia and/or jaundice during the first week of life in infants who experienced delayed cord clamping. The authors found that delayed cord clamping, especially in anemic mothers, increased hemoglobin status and reduced the risk of anemia at 2 to 3 months of age (RR, 0.32; 95% CI, 0.02–0.52). Although infants with delayed clamping had higher hematocrit levels, no reports of symptomatic polycythemia or jaundice were found. The authors stated that delaying clamping may be especially beneficial in developing countries where anemia rates are high.

The current literature refutes the idea that delayed cord clamping causes symptomatic polycythemia and indicates that immediate clamping of the cord may often lead to anemia of infancy.

Clamping the Nuchal Cord Before Delivery of the Shoulders

In addition to anemia, possible neurologic harm from clamping a nuchal cord before birth has been identified.[37] A recent integrated review of the literature on nuchal

Table 1. Randomized, Controlled Trials on Cord Clamping in Full-Term Infants

Authors, Year, Location	Study Population	Cord Management Placement of Infant	Significant Results	Comments
Chaparro et al. (2006)[32]; Mexico	Women 37–42 wks; singleton pregnancy, vaginal birth, normal pregnancies, plan to breastfeed for 6 mo, no smokers; no IUGR or major anomalies (excluded after birth); 358 infants randomized	EC: CC at 10 s (mean = 16.5 s); DC: CC at 2 minutes (mean = 94 s); Level: held at the level of the uterus	POV: At 6 mo, DC infants had higher MCV (81 vs. 79.5 fL; $P = .001$), ferritin (51 vs. 34 mL; $P = .0002$), and total body iron (48 vs. 44 μg/dL, $P = .0003$) than EC infants. Diff HCT in NB period: 62% vs. 60%; $P = .003$. After birth, HCT > 70%: DC 13% vs. EC 8%; $P < .15$. Jaundice: DC 17% vs. EC 14%; $P \leq .36$	Largest study to date to look at any long-term outcomes. Conservative in that they used only a 2-min delay. No significant differences in HGB or HCT at 6 mo, but iron stores increased by 27–47 mg in infants with DC. No harmful effects noted.
Cernadas et al. (2006)[33]; Argentina	276 term infants; vaginal and cesarean birth, no complications, normal pregnancies	EC: CC at 15 s (n = 93); IC: CC at 1 min (n = 91); DC: CC 3 min (n = 92)	POV: Venous HCT at 6 hrs: EC 54% vs. IC 57% vs. DC 59%. HCT < 45% highest with EC at 6 and 24 hrs. HCT > 65% was highest in DC at 6 and 24 hrs without clinical symptoms	No harmful effects were seen. At 24–48 hrs, 16.9% of infants with EC had HCT < 45%. No increase in maternal postpartum hemorrhage. Authors recommend DC.
Emhamed, van Rheenen, and Brabin (2004)[35]; Libya	Women 37–42 wks; singletons; excluded for major congenital anomalies, maternal complications; tight nuchal cord, need for resuscitation; 102 infants > 2500 gms	EC: immediate (n = 45); DC: after cord stopped pulsating (n = 57); oxytocic after CC	DC infants had significantly higher HCT (53% vs. 49%; $P = .004$) and Hgb 17.1 vs. 18.5 g/dL ($P = .0005$) at 24 hrs. Three DC infants had polycythemia with no symptoms; two EC infants needed phototherapy	No perinatal complications from DC in this study. Authors recommend DC as a safe, simple intervention to increase red cell mass.
Gupta and Ramji (2002)[34]; India	Term infants (n = 102) born to anemic mothers (HGB < 10 g/dL); vaginal birth, no resuscitation needed at birth; no major congenital anomalies	EC: immediate (n = 53); LC: when placenta in vagina (n = 49); Infant held 0–10 cm below introitus	At 3 mos of age (n = 58), infants with LC had higher serum ferritin levels (118 vs. 73; $P = .001$). Odds risk for anemia at 3 mos was 7.7 times higher for the EC group (95% CI, 1.84–34.9)	EC Infants weighed 2707 gms, LC infants 2743 g. Iron stores in neonates born to anemic mothers can be improved by LC (jaundice and polycythemia not addressed)

CC = cord clamping; DC = delayed cord clamping; EC = early cord clamping; HCT = hematocrit; HGB = hemoglobin; IC = intermediate cord clamping; IUGR = intrauterine growth restriction; MCV = mean corpuscular volume; NB = newborn; LC = late cord clamping; POV = primary outcome variable.

cord management found reports showing increased risks to the newborn when the cord was clamped before the shoulders are delivered.[38] Leaving the cord intact and using the somersault maneuver is recommended especially if shoulder dystocia is suspected. During the somersault maneuver, the infant's head is kept near the perineum as the body delivers so that little traction is exerted on the cord (Figure 1).[38] Resuscitation at the perineum allows the infant to regain the blood trapped in the placenta and can be accomplished using all the proper tenets of neonatal resuscitation.

Cord Blood Harvesting

Increasing blood volume by delayed clamping should result in the infant receiving a greater allotment of hematopoietic stem cells and red blood cells. Hematopoietic stem cells are pluripotent, meaning that they can develop into many different cell types.[39] Evidence suggests that hematopoietic stem cells may migrate to and help repair damaged tissue during inflammation and can differentiate into such cells as glia, oligodendrocytes, and cardiomyocytes as needed.[40] In a rat model of cerebral palsy, half the damaged rats were given human umbilical stem cells within 24 hours of the injury. The infusion of cord blood appeared to prevent development of the rodent version of cerebral palsy, which was clearly evident in the damaged rats who did not get human cord blood.[41] Yet cord blood harvesting companies advertise cord blood as "medical waste" and encourage parents to collect it at birth. Although cord clamping time is not prescribed in the instructions for cord blood harvesting, the suggestion is that the earlier the cord is clamped, the larger the harvest will be. This practice of cord blood harvesting is not supported by the American Academy of Pediatrics unless there is a clear medical need within the family.[42] Parents need to be fully informed by providers

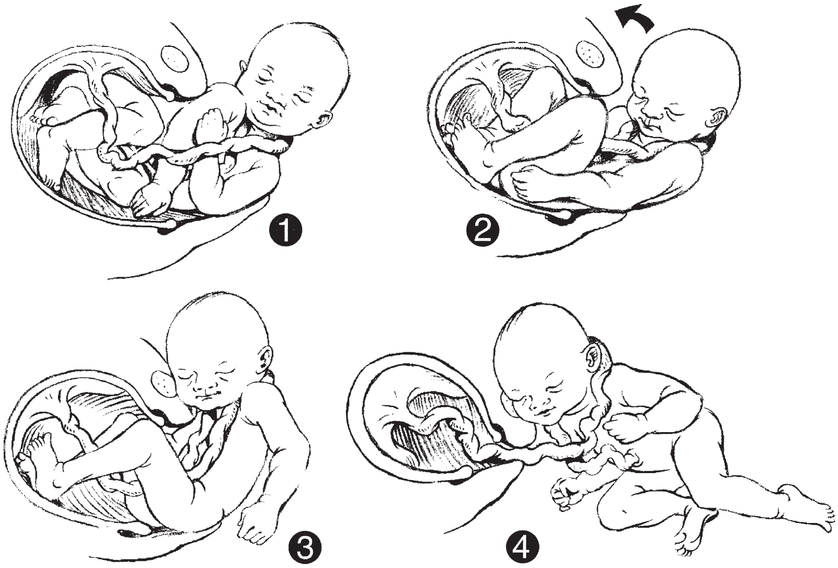

Figure 1. Somersault maneuver. The somersault maneuver involves holding the infant's head flexed and guiding it upward or sideways toward the pubic bone or thigh, so the baby does a "somersault," ending with the infant's feet toward the mother's knees and the head still at the perineum. **1**, Once the 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. Figure adapted with permission from Mercer et al.[38]

during pregnancy in order to make sound decisions about storing cord blood.

In summary, the current literature supports a lack of harm for full term infants when cord clamping is delayed up to 10 minutes with the newborn placed on the maternal abdomen or held below the level of the perineum. In addition, the evidence is strong that delayed cord clamping offers full-term infants protection from anemia. Based on the current evidence, the recommendation is to delay cord clamping to prevent anemia of infancy. Also, we recommend that clinicians not cut a nuchal cord before delivery of the shoulders, but instead, use the somersault maneuver to deliver the child and resuscitate at the perineum as necessary.

Thermoregulation and Infant Placement

Keeping infants warm at birth is an essential part of immediate newborn management. Newborns are at risk for heat loss at birth because of their large surface area to mass ratio, minimal subcutaneous tissue, and skin permeability to water. The procedure of skin-to-skin care requires that the bare newborn is placed in direct contact with the mother's bare skin (usually prone). Skin-to-skin care can occur immediately after birth and during the first hour of life. When a newborn is placed skin-to-skin, the woman provides heat directly to her newborn via conduction. Frequently, the newborn is dried completely and a blanket is placed over infant and mother to prevent heat loss through convection and evaporation.

A literature search on the topic of newborn thermoregulation revealed one 2004 Cochrane review, two RCTs, and one observational physiologic study. Only those studies published since the Cochrane review are included in Table 2.[1,43–46]

In the term newborn, skin-to-skin care is associated with both short- and long-term benefits. In the short term, the newborn experiences an increase in body temperature when compared to infants cared for in a warmer or dressed and placed in a crib.[43,47,48] Even when a dressed newborn is with the mother after the initial hour of skin-to-skin contact, Fransson[45] found less difference between the newborn's core (rectal) temperature and the temperature of the skin when compared to the temperature differential in newborns cared for in a crib. In addition to aiding in maintaining temperature, infants who had skin-to-skin care in the first hour were found to sleep longer, spend more time in a quiet state, and were better organized at 4 hours of age[46] (Table 2).

Long-term benefits of immediate skin-to-skin contact and suckling during the first hour of life include a longer duration of breastfeeding,[44] more maternal positive feelings towards child rearing,[49] and improved scores for maternal affection and maternal attachment.[1] Carfoot[43] found that 90% of the mothers who had skin-to-skin care were very satisfied and 87% would prefer skin-to-skin care again, compared to only a 59% satisfaction rating by the mothers in routine care group.

In conclusion, skin-to-skin contact is a safe, inexpensive, and acceptable method of regulating the thermal environment for healthy term newborns. This method can

Table 2. Literature Overview on Infant Placement at Birth and Skin-to-Skin Care

Authors, Year, Study Type	Study Population	Style of Thermoregulation	Results	Comments
Carfoot, Williamson, and Dickson (2005)[43]; RCT	204 term mother–baby pairs randomized to either group	Early SSC compared with RNC	Higher temps 1 hr after birth ($P < .02$); no difference in # breastfeeding at 4 mos, mothers more satisfied with SSC (90% vs. 50%)	Largest trial to date; supports no harm with SSC; found warmer infants and high maternal satisfaction with SSC
Vaidya, Sharma, and Dhungel (2005)[44]; RCT	92 lactating mother–baby pairs followed up to 6 mos	Randomized to 15 min of SSC in the first hrs vs. RNC (babies dressed and given to mother)	Significantly more mothers in the SCC group were breastfeeding at 6 mos of age (77% vs. 38%)	Large study from a resource-poor country; well done; cultural differences may play a role
Fransson, Karlsson, and Nilsson (2005)[45]; physiologic study	27 healthy term babies during first 2 days of life	Determine normal temperature patterns and variations and the influence of external factors	Skin temperature of baby was higher when with the mother, even if not skin-to-skin	Highest temperatures were recorded when baby was in close contact with mother, lowest when baby was in the cot
Anderson et al. (2003)[1]; Cochrane review	Cochrane review of 806 participants in 17 studies	Early skin-to-skin contact, baby naked and prone on mother's bare chest versus routine hospital care	Increased scores for maternal love/touch/affection, increased maternal attachment behavior	Safety and breastfeeding success; editors recommended improving methodological and statistical integrity
Ferber and Makhoul (2004)[46]; RCT	47 healthy mother–baby pairs	All infants had SSC for first 5–10 min. The SSC group had SSC from 15 min to 1 hr of life; control group had routine care in the nursery	At 4 hrs, infants in the SSC group slept longer ($P = .02$) with more quiet sleep time ($P = .01$) and had better flexion ($P = .03$) and less extension of limbs ($P = .05$)	SSC appears to influence state organization and motor coordination

RCT = randomized, controlled trial; RNC = routine newborn care; SSC = skin-to-skin.

be applied immediately after birth for most newborns. There are short- and long-term benefits for both mother and baby. The most consistent additional effects are increased success and duration of breastfeeding and scores of bonding and attachment. Skin-to-skin should be considered a primary intervention for prevention of neonatal hypothermia. Birthing units that separate mothers and babies with the intention of preventing cold stress unwittingly increase the risk of cold stress, and at the same time deprive the pair of intimacy and bonding while delaying breastfeeding initiation. The evidence suggests that skin-to-skin contact should be the mainstay of newborn thermoregulation.

Suctioning of the Newborn at Birth

Most obstetric texts describe clearing the newborn's nose and mouth at birth with a bulb syringe. Table 3 summarizes the findings of several small research studies that have examined the impact of suctioning on newborn respiratory status.[50–53] All studies were conducted on vigorous term infants and none found any significant differences in health outcomes between infants suctioned and not suctioned. These studies demonstrate no benefits from routine suctioning after birth and support abandoning suctioning as a routine procedure.

Management of Infants With Meconium-Stained Amniotic Fluid

Treatments to prevent meconium aspiration syndrome have included amnioinfusion during labor, intrapartum suctioning, and endotracheal intubation and suctioning of infants with meconium-stained fluid. The most recent evidence suggests that these practices are not helpful and do not prevent meconium aspiration syndrome. Table 4 offers the current evidence about these practices.[54–56] A 2006 review[57] shows no benefit to infants from these practices.

Two classic nonrandomized studies done in the 1970s[58,59] suggested that suctioning the airway before the birth would decrease the incidence of morbidity and mortality associated with meconium aspiration syndrome. Subsequent studies comparing DeLee suctioning with bulb suctioning found no differences in the incidence and severity of meconium aspiration syndrome, respiratory rates, or Apgar scores between the infants who had suctioning either before delivery of the head or after birth.[60–62] In 2004, the Meconium Study Network[55] conducted a large multicenter RCT comparing outcomes of vigorous infants with meconium staining, with or without suctioning on the perineum (Table 4). No difference was found between the two groups for any outcomes, even when analyzing the subgroup with thick

Table 3. Oropharyngeal Suctioning at Birth*

Author, Year, Study Type*	Intervention and Sample Size	Significant Results	Comments
Cordero and Hon (1971)[53]; non-randomized	Bulb suction (n = 41) vs. catheter suction (n = 46)	The catheter group developed severe arrhythmia (n = 7) and became apneic (n = 5)	First study to show that suctioning disrupted infant transition
Estol et al. (1992)[51]; prospective, non-random trial (assigned by hour of birth)	Bulb suction (n = 20) vs. no suction (n = 20)	Respiratory resistance and lung compliance were not different at 10, 30, or 120 min	No significant differences between infants with and without suctioning; no advantage to infants from suctioning
Carrasco, Martell, and Estol (1997)[50]; RCT	Immediate suction with catheter (n = 15) vs. no suctioning (n = 15)	Suctioned group had lower SaO_2 between 1–6 min of life ($P < .05$); time to reach 86%–92% SaO_2 shorter in nonsuctioned group	No respiratory distress in either group; no advantage to infants from suctioning
Waltman et al. (2004)[52]; RCT	Bulb suction on perineum and just after birth (n = 10) vs. no suction (n = 10)	No difference in Apgar scores at 1, 5, or 10 min; higher heart rate [166–173 (n = 10) bpm] in no suction group compared to suction group (150–166 bpm); lower SaO_2 from 10–20 min in non-suctioned group (although > 90%)	No benefits to the infants from suctioning demonstrated

Bpm = beats per minute.

*Study populations: All infants were vigorous term infants.

meconium. This suggests that intrapartum suctioning does not prevent meconium aspiration syndrome. Similarly, no benefit for the prevention of meconium aspiration syndrome has been found following amnioinfusion[54] or from endotracheal intubation and suctioning of vigorous term infants.[56] These practices should not be used to prevent meconium aspiration syndrome.[57]

Gastric Suctioning

It has been suggested that gastric suctioning of the newborn might prevent regurgitation and aspiration of meconium or other stomach contents. A MEDLINE search on gastric suctioning of the newborn revealed only one study relevant to this review.

Widstrom[63] studied the effect of gastric suction on newborn circulation and subsequent feeding behavior. Healthy, term newborns were randomly assigned to have gastric suction (n = 11) or no gastric suction (n = 10). At birth, the newborns were dried and placed on the mother's chest. No suctioning of the airway was done, and all infants began to breathe spontaneously. The umbilical cord was clamped and cut between 60 and 90 seconds after birth. Pulse and blood pressure were recorded every minute from 5 to 10 minutes of age. Between the first two blood pressure recordings, infants in the suction group had a #8 suction catheter inserted through the mouth into the stomach, and the contents were aspirated. The procedure lasted approximately 20 seconds. The infants were maintained in a prone position on their mother's chests and were

Table 4. Current Evidence for Practices Related to Management of Infants Born With Meconium-Stained Amniotic Fluid

Treatment	Recommendation	Reference	Study Details
Amnioinfusion	No benefit to infants found for the prevention of MAS	Fraser et al. (2005)[54]	Multicenter RCT, women (n = 1998) in labor at term with MSAF stratified by presence of variable decelerations and randomly assigned to amnioinfusion or standard care. Amnioinfusion did not reduce risk of MAS, or perinatal death.
Intrapartum suctioning before delivery of shoulders	No benefit to any infants including high risk infants; suctioning of infant before delivery is not indicated	Vain et al. (2004)[55]	RCT, blinded, infants (n = 1176) suctioned on perineum compared with infants (n = 1225) not suctioned. No difference in Apgar scores, respiratory distress, use of oxygen, need for ventilation, MAS (4% in each group), or death.
Endotracheal intubation and suctioning after birth of vigorous infants	No benefits to any infants; not recommended for vigorous infants	Wiswell et al. (2000)[56]	RCT, vigorous term infants (n = 2094) with MSAF randomly assigned to intubation and suctioning or to expectant management. Intubation and suctioning did not result in lower incidence of MAS or other respiratory disorders.

MAS = meconium aspiration syndrome; MSAF= meconium-stained amniotic fluid; RCT = randomized, controlled trial.

Table 5. Room Air Versus Oxygen for Resuscitation: Randomized, Controlled Trials and Controlled Trials (1995 to Present)

Authors, Year, Type of Study	Study Population	Intervention and Application	Significant Results	Comments
Ramji et al. (2003)[66]; quasi-randomized by date of birth	Term newborns needing resuscitation	RA (n = 210) vs. 100% O_2 (n = 221)	No differences in mortality, heart rate, Apgar scores, time to first breath, HIE. Time to first cry: RA 2 min vs. 3 min in O_2group (P = .008). Duration resuscitation: RA 2 min vs. O_2 3 min (P = .000076)	No indication that 100% O_2 offers benefits over RA. Resuscitation appears faster with RA
Saugstad et al. (2003)[71]; follow-up	Infants in prior trials who had reached 18–24 mos	Follow-up of ResAir study (591 infants, of whom 410 available for follow-up)	No differences in: weight, length, developmental milestones, language development, hearing, or cerebral palsy between infants resuscitated with RA vs. O_2	No long-term advantage to use of 100% O_2. Study weakened by low (70%) follow-up rate
Vento et al. (2003)[69]; blinded, randomized	Term infants needing resuscitation	RA (n = 51) vs. 100% O_2 (n = 55)	No statistical difference in Apgar scores. Time to first cry: RA 1.4 min vs. O_2 1.97 min ($P < .05$). Time to regular respirations: RA 5.3 min vs. O_2 6.8 min ($P < .05$)	No advantage to 100% O_2 use
Vento et al. (2001)[68]; blinded, randomized	Asphyxiated term infants and normal controls	RA (n = 19) vs. 100% O_2 (n = 21) vs. controls (n = 26)	No statistical difference in Apgar scores. Time to first cry: RA 1.2 min vs. O_2 1.7 min ($P < .05$). Time to regular respirations: RA 4.6 min vs. 7.5 min ($P <$ .05). Higher levels of markers of oxygen free radicals at 28 days in O_2 vs. RA groups	Even a brief exposure to 100% O_2 may cause prolonged oxidative stress
Saugstad et al. (1998)[75]; quasi-randomized by date of birth, not blinded	BW >1000 gm, no major anomalies	RA (n = 388) vs. 100% O_2 (n = 311)	No significant difference in mortality, HIE, ABG. Apgar 1 min: RA 5; O_2 4 min (P = .004); no difference in Apgar 5 min; more infants w/5 min Apgar < 7 in O_2 group (P = .03); Time to first breath: RA 1.1 min, O_2 1.5 min (P = .004); first cry: RA 1.6 min, O_2 2.0 min (P = .006)	25.7% "treatment failures" in RA switched to O_2 at 90 sec; comparable to numbers in O_2 group (29.8%) who had bradycardia and/or central cyanosis at 90 s

ABG = arterial blood gas; BW = birth weight; HIE = hypoxic ischemic encephalopathy; O_2= oxygen; RA = room air.

observed for 3 hours. While the two groups did not differ in average heart rate, one infant in the suction group had an episode of bradycardia, and infants in the suction group experienced an increased blood pressure when the catheter was withdrawn. Defensive motions were observed in nine of the suctioned infants. Suckling was delayed until 62 minutes in the suction group versus 55 minutes in the no suction group. There was also a greater lag in hand-to-mouth movements in the suction group (P = .005). This small study found harm and no benefit from gastric suctioning, indicating that it should not be used in the routine care of the neonate.

ROOM AIR VERSUS OXYGEN FOR NEONATAL RESUSCITATION

Current research addressing the potential benefits and risks of use of oxygen versus room air for neonatal resuscitation included six intervention studies[64–69] and a Cochrane Library review.[70] The outcomes of these studies demonstrate no differences between the oxygen and room air groups in mortality, Apgar scores, time to first cry, time to onset of regular respirations, hypoxic ischemic encephalopathy, or neurologic follow-up examination results (Table 5).[71] One study evaluated markers of oxidative stress.[68]

History of Oxygen Use and Studies

By the 1950s, it was recognized that the administration of high levels of oxygen to premature infants led to vasoconstriction of the retinal arteries followed by disordered vessel growth causing retrolental fibroplasias, now known as retinopathy of prematurity.[72] Research in the late 1970s demonstrated that administration of 100% oxygen also reduced cerebral blood flow in the newborn infant.[73,74]

Saugstad[75] conducted animal studies, which suggested that the use of 100% oxygen during neonatal resuscitation might result in excess oxygen radicals and slower response to resuscitation. A pilot study with human infants supported the safety of using room air during newborn resuscitation.[65] A follow-up multicenter, international quasiexperimental study of 599 infants weighing more than 1000 gm who required positive pressure ventilation for resuscitation (ResAir 2), found no differences in outcomes when infants were resuscitated with room air versus 100% oxygen (Table 5).[67]

Cerebral Blood Flow

To investigate the effect of supplemental oxygen on cerebral blood flow, Lundstom[64] randomized 70 preterm infants to receive either room air (group I) or 80% oxygen (group II) during initial stabilization in the delivery room. The primary outcome of cerebral blood flow was significantly higher in group I randomized to room air (median 15.9; interquartile range 13.6–21.9 mL/100 g/min) compared to group II with 80% oxygen (median 12.3; interquartile range 10.7–13.8 mL/100 g/min; $P < .0001$) at 2 hours of age.

Markers of Oxidative Stress

Vento et al.[68,69] measured the effect of resuscitation with room air or 100% oxygen on levels of markers of oxidative stress in term infants delivered vaginally (Table 5). Nineteen asphyxiated infants were randomized to resuscitation with room air, 21 were randomized to 100% oxygen, and 26 infants without asphyxia served as controls. The markers of oxidative stress were initially higher in the umbilical arteries of both the asphyxiated groups compared to the controls. At 72 hours of age, the oxygen group had levels of oxygen-free radicals that were statistically higher than the newborns in the room air group. By 28 days of age, the infants in the room air group had values similar to the values of the newborns in the control group, whereas the infants in the oxygen group continued to have statistically higher oxygen-free radical values than either the room air subjects or controls. Even a short exposure to 100% oxygen may result in prolonged oxidative stress.

Neonatal Resuscitation Guidelines

The American Academy of Pediatrics/American Heart Association Neonatal Resuscitation Program provides an authoritative set of recommendations. The fifth edition of *Textbook of Neonatal Resuscitation*[76] contains a significant change in the use of 100% oxygen from earlier editions. Although the authors continue to recommend the use of 100% oxygen, they acknowledge that research suggests that "less than 100% may be just as useful."[77] The new guideline recommends use of room air at time of resuscitation, but if there is not an appropriate response within 90 seconds, oxygen is indicated.

CONCLUSION

An important tenet of practice for all health care personnel is to first do no harm. This idea takes on additional importance when dealing with newborns, as there is almost no long-term data on the safety of many procedures. No clear conclusions can be drawn from studies on maternal analgesia effects on the newborn; thus, judicious use of medications in labor is recommended with further study of better biobehavioral assessment tools to differentiate outcomes. Delaying clamping of the umbilical cord appears to offer protection from anemia without harmful effects. The practice of immediate clamping, especially with a nuchal cord, should be discontinued. The evidence suggests that skin-to-skin care of the newborn after birth and during the first hour of life should be the mainstay of newborn thermoregulation and care. Routine suctioning of the infant at birth should be abandoned. Meconium-stained babies should not be suctioned on the perineum and vigorous infants should not be intubated and suctioned. There is no evidence that amnioinfusion prevents meconium aspiration syndrome. The mounting evidence suggests that use of 100% oxygen at birth to resuscitate newborns may cause harmful effects. Room air is permissible for the first 90 seconds with oxygen available if there is not an appropriate response in that time.

Routine interventions, such as suctioning the airway or stomach or using 100% oxygen for resuscitation, or immediate clamping of the umbilical cord, have never based on any clear evidence that they improve newborn care or outcomes. Yet some of these practices are so firmly entrenched that it will take a large body of research to change the standard. We must continue to build a body of knowledge that supports the evidence: more often than not, less intervention is better.

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