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Abstract

A careful assessment of the postnatal condition of a newborn is mandatory. However, to assess the condition appropriately, the purpose of the assessment has to be known. The following three aims of assessing an infant's postnatal condition are discussed: (1) To predict outcome and to perform clinical studies, an objective, numerical score is needed to describe the condition of groups of infants. The Combined Apgar consists of the Specified and the Expanded Apgar and allows a more detailed description of infant's postnatal condition. Whereas the Specified Apgar describes the infant's condition regardless of gestational age and interventions needed to achieve the condition, the Expanded Apgar gives a description of the administered interventions. (2) To guide interventions in clinical routine, a conceptual approach for assessing the postnatal condition in the individual infant is needed. The single items of the conventional Apgar score are a system of interdependent variables; respiration affects oxygenation (color), which affects heart rate and subsequently muscle tone and reflexes. Keeping the interdependency in mind helps to give the appropriate medical support. (3) To improve the quality of delivery room management in extremely preterm infants, a detailed description of the clinical condition, administered interventions with the subsequent response, and other environmental factors (team work, communication, technical parameters, etc) are needed. For that purpose, new technologies have demonstrated to be more reliable than clinical assessment to evaluate the classic Apgar parameters and on the other hand, uniform recordings of resuscitation interventions should be performed. In relation to this, video recording in the delivery room might help to register all these data as objectively as possible.

Objectives After completing this article, readers should be able to:

1. Distinguish between three different purposes of evaluating postnatal condition of the newborn.
2. Properly assess the newborn in the delivery room by using the best available technology.
3. Score infant's condition and interventions needed to achieve the condition.
4. Record carefully all interventions made during the resuscitation process.
5. Critically evaluate the quality of delivery room management.

Why Is an Assessment of an Infant's Postnatal Condition Needed?

Transition from fetal to neonatal life represents a major challenge. Term infants mainly adapt spontaneously to postnatal conditions, and only a few of them will require medical support in the form of resuscitative interventions due to life-threatening complications during birth. Preterm infants are often born because of maternal problems. Because vital parameters in these infants are not disturbed, resuscitation becomes seldom necessary. However, preterm infants do often require medical support during postnatal adaptation due to immaturity of organ systems.

The process of postnatal adaptation and the need for interventions varies between infants. Thus, an individual approach with a careful evaluation of the postnatal condition

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is required. To assess the condition appropriately, the purpose of the assessment has to be known.

The following three aims of assessing an infant's postnatal condition will be discussed in more detail:

1. To predict outcome and to perform clinical studies, an objective, numerical score is needed to describe the condition of groups of infants.
2. To guide interventions in clinical routine, a conceptual approach for assessing the postnatal condition in the individual infant is needed.
3. To improve quality of delivery room (DR) management in extremely preterm infants, a detailed description of the clinical condition, administered interventions with the subsequent response, and other environmental factors (team work, communication, technical parameters, etc) are needed.

A Numerical Score to Assess Groups of Infants

Management in the DR should be based on clinical evidence. The clinician not only needs to know about the efficacy of medical interventions but should also be able to predict the risk of mortality and morbidity. Therefore, valid clinical data for large groups of infants are needed.

A Historical Perspective

The question on the prognosis of a newborn is not a recent one. Soranus and Temkin (1) put the question ~2,000 years ago as follows: "How to recognize the newborn that is worth rearing?" According to his description, "the infant, which is suited by nature for rearing will be distinguished … by the fact that it has been born at the due time … it immediately cries with proper vigor … and is properly sensitive in every respect."

At the end of the 19th century, Max Runge (2) in his text book "Die Krankheiten der ersten Lebenstage" mentioned the following aspects as being of importance for the assessment of the newborn: a deep blue skin color is a sign of moderate asphyxia, whereas the skin is pale in infants who have severe asphyxia. Heart frequency is slow but strong in mild asphyxia but weak in severe asphyxia. Respiration is missing in both types of asphyxia. Although the infant responds to an external stimulus in mild asphyxia, there is no response in infants who have severe asphyxia. Muscle tone is weak but present in mild asphyxia but absent in severe asphyxia.

More than half a century later, Virginia Apgar developed a score consisting of five clinical signs: heart rate (HR), skin color, respiratory efforts, muscle tone, and reflex status. (3) The score, which bears her name, is now being used to describe the postnatal condition of almost every newborn in developed countries.

The Apgar Score: How It Is Used Today

The Apgar score was initially designed to help in deciding what interventions are required to support postnatal adaptation. However, it has been (mis-)used for different purposes in subsequent years.

Shortly after its introduction in clinical routine, the Apgar score was used to predict mortality, not only in term but also in preterm infants. (4)(5)(6)(7) Because it was not her initial intention, Apgar warned that the score cannot be used to predict outcome in individual infants but only in groups of infants. (8)

Later, the score was also used to predict neurological long-term outcome. (9) Even recent studies, using the Apgar score, reveal "infants with a poor condition at birth have an increased risk of poor functioning in cognitive test at age 18, even if they recovered quickly and did not develop encephalopathy." (10) In the light of newly emerging therapies, the use of the Apgar score to predict mortality and neurological disability and to subsequently help in clinical decision-making was discussed. (11)(12)

Besides using the Apgar score to predict outcome of groups of infants, it has also been used for clinical studies. In many studies on hypothermia, a low Apgar score was an important inclusion criterion. (13)(14) Furthermore, the authors of other studies used the Apgar score as the primary end point of DR interventions. (15)

Apgar Score: An Objective Parameter?

As described above, the Apgar score has been used for different purposes during the last decades. Therefore, it is reasonable to assume that the Apgar score represents an objective tool with a high reproducibility. However, in recent years, several studies have revealed that the "conventional Apgar" has a poor reproducibility.

Apgar et al (16) found only small variations if different caregivers assess an infant; however, she noted that the infants should be scored by someone who was not involved in the DR. O'Donnell et al (17) showed great variations if medical professionals assessed the condition of video recorded newborns. Similar variations were described by Lopriore et al (18) by using written case descriptions. Our group was able to show that variation on assessing written case descriptions directly translate into variations in clinical care. Centers that scored low case descriptions did also have lower Apgar scores in their very low birth weight infants. (19)

The large variations can be explained by two main reasons. Despite assessing preterm infants, Virginia Apgar did not define how to evaluate muscle score and reflexes in preterm infants. Because both are physiologically reduced when compared with term infants, it has been argued to score preterm infants lower than term infants. The second reason is the missing agreement on how to score the condition of infants receiving medical interventions. Scoring of a pink skin color in a newborn receiving oxygen can vary between zero points (because the infant requires oxygen) to two points (skin color is pink). To overcome that problem, it has been suggested to stop the intervention during scoring; however, that would be in contrast to the intention of Virginia Apgar to have a score that does not interfere with the interventions.

To objectively describe the condition of an infant appropriately without interfering with the medical interventions, a score is needed that (a) describes the condition of the infant regardless of the interventions or gestational age and (b) describes the medical interventions needed to achieve the condition. (20)

The Combined Apgar

To overcome that problem, we have suggested a specification of the conventional Apgar score. (21) According to our suggestion, the Specified Apgar will contain the same items as the Conventional Apgar; however, this will slightly change its perspective. It will describe the condition regardless of the interventions needed to achieve the condition or the gestational age. Thus, for instance the term "respiration" will be substituted by "chest movement" regardless of its origin. The advantage of that specification is an assessment without interfering with medical interventions (Fig 1).

In addition to that specification, the American Academy of Pediatrics and the American College of Obstetricians and Gynecologists suggested an extension of the conventional Apgar score. (22) This Expanded Apgar will count the medical interventions given to the infant. If the infant receives an intervention, it will be scored 0; if not, the intervention is scored 1. Thus, an optimal Expanded Apgar of 7 points describes an infant who is receiving no interventions; a score of 0 points represents an infant receiving all seven interventions (Fig 1).

The combination of both scores (Combined Apgar) results in a maximum of 17 points and describes a perfect clinical condition of the infant without any medical intervention. In contrast, a poor score of 0 points will describe an infant who is receiving all resuscitative interventions but without any clinical response.

The Combined Apgar has been tested in a multicenter trial (entitled "Trial to evaluate a specified type of Apgar") in preterm infants. We were able to show that the Combined Apgar predicts perinatal mortality significantly better than the Specified or Expanded Apgar alone. Currently, the Combined Apgar is also tested in term infants requiring postnatal interventions.

A Conceptual Approach to Guide Management of the Individual Infant

Although clinical decisions are based on data obtained from groups of infants, in a clinical routine a conceptual approach will help to evaluate the clinical situation of the individual infant and help to guide interventions. Virginia Apgar's original intent was to provide a valuable tool that helps to decide what to do in clinical routine. However, that aspect has been forgotten due to (mis-)using the Apgar score as a tool to predict outcome.

Recently, Pinheiro (23) revitalized the usage of the Apgar score as a system of interdependent parameters.

The clinician should be aware of the importance of respiration during the process of postnatal adaptation. Disturbances in respiration will cause deterioration in oxygenation (skin color), which subsequently will lead to poor cardiac perfusion causing bradycardia (HR). As a consequence, ventilation and oxygenation do not improve, muscle tone decreases, and subsequently muscle reflexes disappear. Viewing the Apgar score as a circle of interdependent variables will help with understanding the process of postnatal adaptation and guiding interventions. It stresses the importance of respiration within the complex process of postnatal adaptation. Therefore, causal treatment of low HR will be respiratory support instead of cardiac massage. The interdependency of single Apgar items is shown in Figure 2.

A Detailed Description to Improve the Quality of DR Management

There are significant intercenter variations not only in the outcome of preterm infants but also in the care given. (24)(25) It could be speculated that reducing variations will not only improve care of the newborn but will also help to improve the outcome in that vulnerable population.

A first step in decreasing variations is awareness of variations. Although different benchmarking activities concerning the care in the NICU have been described, (26)(27)(28) the DR still represents a magic black box. Only a small group of professionals takes care of the newborn and reports thereafter upon their activities. Thus, an objective, external evaluation of the interventions is difficult to obtain.

		Minute(s)		
		1	5	10
C	Continuous positive airway pressure[a]			
O	Oxygen			
M-B	Mask and Bag Ventilation[b]			
I	Intubation and Ventilation			
N	Neonatal Chest Compression			
E	Exogenous Surfactant			
D	Drugs			
	Sum of *Expanded Apgar*			
	Scoring each item: 0 = intervention was performed; 1 = no intervention was performed			
	[a] Score 0 if "Mask and Bag" or "Intubation and Ventilation" is scored 0 [b] Score 0 if "Intubation and Ventilation" is scored 0			
A	Appearance (Skin Color) 2 = Completely pink 1 = Centrally pink with acrocyanosis 0 = Centrally blue or pale			
P	Pulse (HR) 2 = >100 beats per min 1 = <100 beats per min 0 = no heart beat			
G	Grimmacing (Reflex) 2 = Appropriate for gestational age 1 = Reduced for gestational age 0 = No reflex response			
A	Appearance (Muscle tone) 2 = Appropriate for gestational age 1 = Reduced for gestational age 0 = No reflex response			
R	Respiration (Chest movement) 2 = Regular chest movement 1 = Small or irregular chest movement 0 = No chest movement			
	Sum of *Specified Apgar*			
Total (Sum of *Expanded + Specified*)				

Figure 1. The Combined Apgar: Consists of the Expanded and Specified Apgar.

To raise awareness of the management in the DR and to expose the situation to effective benchmarking activities, a detailed description of the postnatal situation is warranted. The description should include a detailed recording of vital parameters, of administered medical interventions, of teamwork, and other influencing factors (that maybe nobody is aware of at the moment).

These data can be used not only to improve individual performance but also team interaction. Furthermore, these recordings provide good data for teaching young colleagues and for benchmarking activities.

Recording Vital Parameters

Although the Apgar score contains different vital parameters, recent studies have revealed that these clinical signs are relevant to subjective interpretation by the caregiver. To obviate these inconveniences and seeking objectivity, more reliable approaches have been developed in the last 10 years. This approach brings DR stabilization much closer to the new concept of DR intensive care emphasized by Vento et al, (29) providing a controlled and monitored environment in these first golden minutes after birth, which have been shown to be one of the most decisive moments in the newborn's life. (30)

OXYGENATION. Accuracy in the clinical assessment of color in the first minutes after birth is poor. O'Donnell et al (31) demonstrated a low consistency when they tried to match the perception of "pink" color and oxygen saturation measured by pulse oximetry among medical and nursing staff.

Oxygenation can be easily measured by pulse oximetry. In addition, Kopotic et al (32) confirmed an improvement in patient outcome

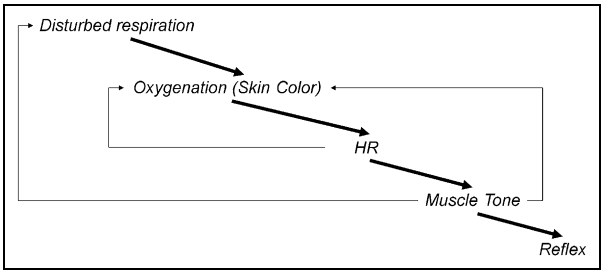

Figure 2. Apgar score as a system of interdependent parameters.

when this new technology was applied to newborn resuscitation in terms of more appropriate and gentle management. The use of pulse oximetry is even more important during preterm infant resuscitation because frequently they require assistance with ventilatory support and supplementary oxygen only because of their premature condition.

Given that in this period premature infants are most vulnerable to both hyper- and hypoxemia, the need to provide a strict control of oxygenation state has been confirmed. (33) Of note, the new resuscitation guidelines have echoed all these clinical research studies, and the 2010 recommendations have removed color for oxygenation assessment and have included pulse oximetry as the routine method. (34) Therefore, it is desirable that all DRs have a pulse oximetry for oxygen monitoring and all teams involved in resuscitation know how to use it. Some studies have revealed that measurements are obtained faster by applying the oximeter sensor on the right hand (preductal) and attaching it to the infant before connecting it to the oximeter. (35) Finally, it is essential to know the dynamic changes in pulse oxygen saturation in both term and preterm infants. Dawson et al (36) have published the first reference chart showing pulse oxygen saturation changes in the first minutes after birth, providing a tool for guiding oxygen administration in the DR.

HEART RATE. HR guides the need of resuscitation and the efficacy of this. International consensus statements recommend HR evaluation by auscultation or palpation of umbilical cord pulsations, but this traditionally performed appraisal has also important inconsistencies. Kamlin et al (37) compared HR determined clinically with data obtained from electrocardiographic monitoring of the newly born infant as gold standard and found that clinical methods were inaccurate and often underestimated the real HR.

The slow reading in a wet newborn and the technical difficulties of electrocardiographic monitoring in the DR make it hard for widespread use. Instead of this, heart monitoring in the DR can be easily performed by pulse oximetry and has been shown to be the best available procedure to reliably evaluate both parameters (HR and saturation). Kamlin et al (38) corroborated how pulse oximetry can provide an accurate display of HR in the DR including infants receiving advance resuscitation. Because of that, once again, pulse oximetry proves to be the best option to monitor heart beat and avoid unnecessary resuscitation maneuvers. Besides, Dawson et al (39) published recently the first centile charts of HR changes in the first minutes after birth, which now makes it possible to guide resuscitation accurately.

RESPIRATION. Resuscitation guidelines state that newborn respiratory effort should be assessed and if it is not sufficient or the patient is apneic, intermittent positive-pressure ventilation must be initiated. The peak inflating pressures used must achieve chest movement, trying to open the lung, and administering a physiologic tidal volume. However, chest rise is a subjective measure of chest expansion and has an inaccurate correlation with the tidal volume given, as has been shown by Brugada et al. (40) Therefore, low or excessive volumes may be given leading to inadequate ventilation or volutrauma. On the other hand, mask leak is a common and underestimated problem during ventilation, reported as high as 100%, (41) making the situation worse. Consequently, better assessment of ventilatory support is needed in the DR, and recent publications have confirmed how the use of respiratory function monitors can improve ventilatory techniques, allowing recognition of incorrect pressures and mask leak. (42)

Recording Administered Medical Interventions

Registration of medical interventions at any point of care of the newborn is a universal practice at NICUs. However, this is not always so in the DR, and important actions are often not recorded and lost. Like any other time in patient care, maneuvers, drugs, or any other support should be carefully registered besides the classical parameters of the Apgar score. Data collection should be performed in a uniform manner with defined criteria because of medico-legal and professional implications, and more important, for improving the quality of care, research, and resource provision. All registered information could determine the most effective actions during neonatal resuscitation.

VENTILATION. Ventilatory support is clearly the most recurrent and important intervention in neonatal resuscitation. It is necessary to collect the reason for needing respiratory support, airway management (opening

maneuvers, suction), type of support (continuous positive airway pressure or intermittent positive pressure ventilation), device used, and parameters administered such as peak pressure, end expiratory pressure, flow, and supplementary oxygen. If intubation is needed, also register the moment of intubation and the number of attempts.

CHEST COMPRESSION. Chest compressions are infrequently given in the DR but mean a greater severity. The essential information to record is the moment of starting and its duration.

DRUGS. The use of medications during neonatal resuscitation is an even more uncommon event, required in only 0.1% to 0.15% of all live-born deliveries. Any drug dispensed during neonatal resuscitation should be registered with its doses and route of administration.

Video Recording DR Management

The Apgar score has been, for decades, the only way to compare resuscitation results with regard to patient outcome and between different centers. However, Apgar scoring has a poor interobserver reliability independent of the degree of experience or qualification, which has been shown by using video recording of newborn resuscitation. (17) Of note, video recording has been used to evaluate patients' behavior since the 1980s. Neonates were first video recorded to monitor feeding behavior, (43) presence of seizures, (44) or even sleeping patterns. (45) A few years later, this technology was applied to the DR. The first study in this area was carried out to evidence the kind of touch a preterm infant receives during the resuscitation, including mechanical and human touch, which many times caregivers are unaware of because of the stressful environment. (46) The purpose of this qualitative study was to describe in an objective way how an intervention given in a stressful environment such as the DR was performed. Seemingly, in this scenario, it is really difficult to remember and recognize all the details related to the intervention. Furthermore, circumstances accompanying such a stressful situation are not the most favorable for learning and teaching. Resuscitation video recording has the advantage of documenting timing and events during DR interventions and has been used therefore for performing trials, audits, and internal quality improvement in many hospitals. There are some reports that trials in which this technology was used revealed video recording to be a powerful educational tool valuable in auditing and improving performance. (47)(48)(49) Therefore, the challenge in the coming years will be to establish this procedure as a routine in the DR aiming to achieve excellence in newborn resuscitation.

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American Board of Pediatrics Neonatal–Perinatal Medicine Content Specifications

- Understand the significance, limitations, and causes of low Apgar scores.

References

1. Soranus E. Temkin O (trans.). *Gynecology*. Baltimore, MD: The Johns Hopkins Press; 1956
2. Runge M. *Die Krankheiten der ersten Lebenstage. zweite, umgearbeitete und vermehrte Auflage*. Stuttgart, Germany: Verlag von Ferdinand Enke; 1893
3. Apgar V. A proposal for a new method of evaluation of the newborn infant. *Curr Res Anest Anal*. 1953;32(4):260–267
4. Drage JS, Kennedy C, Schwarz BK. The Apgar Score as an index of neonatal mortality: a report from the Collaborative Study of Cerebral Palsy. *Obstet Gynecol*. 1964;24:222–230
5. Casey BM, McIntire DD, Leveno KJ. The continuing value of the Apgar score for the assessment of newborn infants. *N Engl J Med*. 2001;344(7):467–471
6. Moster D, Lie RT, Irgens LM, Bjerkedal T, Markestad T. The association of Apgar score with subsequent death and cerebral palsy: a population-based study in term infants. *J Pediatr*. 2001;138(6):798–803
7. Mori R, Shiraishi J, Negishi H, Fujimura M. Predictive value of Apgar score in infants with very low birth weight. *Acta Paediatr*. 2008;97(6):720–723
8. Apgar V, James LS. Further observations on the newborn scoring system. *Am J Dis Child*. 1962;104:419–428
9. Nelson KB, Ellenberg JH. Apgar scores as predictors of chronic neurologic disability. *Pediatrics*. 1981;68(1):36–44
10. Odd DE, Rasmussen F, Gunnell D, Lewis G, Whitelaw A. A cohort study of low Apgar scores and cognitive outcomes. *Arch Dis Child Fetal Neonatal Ed*. 2008;93(2):F115–F120
11. Laptook AR, Shankaran S, Ambalavanan N, et al; Hypothermia Subcommittee of the NICHD Neonatal Research Network. Outcome of term infants using apgar scores at 10 minutes following hypoxic-ischemic encephalopathy. *Pediatrics*. 2009;124(6):1619–1626
12. Harrington DJ, Redman CW, Moulden M, Greenwood CE. The long-term outcome in surviving infants with Apgar zero at 10 minutes: a systematic review of the literature and hospital-based cohort. *Am J Obstet Gynecol*. 2007;196(5):463.e1–463.e5
13. Shankaran S, Laptook AR, Ehrenkranz RA, et al; National Institute of Child Health and Human Development Neonatal Research Network. Whole-body hypothermia for neonates with hypoxic-ischemic encephalopathy. *N Engl J Med*. 2005;353(15):1574–1584
14. Gluckman PD, Wyatt JS, Azzopardi D, et al. Selective head cooling with mild systemic hypothermia after neonatal encephalopathy: multicentre randomised trial. *Lancet*. 2005;365(9460):663–670

15. Hellström-Westas L, Forsblad K, Sjörs G, et al. Earlier Apgar score increases in severely depressed term infants cared for in Swedish level III units with 40% oxygen versus 100% oxygen resuscitation strategies: a population-based register study. *Pediatrics*. 2006;118(6):e1798–e1804
16. Apgar V, Holaday DA, James LS, Weisbrot IM, Berrien C. Evaluation of the newborn infant; second report. *J Am Med Assoc*. 1958;168(15):1985–1988
17. O'Donnell CPF, Kamlin COF, Davis PG, Carlin JB, Morley CJ. Interobserver variability of the 5-minute Apgar score. *J Pediatr*. 2006;149(4):486–489
18. Lopriore E, van Burk GF, Walther FJ, de Beaufort AJ. Correct use of the Apgar score for resuscitated and intubated newborn babies: questionnaire study. *BMJ*. 2004;329(7458):143–144
19. Rüdiger M, Küster H, Herting E, et al. Variations of Apgar score of very low birth weight infants in different neonatal intensive care units. *Acta Paediatr*. 2009;98(9):1433–1436
20. Rüdiger M, Braun N, Gurth H, Bergert R, Dinger J. Preterm resuscitation I: clinical approaches to improve management in delivery room. *Early Hum Dev*. 2011;87(11):749–753
21. Rüdiger M, Wauer RR, Schmidt K, Küster H. The Apgar score. [Letter to the Editor]*Pediatrics*. 2006;118(3):1314–1315, author reply 1315–1316
22. American Academy of Pediatrics, Committee on Fetus and Newborn; American College of Obstetricians and Gynecologists and Committee on Obstetric Practice. The Apgar score. *Pediatrics*. 2006;117(4):1444–1447
23. Pinheiro JMB. The Apgar cycle: a new view of a familiar scoring system. *Arch Dis Child Fetal Neonatal Ed*. 2009;94(1):F70–F72
24. Walsh MC, Wilson-Costello DE, Zadell A, Newman N, Fanaroff AA. Safety, reliability, and validity of a physiologic definition of bronchopulmonary dysplasia. *J Perinatol*. 2003;23(6):451–456
25. Vohr BR, Wright LL, Dusick AM, et al; Neonatal Research Network. Center differences and outcomes of extremely low birth weight infants. *Pediatrics*. 2004;113(4):781–789
26. Birenbaum HJ, Dentry A, Cirelli J, et al. Reduction in the incidence of chronic lung disease in very low birth weight infants: results of a quality improvement process in a tertiary level neonatal intensive care unit. *Pediatrics*. 2009;123(1):44–50
27. Geary C, Caskey M, Fonseca R, Malloy M. Decreased incidence of bronchopulmonary dysplasia after early management changes, including surfactant and nasal continuous positive airway pressure treatment at delivery, lowered oxygen saturation goals, and early amino acid administration: a historical cohort study. *Pediatrics*. 2008;121(1):89–96
28. Walsh MC, Laptook A, Kazzi SN, et al; National Institute of Child Health and Human Development Neonatal Research Network. A cluster-randomized trial of benchmarking and multimodal quality improvement to improve rates of survival free of bronchopulmonary dysplasia for infants with birth weights of less than 1250 grams. *Pediatrics*. 2007;119(5):876–890
29. Vento M, Aguar M, Leone TA, et al. Using intensive care technology in the delivery room: a new concept for the resuscitation of extremely preterm neonates. *Pediatrics*. 2008;122(5):1113–1116
30. Vento M, Cheung PY, Aguar M. The first golden minutes of the extremely-low-gestational-age neonate: a gentle approach. *Neonatology*. 2009;95(4):286–298
31. O'Donnell CPF, Kamlin COF, Davis PG, Carlin JB, Morley CJ. Clinical assessment of infant colour at delivery. *Arch Dis Child Fetal Neonatal Ed*. 2007;92(6):F465–F467
32. Kopotic RJ, Lindner W. Assessing high-risk infants in the delivery room with pulse oximetry. *Anesth Analg*. 2002;94(suppl 1):S31–S36
33. Finer N, Leone T. Oxygen saturation monitoring for the preterm infant: the evidence basis for current practice. *Pediatr Res*. 2009;65(4):375–380
34. Perlman JM, Wyllie J, Kattwinkel J, et al; Neonatal Resuscitation Chapter Collaborators. Part 11: neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation*. 2010;122(16 suppl 2):S516–S538
35. Dawson J, Davis P, O'Donnell C. Pulse oximetry for monitoring infants in the delivery room: a review. *Arch Dis Chil Fetal Neonatal Ed*. 2007;92:F4–F7
36. Dawson JA, Kamlin CO, Vento M, et al. Defining the reference range for oxygen saturation for infants after birth. *Pediatrics*. 2010;125(6):e1340–e1347
37. Kamlin COF, O'Donnell CPF, Everest NJ, Davis PG, Morley CJ. Accuracy of clinical assessment of infant heart rate in the delivery room. *Resuscitation*. 2006;71(3):319–321
38. Kamlin COF, Dawson JA, O'Donnell CPF, et al. Accuracy of pulse oximetry measurement of heart rate of newborn infants in the delivery room. *J Pediatr*. 2008;152(6):756–760
39. Dawson JA, Kamlin CO, Wong C, et al. Changes in heart rate in the first minutes after birth. *Arch Dis Child Fetal Neonatal Ed*. 2010;95(3):F177–F181
40. Brugada M, Schilleman K, Witlox RS, Walther FJ, Vento M, Te Pas AB. Variability in the assessment of 'adequate' chest excursion during simulated neonatal resuscitation. *Neonatology*. 2011;100(1):99–104
41. Schmölzer GM, Kamlin OC, O'Donnell CP, Dawson JA, Morley CJ, Davis PG. Assessment of tidal volume and gas leak during mask ventilation of preterm infants in the delivery room. *Arch Dis Child Fetal Neonatal Ed*. 2010;95(6):F393–F397
42. Schmölzer GM, Morley CJ, Wong C, et al. Respiratory function monitor guidance of mask ventilation in the delivery room: a feasibility study. *J Pediatr*. 2012;160(3):377–381, e2
43. Rybski DA, Almli CR, Gisel EG, Powers J, Maurer M Jr. Sucking behaviors of normal 3-day-old female neonates during a 24-hr period. *Dev Psychobiol*. 1984;17(1):79–86
44. Mizrahi EM, Kellaway P. Characterization and classification of neonatal seizures. *Neurology*. 1987;37(12):1837–1844
45. Drakulic BS, Garbanati JA, Gold MN. Design of a data-acquisition system for monitoring sleep organization in preterm infants. *Biomed Instrum Technol*. 1989;23(1):44–49
46. Kitchin LW, Hutchinson S. Touch during preterm infant resuscitation. *Neonatal Netw*. 1996;15(7):45–51
47. Carbine DN, Finer NN, Knodel E, Rich W. Video recording as a means of evaluating neonatal resuscitation performance. *Pediatrics*. 2000;106(4):654–658
48. Ellis DG, Lerner EB, Jehle DV, Romano K, Siffring C. A multistate survey of videotaping practices for major trauma resuscitations. *J Emerg Med*. 1999;17(4):597–604
49. Finer NN, Rich W. Neonatal resuscitation: toward improved performance. *Resuscitation*. 2002;53(1):47–51

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