

## Resuscitation of extremely preterm infants - controversies and current evidence

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### Abstract

Despite significant advances in perinatal medicine, the management of extremely preterm infants in the delivery room remains a challenge. There is an increasing evidence for improved outcomes regarding the resuscitation and stabilisation of extremely preterm

infants but there is a lack of evidence in the periviable (gestational age 23-25 wk) preterm subgroup. Presence of an experienced team during the delivery of extremely preterm infant to improve outcome is reviewed. Adaptation from foetal to neonatal cardiorespiratory haemodynamics is dependent on establishing an optimal functional residual capacity in the extremely preterm infants, thus enabling adequate gas exchange. There is sufficient evidence for a gentle approach to stabilisation of these fragile infants in the delivery room. Evidence for antenatal steroids especially in the periviable infants, delayed cord clamping, strategies to establish optimal functional residual capacity, importance of temperature control and oxygenation in delivery room in extremely premature infants is reviewed in this article.

**Key words:** Extremely preterm infants; Resuscitation; Antenatal steroids; Delayed cord clamping; Ventilator support; Oxygenation in delivery room; Temperature stability

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**Core tip:** Management of extremely preterm resuscitation is one of the most challenging aspects of perinatal medicine. There is increasing evidence towards a trend for a more gentle measure of resuscitation to avoid injury both immediate and long term. In this article, we review the evolving strategies to aid the complex process of adaptation to extra uterine life for extreme preterm infants.

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## INTRODUCTION

The physiological adaptation to extra uterine life for a preterm neonate involves a series of complex processes, it is more pronounced in extremely preterm gestation (gestational age less than 27 wk)<sup>[1]</sup>. Aerating the fluid filled lung and thereby attaining an adequate functional residual capacity, ability to perform gas exchange and switching to an oxygen enriched metabolism, establishing adult type circulation with stable haemodynamics along with maintaining body temperature are some of the key processes that occur within the first few minutes of life in any new-born<sup>[2]</sup>. Furthermore, in the extremely preterm infants there is an overriding need for intervention to enable them to adapt to the above processes. Periviable infants are fragile and have many features that increase the difficulty of stabilisation immediately after birth.

Experimental and clinical studies done in past few decades related to resuscitation of preterm infants have shown that interventions by trained personnel during this critical period can not only improve immediate survival but also reduce long term morbidity<sup>[3,4]</sup>. There is also growing evidence that some of these interventions can also trigger inflammatory and oxidative cascades injuring the organs, predisposing to long-term conditions<sup>[3]</sup>. This evidence have supported in developing a trend towards gentle management in delivery room in the first "golden hour"<sup>[5]</sup>. Data for stabilisation and resuscitation of periviable neonate is still limited. The aim of this article is to review the evolving approaches in resuscitation of extremely preterm infants. We searched PubMed, EMBASE, and the Cochrane Central Register of Controlled Trials and performed a manual search of references in narrative and systematic reviews. Search terms included "neonate", "newborn", "resuscitation", "delayed cord clamping", "antenatal steroids", "resuscitation of extremely preterm", "continuous positive airway pressure", and "sustained inflation".

## DISCUSSION

Having an experienced neonatal resuscitation team during delivery, for appropriate stabilisation and resuscitation, improve outcome<sup>[6-9]</sup>. Multiple studies have demonstrated improved outcomes for very low birth weight babies born in tertiary care centres vs out born infants<sup>[6-9]</sup>. The combined risk of death and major morbidities such as neuro-disability at 36 wk, chronic lung disease and hospital stay in extremely low birth weight (500-999 g) infants born in tertiary maternity hospitals as compared to non-tertiary centres has recently been reported (OR = 3.86; 95%CI: 2.21-6.76) in a large cohort by Binder *et al*<sup>[6]</sup>.

### Antenatal steroids

Antenatal corticosteroids have been proven to accelerate foetal lung development and reduce neonatal

morbidity and mortality when given between 28 and 34 wk of gestation<sup>[6]</sup>. However, there is only limited research to guide their use in the peri-viable period (22-26 wk gestational age). To date, there have been 6 prospective and retrospective cohort studies evaluating ante-natal corticosteroids use in the periviable period (Table 1); these studies have used the same dosing schedule of betamethasone as the antenatal steroid.

Majority of these studies exhibited OR for neonatal death of 0.6 with antenatal steroid treatment, which is the same relative benefit demonstrated for corticosteroid use in later gestation. Amongst infants born at < 26 wk of gestational age, 7-9 mothers need to receive antenatal steroids to prevent 1 neonatal death. In this group of infants use of antenatal steroids have also been shown to reduce the incidence of intra-ventricular haemorrhage (IVH) as an outcome. Tyson *et al*<sup>[11]</sup> have looked at the follow-up of periviable infants exposed to antenatal corticosteroids compared to those not treated with steroids. They demonstrated that when evaluated at 18-22 mo, the infants that delivered between 22 and 25 wk of gestation continued to demonstrate a reduction in mortality (OR = 0.55; 95%CI: 0.45-0.66). One must remain cautious while making decisions based on cohort studies, which have the potential for unintended bias. While further studies such as randomised clinical trials would be beneficial, the current available evidence strongly suggest that antenatal corticosteroids have value when given in the periviable period and should be offered when clinically appropriate. This benefit is clear from 23 wk onwards as seen by the above studies. It is less certain whether they should be utilized at 22 wk or less due to lack to data in this gestation. Because of the uncertainty in gestational age prediction, it is suggested that they should be used at this gestational age if preterm birth appears to be imminent.

### Delivery room resuscitation

**Delayed umbilical cord clamping:** Delaying umbilical cord clamping in term infants is generally considered to be beneficial<sup>[16]</sup>. The evidence for benefit of delayed cord clamping in preterm infants is not clear. Maintaining blood supply to heart while pulmonary vascular system gets replenished contributes to keeping an adequate left ventricular output, thereby avoiding reduced blood flow to the brain, coronary arteries, kidneys and rest of the body<sup>[17]</sup>. A systematic review by Rabe *et al*<sup>[16]</sup> reviewed 15 studies on delayed cord clamping in preterm infants. They concluded that providing additional placental blood to the preterm infants by delaying cord clamping for 30 to 120 s, rather than early clamping, seems to be associated with less need for transfusion, better circulatory stability, less IVH (all grades) and lower risk for necrotising enterocolitis (NEC). However primary outcomes of death as well as death or neuro-disability at 2-3 years were inconclusive. The optimal

**Table 1** Studies reporting the outcomes of antenatal steroid use in periviable births

Ref.	Year published	Country of origin	No. of babies	Birth weight (g)	Gestational age (GA)	Mortality OR (95%CI)	IVH OR (95%CI)
Costeloe <i>et al</i> <sup>[10]</sup>	2000	United Kingdom	811	400-1000	< 26 wk	0.6 (0.34-0.89)	0.39 (0.2-1.0)
Tyson <i>et al</i> <sup>[11]</sup>	2008	United States	4446	400-900	< 26 wk	0.6 (0.23-0.78)	-
Hayes <i>et al</i> <sup>[12]</sup>	2008	United States	450	400-550	< 23 wk	0.3 (0.2-0.65)	-
Mori <i>et al</i> <sup>[13]</sup>	2011	Japan	11607	400-1000	< 26 wk	0.7 (0.44-1.24)	0.65 (0.21-1.68)
Bader <i>et al</i> <sup>[14]</sup>	2010	Israel	3450	400-1000	< 26 wk	0.6 (0.4-0.68)	-
Carlo <i>et al</i> <sup>[15]</sup>	2011	United States	10541	400-1000	22-25 wk	0.58 (0.52-0.65)	0.55 (0.50-0.62)

OR: Odds ratio; IVH: Intra-ventricular haemorrhage.

time to clamp the umbilical cord remains controversial. In all the studies, early clamping was defined as less than 15 s, the definition of late clamping was varied from more than 30 s to 3 min. There are several small randomized control trials that have compared early (< 15 s) with late clamping (> 30 s) following preterm birth and there are several prospective observational studies<sup>[18-22]</sup>. However, there is limited data in periviable or non-vigorous preterm infants demonstrating improved mortality and morbidity following delayed umbilical cord clamping. A recent experimental study in lamb model demonstrated the effects of early vs delayed cord clamping on transitional haemodynamics<sup>[23]</sup>. They reported that delayed cord clamping after initiation of positive pressure ventilation and establishment of functional residual capacity markedly improved cardiovascular function by increasing the pulmonary blood flow and stabilising the cerebral haemodynamics transition.

Although experimental studies support delayed cord clamping having a positive effect on the preterm, the setup needed to practically perform resuscitation manoeuvres with an intact cord still remains an impediment. There is lack of evidence for delayed cord clamping in a preterm who is moderately depressed. An alternative to this of cord milking has been suggested as a more rapid method to influence placental transfusion<sup>[16,23,24]</sup>. This technique requires clamping the cord near the placenta and stripping around 20 centimetres, 2-4 times, from placental to foetal side. This can be performed within a few seconds. There have been five randomised control trials have been performed in preterm infants, but only with small number of preterm infants<sup>[24-28]</sup>. Rabe *et al*<sup>[24]</sup>, Hosono *et al*<sup>[25]</sup> and March *et al*<sup>[26]</sup> have looked at need for the blood transfusions and the number in preterm babies, while Takami *et al*<sup>[27]</sup> and Katheria *et al*<sup>[28]</sup> have looked at haemodynamics following milking of cords. Further larger studies are needed for this procedure. There are some concerns that milking might not replicate the haemodynamic benefits of delayed cord clamping<sup>[29]</sup>. Retrospective studies have shown Haemoglobin levels at birth of > 12 g/dL results in reduced mortality and improved morbidity in preterm infants < 32 wk of gestational age<sup>[30,31]</sup>.

Several trials are currently on-going for both

delayed cord clamping in preterm infants as well as for milking of cord as an alternative<sup>[32,33]</sup>. A recent multicentre feasibility study of delayed cord clamping in preterm infants less than 32 wk gestation in United Kingdom (United Kingdom CORD trial) has compared early < 20 s to delayed cord clamping for at least 2 min. The study has been concluded and the results are awaited<sup>[32]</sup>. A large randomised trial is currently been undertaken in Australia which is nearing completion of recruitment<sup>[33]</sup>. The CORD trial will contribute to an international collaborative individual patient meta-analysis of similar trials of enhanced placental transfusion, including the Australian Placental Transfusion trial. Altogether, these trials will enrol 2000-5000 very preterm infants, which are expected to improve our current understanding and evidence of delayed cord clamping in these infants and its impact on survival and neurodevelopment in childhood.

#### **Stabilising temperature of preterm infants:**

Preterm infants lack adequate brown adipose tissue and therefore cannot activate thermogenesis. They quickly lose heat in the delivery room by evaporation of amniotic fluid, by conduction of heat from the body touching cool surfaces, by convection and radiation to cooler surroundings. They are highly susceptible to hypothermia unless preventive efforts are made. A study has shown that for every 1 °C below 36 °C on admission temperature, mortality increases by 28%<sup>[34]</sup>. Increasing the ambient temperature of delivery room to at least 26 °C before the delivery is an important intervention<sup>[35]</sup>. Both hypothermia and hyperthermia during stabilisation can be detrimental<sup>[36]</sup>. All extremely preterm infants should be brought in the resuscitaire under radiant heat and wrapped in polyethylene or polyurethane bags or wrap, up to their shoulders without drying<sup>[37-39]</sup>. This reduces heat loss and maintains adequate humidity. All subsequent stabilisation and assessment should be done through the plastic bag. Multiple studies have shown that plastic bags improve temperature upon admission<sup>[39,40]</sup> but there are no studies powered for clinical outcomes like death and long term neurodevelopmental outcome<sup>[40]</sup>. Preterm infants can be placed on a chemically activated thermal mattress in combination<sup>[41]</sup>. The head should be

**Table 2 Overview of the results of the studies comparing continuous positive airway pressure and invasive ventilation**

Ref.	Total number	Gestational age (GA) in wk	Death or BPD CPAP	Death or BPD non CPAP	Death or BPD relative risk (95%CI)	Days needing mechanical ventilation CPAP	Days needing mechanical ventilation non CPAP	Days needing mechanical ventilation P value
Morley <i>et al</i> <sup>[51]</sup>	610	25-28	108/307	118/303	0.9 (0.73-1.11)	0-11	11-14	< 0.001
SUPPORT <sup>[52]</sup>	1316	24-27	323/663	353/653	0.9 (0.81-1.00)	2-32	2-36	0.01
Sandri <i>et al</i> <sup>[54]</sup>	208	25-28	53/103	32/105	1.01 (0.7-1.57)	1-14	1-18	< 0.01
Dunn <i>et al</i> <sup>[53]</sup>	648	26-29	68/223	138/425	0.94 (0.74-1.19)	1-8	1-10	0.01

Infants randomised to prophylactic surfactant group and intubate, surfactant, or extubate group were combined in the intubation group. CPAP: Continuous positive airway pressure; BPD: Bronchopulmonary dysplasia.

covered by a hat. Care should also be taken to ensure that hyperthermia is avoided. Monitoring infants' temperature is of paramount importance. Perinatal hyperthermia is associated with respiratory depression as well as risk of adverse neurological outcome<sup>[36]</sup>. Every hospital delivering high risk infants should have protocols for controlling delivery room temperature, systematic use of plastic bags and hats, monitoring temperature during stabilisation and transport to avoid hypothermia or hyperthermia. Admission temperature is an integral part of the Clinical risk Index for Babies II (CRIB II) score. The CRIB score was developed to predict mortality for infants born at less than 32 wk gestation at birth and was derived using data from infants admitted to four UK tertiary neonatal units from 1988 to 1990<sup>[42]</sup>. This score has been widely used to quantify the risk of mortality among very preterm infants<sup>[42]</sup>; it is assessed in the first 12 h of birth. The CRIB score was modified in 2003 as CRIB II score<sup>[43]</sup>, where gestational age and birth weight together with admission temperature and base excess were added to predict mortality. The new score was intended to improve predictions for smaller, very premature infants and to exclude variables that could be influenced by care given to the infant. Score for acute neonatal physiology (SNAP) is another mortality prediction score developed in United States<sup>[44]</sup> a simpler version called SNAP II was developed later using data from 30 American units<sup>[45]</sup>. Admission temperature was one of the important components of these mortality prediction scores.

### Respiratory support in stabilisation

**Ventilatory support:** Despite considerable advances in perinatal-neonatal care, there is a trend for increased incidence of bronchopulmonary dysplasia among survivors of prematurity<sup>[46,47]</sup>. Appropriate respiratory support in the delivery room can ensure reduction in the damage caused to the lungs. Preterm infants are unique due to their poor respiratory drive, structurally immature lungs, surfactant deficiency and highly non-compliant chest wall. Respiratory support should improve lung compliance thereby achieving adequate minute ventilation, decrease work of breathing and provide assisted ventilation as required. In order to ensure good gas exchange, consistent

functional capacity has to be established, while avoiding areas of atelectasis and over distension.

Use of positive end expiratory pressure (PEEP) during intermittent positive pressure ventilation (IPPV) or use of continuous positive airway pressure (CPAP) alone, after birth to facilitate alveolar recruitment and to avoid barotrauma and volutrauma from mechanical ventilation is recommended<sup>[48]</sup>. CPAP can help establish and maintain a functional residual capacity in preterm lung, thereby improving pulmonary haemodynamics and respiratory distress<sup>[48]</sup>. Most neonatal resuscitation guidelines (NRP/NLS) have supported the use of CPAP as a mode of ventilator support for preterm babies soon after birth<sup>[49]</sup>.

A systematic review with meta-analysis in 2013 by Schmöler *et al*<sup>[50]</sup> evaluated the difference of outcomes between invasive and non-invasive respiratory support in preterm infants at birth. Four randomised controlled trials were evaluated and they concluded that nasal CPAP initiated in the delivery room compared with intubation reduces death or bronchopulmonary dysplasia in very preterm babies (Table 2)<sup>[51-54]</sup>. The meta-analysis suggested that one additional infant could survive to 36 wk without bronchopulmonary dysplasia for every 25 babies treated with nasal CPAP in the delivery room rather than being intubated and mechanically ventilated. Pooled analysis showed a significant benefit for the combined outcome of death or bronchopulmonary dysplasia, or both, at 36 wk corrected gestation for babies treated with nasal CPAP: RR = 0.91; 95%CI: 0.84-0.99; RD = -0.04; 95%CI: -0.07 to -0.00; NNT of 25.

However none of these trials included infants less than 23 wk and only 1 trial had infants at 24 wk gestation. There are four small studies in periviable babies comparing invasive and non-invasive ventilation. Finer *et al*<sup>[55]</sup> demonstrated that although about half of 24 wk GA infants can be stabilised on CPAP in the delivery room, very few infants of less than 24 wk GA avoided delivery room intubation.

These trials indicate that despite a strategy of CPAP use after birth in extremely low gestational age infants, rates of bronchopulmonary dysplasia (BPD) or death at 36 wk postmenstrual age (PMA) remain high, ranging from 41% to 64%<sup>[52,56,57]</sup>.

CPAP should not be used in place of positive

pressure ventilation when respiratory effort is poor or absent<sup>[54,58]</sup>. In a recent study, it was shown that a stepwise PEEP strategy after birth improved gas exchange, lung mechanics and end expiratory volume without increasing lung injury in preterm lambs<sup>[59]</sup>.

Sustained inflation (SI) has been suggested as an alternative to CPAP. Sustained inflation is application of higher pressure (25 cm H<sub>2</sub>O) for a prolonged time than normal (15-25 s)<sup>[60]</sup>. A systemic review in 2014 by Schmöler *et al*<sup>[61]</sup> compared sustained inflation vs positive pressure ventilation. Four RCTs were analysed showing SI improves functional residual capacity (FRC) and therefore the need for mechanical ventilation during the first 72 h, the pulmonary protective effect is lost in the subsequent development to BPD<sup>[62-65]</sup>. Further clinical trials are required to evaluate the efficacy, including risk of pneumothorax, long term outcomes and safety, of this lung aeration manoeuvre at birth.

The Sustained Aeration of Lung (SAIL) trial, a large, international multi-centred randomised trial is currently on-going evaluating sustained inflation vs positive pressure ventilation<sup>[66]</sup>. This prospective randomized controlled unblinded trial will recruit 600 infants of 23 to 26 wk gestational age who require respiratory support at birth. Infants in both arms will be treated with PEEP 5 to 7 cm H<sub>2</sub>O throughout the resuscitation. The study intervention consists of performing an initial SI (20 cm H<sub>2</sub>O for 15 s) followed by a second SI (25 cm H<sub>2</sub>O for 15 s), and then PEEP with or without IPPV, as needed. The control group will be treated with initial IPPV with PEEP. The primary outcome is the composite outcome of bronchopulmonary dysplasia or death at 36 wk post-menstrual age.

**Oxygenation in delivery room:** Preterm infants are deficient in anti-oxidative protection and are highly susceptible to oxygen toxicity thereby exacerbating morbidities<sup>[67]</sup>. Avoiding hypoxemia and hyperoxaemia during resuscitation is essential. Blended oxygen and pulse oximetry play an important role in titrating the delivery of oxygen. Due to inherent technology behind the pulse oximetry measurements saturation values less than 60%-70% are inaccurate<sup>[68]</sup>. Pulse oximetry should be placed on the right hand or arm to evaluate the pre-ductal oxygen levels; it also measures heart rate accurately, which helps in the resuscitation. The optimal initial fraction of inspired oxygen (FiO<sub>2</sub>) for resuscitating/stabilising premature infants is not known. A recent meta-analysis by Saugstad *et al*<sup>[69]</sup> in 2014 for optimal initial fraction of oxygen in less than 32 wk gestation analysed 10 published studies covering 677 infants. It shows that the outcomes of starting with a low initial FiO<sub>2</sub> (0.21-0.30) were as good as starting with a high FiO<sub>2</sub> (0.6-1.0). Oxygen should be individually titrated based on the neonate's response.

Harling *et al*<sup>[70]</sup> performed the first resuscitation trial

of infants of less than 31 wk GA with either 50% or 100% oxygen for the entire time of the resuscitation and found no significant differences in cytokines, death, or survival without BPD. All subsequent trials in preterm infants comparing a high vs low oxygen concentration utilized a targeted oxygen saturation strategy. The room air vs oxygen administration in preterm Resuscitation (ROAR) study randomised 106 infants  $\leq$  32 wk gestation comparing three O<sub>2</sub> strategies: 100% throughout (High oxygen group), 100% initially (Moderate oxygen group) and 21% (Low oxygen group) initially. The last two groups had the FiO<sub>2</sub> titrated until a SpO<sub>2</sub> of 85% to 92% was reached<sup>[71]</sup>. This study demonstrated that targeting resuscitation SpO<sub>2</sub> values was feasible for very preterm infants. Ezaki *et al*<sup>[72]</sup> studied infants < 35 wk' gestation born by caesarean section. Twenty one infants received 100% oxygen and 23 were treated with a targeted oxygen saturation strategy. They reported lower 5 min Apgar scores, and higher total hydro peroxides in the 100% oxygen group which implies an improved outcome with targeted oxygen saturation strategy. None of the studies have evaluated long term outcomes in these infants, which is of utmost importance. That is why larger prospective randomised controlled trials with long term outcome measures are required.

There are several experimental and clinical studies to assess the initial oxygen concentration during resuscitation<sup>[73,74]</sup>. The To2pido (Targeted oxygenation in the resuscitation of premature infants and their developmental outcome) study is an international, multicentre trial currently set up in Australia, Malaysia, and Singapore and with centres starting in India<sup>[75]</sup>. It is to determine the outcome of very premature infants (< 30.6 wk gestation) who have had resuscitation at birth starting with either room air or 100% oxygen. The trial is currently recruiting and the target number of infants to be recruited is 1892. The primary outcome is said to be death at 2 years and secondary outcomes are evidence of bronchopulmonary dysplasia at 36 wk gestation or major disability at 2 years of age. The Premature Infants Resuscitated with Oxygen or Air (PRESOX) trial, which is planning to recruit 1260 infants, is a prospective randomized clinical trial of extremely premature infants that will assess the use of a low and high oxygen concentration for the initial resuscitation<sup>[76]</sup>. This proposed trial will use targeted oxygen saturation levels over the first 15 to 20 min of life to compare a low and a higher initial oxygen level for the resuscitation of such infants, and is powered to evaluate short term outcomes of survival without oxygen at 36 wk and survival without retinopathy of prematurity, and the long term outcome of survival without significant neurodevelopmental impairment at 2 years of age.

In 2010, Dawson *et al*<sup>[75]</sup> developed SpO<sub>2</sub> reference range for the first ten min of term, preterm and extremely preterm infants. Three databases were merged, two from Australia and one from Spain to

evolve this range. At present Dawson's nomogram is the best available reference range for titration of oxygen in preterm infants. However it should be noted that the reference range was based on the infants who were breathing in air. A study by Vento *et al.*<sup>[76]</sup> in 2013 showed that preterm infants requiring CPAP but in air attained higher saturation significantly earlier than in Dawson's nomogram.

There is growing interest in monitoring CO<sub>2</sub> levels in delivery room and using it as a tool for assessment of functional residual capacity. A systematic review in 2014 by Hawkes *et al.*<sup>[77]</sup> reviewed the current evidence for CO<sub>2</sub> monitoring. These mainly included observational studies with only one RCT. Observational studies have a higher degree of bias and can also mask cause and effect relationships or, alternatively, suggest correlations where there are none. The conclusion was that CO<sub>2</sub> detection may be of particular benefit for preterm infants in the delivery suite. However, there is a need for further research into CO<sub>2</sub> detection, in particular, capnography, as a means of confirming effective IPPV in neonatal resuscitation.

## CONCLUSION

Resuscitation and stabilisation of a preterm neonate consists of complex decisions and tasks undertaken by the team. In recent years, there is growing evidence for providing a gentle, least invasive support in the delivery room to reduce immediate and long term morbidities. There needs to be further research in all the aspects of resuscitation especially for periviable neonate.

## REFERENCES

- 1 **Lawn JE**, Gravett MG, Nunes TM, Rubens CE, Stanton C. Global report on preterm birth and stillbirth (1 of 7): definitions, description of the burden and opportunities to improve data. *BMC Pregnancy Childbirth* 2010; **10** Suppl 1: S1 [PMID: 20233382 DOI: 10.1186/1471-2393-10-S1-S1]
- 2 **Vento M**, Lista G. Managing preterm infants in the first minutes of life. *Paediatr Respir Rev* 2015; **16**: 151-156 [PMID: 25827245 DOI: 10.1016/j.prrv.2015.02.004]
- 3 **Vento M**, Cheung PY, Aguar M. The first golden minutes of the extremely-low-gestational-age neonate: a gentle approach. *Neonatology* 2009; **95**: 286-298 [PMID: 19052475 DOI: 10.1159/000178770]
- 4 **Rojas-Reyes MX**, Morley CJ, Soll R. Prophylactic versus selective use of surfactant in preventing morbidity and mortality in preterm infants. *Cochrane Database Syst Rev* 2012; **3**: CD000510 [PMID: 22419276 DOI: 10.1002/14651858.CD000510]
- 5 **Castrodale V**, Rinehart S. The golden hour: improving the stabilization of the very low birth-weight infant. *Adv Neonatal Care* 2014; **14**: 9-14; quiz 15-16 [PMID: 24472882 DOI: 10.1097/ANC.0b013e31828d0289]
- 6 **Binder S**, Hill K, Meinzen-Derr J, Greenberg JM, Narendran V. Increasing VLBW deliveries at subspecialty perinatal centers via perinatal outreach. *Pediatrics* 2011; **127**: 487-493 [PMID: 21321032 DOI: 10.1542/peds.2010-1064]
- 7 **Phibbs CS**, Baker LC, Caughey AB, Danielsen B, Schmitt SK, Phibbs RH. Level and volume of neonatal intensive care and mortality in very-low-birth-weight infants. *N Engl J Med* 2007; **356**: 2165-2175 [PMID: 17522400]
- 8 **Bartels DB**, Wypij D, Wenzlaff P, Dammann O, Poets CF. Hospital volume and neonatal mortality among very low birth weight infants. *Pediatrics* 2006; **117**: 2206-2214 [PMID: 16740866]
- 9 **Upadhyay K**, Pourcyrous M, Dhanireddy R, Talati AJ. Outcomes of neonates with birth weight  $\leq$  500 g: a 20-year experience. *J Perinatol* 2015; **35**: 768-772 [PMID: 25950920 DOI: 10.1038/jp.2015.44]
- 10 **Costeloe K**, Hennessy E, Gibson AT, Marlow N, Wilkinson AR. The EPICure study: outcomes to discharge from hospital for infants born at the threshold of viability. *Pediatrics* 2000; **106**: 659-671 [PMID: 11015506]
- 11 **Tyson JE**, Parikh NA, Langer J, Green C, Higgins RD. Intensive care for extreme prematurity--moving beyond gestational age. *N Engl J Med* 2008; **358**: 1672-1681 [PMID: 18420500 DOI: 10.1056/NEJMoa073059]
- 12 **Hayes EJ**, Paul DA, Stahl GE, Seibel-Seamon J, Dysart K, Leiby BE, Mackley AB, Berghella V. Effect of antenatal corticosteroids on survival for neonates born at 23 weeks of gestation. *Obstet Gynecol* 2008; **111**: 921-926 [PMID: 18378752 DOI: 10.1097/AOG.0b013e318169ce2d]
- 13 **Mori R**, Kusuda S, Fujimura M. Antenatal corticosteroids promote survival of extremely preterm infants born at 22 to 23 weeks of gestation. *J Pediatr* 2011; **159**: 110-114.e1 [PMID: 21334006 DOI: 10.1016/j.jpeds.2010.12.039]
- 14 **Bader D**, Kugelman A, Boyko V, Levitzki O, Lerner-Geva L, Riskin A, Reichman B. Risk factors and estimation tool for death among extremely premature infants: a national study. *Pediatrics* 2010; **125**: 696-703 [PMID: 20351002 DOI: 10.1542/peds.2009-1607]
- 15 **Carlo WA**, McDonald SA, Fanaroff AA, Vohr BR, Stoll BJ, Ehrenkranz RA, Andrews WW, Wallace D, Das A, Bell EF, Walsh MC, Laptook AR, Shankaran S, Poindexter BB, Hale EC, Newman NS, Davis AS, Schibler K, Kennedy KA, Sánchez PJ, Van Meurs KP, Goldberg RN, Watterberg KL, Faix RG, Frantz ID, Higgins RD. Association of antenatal corticosteroids with mortality and neurodevelopmental outcomes among infants born at 22 to 25 weeks' gestation. *JAMA* 2011; **306**: 2348-2358 [PMID: 22147379 DOI: 10.1001/jama.2011.1752]
- 16 **Rabe H**, Diaz-Rossello JL, Duley L, Dowswell T. Effect of timing of umbilical cord clamping and other strategies to influence placental transfusion at preterm birth on maternal and infant outcomes. *Cochrane Database Syst Rev* 2012; **8**: CD003248 [PMID: 22895933 DOI: 10.1002/14651858.CD003248.pub3]
- 17 **Peltonen T**. Placental transfusion--advantage an disadvantage. *Eur J Pediatr* 1981; **137**: 141-146 [PMID: 7308224]
- 18 **Rabe H**, Wacker A, Hülkamp G, Hörnig-Franz I, Schulze-Everding A, Harms E, Cirkel U, Louwen F, Witteler R, Schneider HP. A randomised controlled trial of delayed cord clamping in very low birth weight preterm infants. *Eur J Pediatr* 2000; **159**: 775-777 [PMID: 11039135]
- 19 **Raju TN**, Singhal N. Optimal timing for clamping the umbilical cord after birth. *Clin Perinatol* 2012; **39**: 889-900 [PMID: 23164185 DOI: 10.1016/j.clp.2012.09.006]
- 20 **Oh W**, Fanaroff AA, Carlo WA, Donovan EF, McDonald SA, Poole WK. Effects of delayed cord clamping in very-low-birth-weight infants. *J Perinatol* 2011; **31** Suppl 1: S68-S71 [PMID: 21448208 DOI: 10.1038/jp.2010.186]
- 21 **Ersdal HL**, Linde J, Mdua E, Auestad B, Perlman J. Neonatal outcome following cord clamping after onset of spontaneous respiration. *Pediatrics* 2014; **134**: 265-272 [PMID: 25022738 DOI: 10.1542/peds.2014-0467]
- 22 **Meyer MP**, Mildenhall L. Delayed cord clamping and blood flow in the superior vena cava in preterm infants: an observational study. *Arch Dis Child Fetal Neonatal Ed* 2012; **97**: F484-F486 [PMID: 21586482 DOI: 10.1136/adc.2010.199703]
- 23 **Bhatt S**, Alison BJ, Wallace EM, Crossley KJ, Gill AW, Kluckow M, te Pas AB, Morley CJ, Polglase GR, Hooper SB. Delaying cord clamping until ventilation onset improves cardiovascular function at birth in preterm lambs. *J Physiol* 2013; **591**: 2113-2126 [PMID: 23401615 DOI: 10.1113/jphysiol.2012.250084]
- 24 **Rabe H**, Jewison A, Alvarez RF, Crook D, Stilton D, Bradley R,

- Holden D. Milking compared with delayed cord clamping to increase placental transfusion in preterm neonates: a randomized controlled trial. *Obstet Gynecol* 2011; **117**: 205-211 [PMID: 21252731 DOI: 10.1097/AOG.0b013e3181fe46ff]
- 25 **Hosono S**, Mugishima H, Fujita H, Hosono A, Minato M, Okada T, Takahashi S, Harada K. Umbilical cord milking reduces the need for red cell transfusions and improves neonatal adaptation in infants born at less than 29 weeks' gestation: a randomised controlled trial. *Arch Dis Child Fetal Neonatal Ed* 2008; **93**: F14-F19 [PMID: 17234653 DOI: 10.1136/adc.2006.108902]
- 26 **March MI**, Hacker MR, Parson AW, Modest AM, de Veciana M. The effects of umbilical cord milking in extremely preterm infants: a randomized controlled trial. *J Perinatol* 2013; **33**: 763-767 [PMID: 23867960 DOI: 10.1038/jp.2013.70]
- 27 **Takami T**, Suganami Y, Sunohara D, Kondo A, Mizukaki N, Fujioka T, Hoshika A, Akutagawa O, Isaka K. Umbilical cord milking stabilizes cerebral oxygenation and perfusion in infants born before 29 weeks of gestation. *J Pediatr* 2012; **161**: 742-747 [PMID: 22578578 DOI: 10.1016/j.jpeds.2012.03.053]
- 28 **Katheria AC**, Leone TA, Woelkers D, Garey DM, Rich W, Finer NN. The effects of umbilical cord milking on hemodynamics and neonatal outcomes in premature neonates. *J Pediatr* 2014; **164**: 1045-1050.e1 [PMID: 24560179 DOI: 10.1016/j.jpeds.2014.01.024]
- 29 **Raju TN**. Timing of umbilical cord clamping after birth for optimizing placental transfusion. *Curr Opin Pediatr* 2013; **25**: 180-187 [PMID: 23407180 DOI: 10.1097/MOP.0b013e32835d2a9e]
- 30 **Banerjee J**, Asamoah FK, Singhvi D, Kwan AW, Morris JK, Aladangady N. Haemoglobin level at birth is associated with short term outcomes and mortality in preterm infants. *BMC Med* 2015; **13**: 16 [PMID: 25622597 DOI: 10.1186/s12916-014-0247-6]
- 31 **Hosono S**, Mugishima H, Kitamura T, Inami I, Fujita H, Hosono A, Minato M, Okada T, Takahashi S, Harada K. Effect of hemoglobin on transfusion and neonatal adaptation in extremely low-birthweight infants. *Pediatr Int* 2008; **50**: 306-311 [PMID: 18533942 DOI: 10.1111/j.1442-200X.2008.02586.x]
- 32 **Pushpa-Rajah A**, Bradshaw L, Dorling J, Gyte G, Mitchell EJ, Thornton J, Duley L. Cord pilot trial - immediate versus deferred cord clamping for very preterm birth (before 32 weeks gestation): study protocol for a randomized controlled trial. *Trials* 2014; **15**: 258 [PMID: 24981366 DOI: 10.1186/1745-6215-15-258]
- 33 **Tarnow-Mordi W**. The Australian Placental Transfusion Study (APTS): Should very pre term babies receive a placental blood transfusion at birth via deferring cord clamping versus standard cord clamping procedures? 2010-08-02. Available from: URL: <http://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=335752>
- 34 **Laptook AR**, Salhab W, Bhaskar B. Admission temperature of low birth weight infants: predictors and associated morbidities. *Pediatrics* 2007; **119**: e643-e649 [PMID: 17296783]
- 35 **Jia YS**, Lin ZL, Lv H, Li YM, Green R, Lin J. Effect of delivery room temperature on the admission temperature of premature infants: a randomized controlled trial. *J Perinatol* 2013; **33**: 264-267 [PMID: 22858889 DOI: 10.1038/jp.2012]
- 36 **Kasdorf E**, Perlman JM. Hyperthermia, inflammation, and perinatal brain injury. *Pediatr Neurol* 2013; **49**: 8-14 [PMID: 23683657 DOI: 10.1016/j.pediatrneurol.2012.12.026]
- 37 **Vohra S**, Roberts RS, Zhang B, Janes M, Schmidt B. Heat Loss Prevention (HeLP) in the delivery room: A randomized controlled trial of polyethylene occlusive skin wrapping in very preterm infants. *J Pediatr* 2004; **145**: 750-753 [PMID: 15580195]
- 38 **McCall EM**, Alderdice F, Halliday HL, Jenkins JG, Vohra S. Interventions to prevent hypothermia at birth in preterm and/or low birthweight infants. *Cochrane Database Syst Rev* 2010; **(3)**: CD004210 [PMID: 20238329 DOI: 10.1002/14651858.CD004210.pub4]
- 39 **Reilly MC**, Vohra S, Rac VE, Dunn M, Ferrelli K, Kiss A, Vincer M, Wimmer J, Zayack D, Soll RF. Randomized trial of occlusive wrap for heat loss prevention in preterm infants. *J Pediatr* 2015; **166**: 262-268.e2 [PMID: 25449224 DOI: 10.1016/j.jpeds.2014.09.068]
- 40 **Singh A**, Duckett J, Newton T, Watkinson M. Improving neonatal unit admission temperatures in preterm babies: exothermic mattresses, polythene bags or a traditional approach? *J Perinatol* 2010; **30**: 45-49 [PMID: 19641512 DOI: 10.1038/jp.2009.94]
- 41 **Simon P**, Dannaway D, Bright B, Krous L, Wlodaver A, Burks B, Thi C, Milam J, Escobedo M. Thermal defense of extremely low gestational age newborns during resuscitation: exothermic mattresses vs polyethylene wrap. *J Perinatol* 2011; **31**: 33-37 [PMID: 20410908 DOI: 10.1038/jp.2010.56]
- 42 The CRIB (clinical risk index for babies) score: a tool for assessing initial neonatal risk and comparing performance of neonatal intensive care units. The International Neonatal Network. *Lancet* 1993; **342**: 193-198 [PMID: 8100927]
- 43 **Parry G**, Tucker J, Tarnow-Mordi W. CRIB II: an update of the clinical risk index for babies score. *Lancet* 2003; **361**: 1789-1791 [PMID: 12781540]
- 44 **Richardson DK**, Gray JE, McCormick MC, Workman K, Goldmann DA. Score for Neonatal Acute Physiology: a physiologic severity index for neonatal intensive care. *Pediatrics* 1993; **91**: 617-623 [PMID: 8441569]
- 45 **Richardson DK**, Corcoran JD, Escobar GJ, Lee SK. SNAP-II and SNAPPE-II: Simplified newborn illness severity and mortality risk scores. *J Pediatr* 2001; **138**: 92-100 [PMID: 11148519]
- 46 **Jobe AH**, Bancalari E. Bronchopulmonary dysplasia. *Am J Respir Crit Care Med* 2001; **163**: 1723-1729 [PMID: 11401896]
- 47 **Ancl PY**, Goffinet F, Kuhn P, Langer B, Matis J, Hernandezorena X, Chabanier P, Joly-Pedespan L, Lecomte B, Vendittelli F, Dreyfus M, Guillois B, Burguet A, Sagot P, Sizun J, Beuchée A, Rouget F, Favreau A, Saliba E, Bednarek N, Morville P, Thiriez G, Marpeau L, Marret S, Kayem G, Durrmeyer X, Granier M, Baud O, Jarreau PH, Mitanchez D, Boileau P, Boulot P, Cambonie G, Daudé H, Bédu A, Mons F, Fresson J, Vieux R, Alberge C, Arnaud C, Vayssière C, Truffert P, Pierrat V, Subtil D, D'Ercole C, Gire C, Simeoni U, Bongain A, Sentilhes L, Rozé JC, Gondry J, Leke A, Deiber M, Claris O, Picaud JC, Ego A, Debillon T, Poulichet A, Coliné E, Favre A, Fléchelles O, Samperiz S, Ramful D, Branger B, Benhammou V, Foix-L'Hélias L, Marchand-Martin L, Kaminski M. Survival and morbidity of preterm children born at 22 through 34 weeks' gestation in France in 2011: results of the EPIPAGE-2 cohort study. *JAMA Pediatr* 2015; **169**: 230-238 [PMID: 25621457 DOI: 10.1001/jamapediatrics.2014.3351]
- 48 **Committee on Fetus and Newborn; American Academy of Pediatrics**. Respiratory support in preterm infants at birth. *Pediatrics* 2014; **133**: 171-174 [PMID: 24379228 DOI: 10.1542/peds.2013-3442]
- 49 **Perleman JM**, Wyllie J, Kattwinkel J, Atkins DL, Chameides L, Goldsmith JP, Guinsburg R, Hazinski MF, Morley C, Richmond S, Simon WM, Singhal N, Szlyd E, Tamura M, Velaphi S. Part 11: Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation* 2010; **122**: S516-S538 [PMID: 20956259 DOI: 10.1161/CIRCULATIONAHA.110.971127]
- 50 **Schmölzer GM**, Kumar M, Pichler G, Aziz K, O'Reilly M, Cheung PY. Non-invasive versus invasive respiratory support in preterm infants at birth: systematic review and meta-analysis. *BMJ* 2013; **347**: f5980 [PMID: 24136633 DOI: 10.1136/bmj.f5980]
- 51 **Morley CJ**, Davis PG, Doyle LW, Brion LP, Hascoet JM, Carlin JB. Nasal CPAP or intubation at birth for very preterm infants. *N Engl J Med* 2008; **358**: 700-708 [PMID: 18272893 DOI: 10.1056/NEJMoa072788]
- 52 **SUPPORT Study Group of the Eunice Kennedy Shriver NICHD Neonatal Research Network**, Finer NN, Carlo WA, Walsh MC, Rich W, Gantz MG, Laptook AR, Yoder BA, Faix RG, Das A, Poole WK, Donovan EF, Newman NS, Ambalavanan N, Frantz ID, Buchter S, Sánchez PJ, Kennedy KA, Laroia N, Poindexter BB, Cotten CM, Van Meurs KP, Duara S, Narendran V, Sood BG, O'Shea TM, Bell EF, Bhandari V, Watterberg KL, Higgins RD. Early CPAP versus surfactant in extremely preterm infants. *N Engl J Med* 2010; **362**: 1970-1979 [PMID: 20472939 DOI: 10.1056/NEJMoa0911783]
- 53 **Dunn MS**, Kaempf J, de Klerk A, de Klerk R, Reilly M, Howard D, Ferrelli K, O'Connor J, Soll RF. Randomized trial comparing 3 approaches to the initial respiratory management of preterm

- neonates. *Pediatrics* 2011; **128**: e1069-e1076 [PMID: 22025591 DOI: 10.1542/peds.2010-3848]
- 54 **Sandri F**, Plavka R, Ancora G, Simeoni U, Stranak Z, Martinelli S, Mosca F, Nona J, Thomson M, Verder H, Fabbri L, Halliday H. Prophylactic or early selective surfactant combined with nCPAP in very preterm infants. *Pediatrics* 2010; **125**: e1402-e1409 [PMID: 20439601 DOI: 10.1542/peds.2009-2131]
- 55 **Finer NN**, Carlo WA, Duara S, Fanaroff AA, Donovan EF, Wright LL, Kandefer S, Poole WK. Delivery room continuous positive airway pressure/positive end-expiratory pressure in extremely low birth weight infants: a feasibility trial. *Pediatrics* 2004; **114**: 651-657 [PMID: 15342835]
- 56 **Alallah J**. Early CPAP versus Surfactant in Extremely Preterm Infants. *J Clin Neonatol* 2012; **1**: 12-13 [PMID: 24027675]
- 57 **O'Donnell CP**, Schmölzer GM. Resuscitation of preterm infants: delivery room interventions and their effect on outcomes. *Clin Perinatol* 2012; **39**: 857-869 [PMID: 23164183 DOI: 10.1016/j.clp.2012.09.010]
- 58 **Wyckoff MH**. Delivery room resuscitation. In: Rudolph CDRA LE, First LR, Gershon AA, editors. *Rudolph's Pediatrics*. 22nd ed. New York: McGraw Hill, 2011: 164-170
- 59 **Tingay DG**, Bhatia R, Schmölzer GM, Wallace MJ, Zahra VA, Davis PG. Effect of sustained inflation vs. stepwise PEEP strategy at birth on gas exchange and lung mechanics in preterm lambs. *Pediatr Res* 2014; **75**: 288-294 [PMID: 24257321 DOI: 10.1038/pr.2013.218]
- 60 **Mehler K**, Grimme J, Abele J, Huenseler C, Roth B, Kribs A. Outcome of extremely low gestational age newborns after introduction of a revised protocol to assist preterm infants in their transition to extrauterine life. *Acta Paediatr* 2012; **101**: 1232-1239 [PMID: 23113721 DOI: 10.1111/apa.12015]
- 61 **Schmölzer GM**, Kumar M, Aziz K, Pichler G, O'Reilly M, Lista G, Cheung PY. Sustained inflation versus positive pressure ventilation at birth: a systematic review and meta-analysis. *Arch Dis Child Fetal Neonatal Ed* 2015; **100**: F361-F368 [PMID: 25550472 DOI: 10.1136/archdischild-2014-306836]
- 62 **Lindner W**, Högel J, Pohlandt F. Sustained pressure-controlled inflation or intermittent mandatory ventilation in preterm infants in the delivery room? A randomized, controlled trial on initial respiratory support via nasopharyngeal tube. *Acta Paediatr* 2005; **94**: 303-309 [PMID: 16028648]
- 63 **Lista G**, Boni L, Scopesi F, Mosca F, Trevisanuto D, Messner H, Vento G, Magaldi R, Del Vecchio A, Agosti M, Gizzi C, Sandri F, Biban P, Bellettato M, Gazzolo D, Boldrini A, Dani C. Sustained lung inflation at birth for preterm infants: a randomized clinical trial. *Pediatrics* 2015; **135**: e457-e464 [PMID: 25624390 DOI: 10.1542/peds.2014-1692]
- 64 **te Pas AB**, Walther FJ. A randomized, controlled trial of delivery-room respiratory management in very preterm infants. *Pediatrics* 2007; **120**: 322-329 [PMID: 17671058]
- 65 **Harling AE**, Beresford MW, Vince GS, Bates M, Yoxall CW. Does sustained lung inflation at resuscitation reduce lung injury in the preterm infant? *Arch Dis Child Fetal Neonatal Ed* 2005; **90**: F406-F410 [PMID: 15863490]
- 66 **Foglia EE**, Owen LS, Thio M Ratcliffe SJ, Lista G, te Pas A, Hummler H, Nadkarni V, Ades A, Posencheg M, Keszler M, Davis P, Kirpalani H. Sustained Aeration of Infant Lungs (SAIL) trial: study protocol for a randomized controlled trial. *Trials* 2015; **16**: 95
- 67 **Wyckoff MH**. Initial resuscitation and stabilization of the periviable neonate: the Golden-Hour approach. *Semin Perinatol* 2014; **38**: 12-16 [PMID: 24468564 DOI: 10.1053/j.semperi.2013.07.003]
- 68 **Zonios G**, Shankar U, Iyer VK. Pulse oximetry theory and calibration for low saturations. *IEEE Trans Biomed Eng* 2004; **51**: 818-822 [PMID: 15132508]
- 69 **Saugstad OD**, Aune D, Aguar M, Kapadia V, Finer N, Vento M. Systematic review and meta-analysis of optimal initial fraction of oxygen levels in the delivery room at  $\leq 32$  weeks. *Acta Paediatr* 2014; **103**: 744-751 [PMID: 24716824 DOI: 10.1111/apa.12656]
- 70 **Harling AE**, Beresford MW, Vince GS, Bates M, Yoxall CW. Does the use of 50% oxygen at birth in preterm infants reduce lung injury? *Arch Dis Child Fetal Neonatal Ed* 2005; **90**: F401-F405 [PMID: 15863491]
- 71 **Rabi Y**, Singhal N, Nettel-Aguirre A. Room-air versus oxygen administration for resuscitation of preterm infants: the ROAR study. *Pediatrics* 2011; **128**: e374-e381 [PMID: 21746729 DOI: 10.1542/peds.2010-3130]
- 72 **Ezaki S**, Suzuki K, Kurishima C, Miura M, Weilin W, Hoshi R, Tanitsu S, Tomita Y, Takayama C, Wada M, Kondo T, Tamura M. Resuscitation of preterm infants with reduced oxygen results in less oxidative stress than resuscitation with 100% oxygen. *J Clin Biochem Nutr* 2009; **44**: 111-118 [PMID: 19177196 DOI: 10.3164/jcbn.08-221]
- 73 **Oei J**. The To2rpid0 Study: Targeted Oxygenation in the Resuscitation of Premature Infants and their Developmental Outcome. 2010-12-02. Available from: URL: <http://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=335870>
- 74 **US FDA**. Study of Room Air versus 60% Oxygen for Resuscitation of Premature Infants (PRESOX). 2013-05-18. Available from: URL: <http://www.clinicaltrials.gov/ct2/show/NCT01773746>
- 75 **Dawson JA**, Kamlin CO, Vento M, Wong C, Cole TJ, Donath SM, Davis PG, Morley CJ. Defining the reference range for oxygen saturation for infants after birth. *Pediatrics* 2010; **125**: e1340-e1347 [PMID: 20439604 DOI: 10.1542/peds.2009-1510]
- 76 **Vento M**, Cubells E, Escobar JJ, Escrig R, Aguar M, Brugada M, Cernada M, Saénz P, Izquierdo I. Oxygen saturation after birth in preterm infants treated with continuous positive airway pressure and air: assessment of gender differences and comparison with a published nomogram. *Arch Dis Child Fetal Neonatal Ed* 2013; **98**: F228-F232 [PMID: 23123635 DOI: 10.1136/archdischild-2012-302369]
- 77 **Hawkes GA**, Kelleher J, Ryan CA, Dempsey EM. A review of carbon dioxide monitoring in preterm newborns in the delivery room. *Resuscitation* 2014; **85**: 1315-1319 [PMID: 25086296 DOI: 10.1016/j.resuscitation.2014.07.012]

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