Evaluation of a Comprehensive Delivery Room Neonatal Resuscitation and Adaptation Score (NRAS) Compared to the Apgar Score: A Pilot Study

Shadi R. Jurdi, MD[1], Archana Jayaram, MBBS[1], Adam P. Sima, PhD[1], and Karen D. Hendricks Muñoz, MD, MPH, FAAP[1]

Abstract

This study evaluated the interrater reliability and perceived importance of components of a developed neonatal adaption score, Neonatal Resuscitation Adaptation Score (NRAS), for evaluation of resuscitation need in the delivery room for extremely premature to term infants. Similar to the Apgar, the NRAS highest score was 10, but greater weight was given to respiratory and cardiovascular parameters. Evaluation of provider (N = 17) perception and scoring pattern was recorded for 5 clinical scenarios of gestational ages 23 to 40 weeks at 1 and 5 minutes and documenting NRAS and Apgar score. Providers assessed the tool twice within a 1-month interval. NRAS showed superior interrater reliability ($P < .001$) and respiratory component reliability ($P < .001$) for all gestational ages compared to the Apgar score. These findings identify an objective tool in resuscitation assessment of infants, especially those of smaller gestation age, allowing for greater discrimination of postbirth transition in the delivery room.

Keywords

neonatal, resuscitation, Apgar, delivery room management

Introduction

For the past 5 decades, the Apgar score has been the primary tool used when evaluating the clinical status of neonates at birth. The Apgar score is not a tool to identify need for intervention but provides an overview of the infant's postdelivery transition in the delivery room.[1] Apgar parameters used include respiratory effort, muscle tone, reflex activity, heart rate, and color, with each component valued equally in infants with or without intubation or need for respiratory support (Table 1).[2] Additionally, though not intended for this use, the Apgar score has been used to predict later neonatal morbidity risk and outcome. For instance, in a retrospective cohort of infants between 26 and 36 weeks gestation, a higher neonatal mortality risk was noted for those infants with an Apgar score less than 3 at 5 minutes compared to those with Apgar scores greater than 7.[3] Additionally, the Apgar score has been used to predict neurologic outcome and as a criteria to define neonatal asphyxia.[4] Although universally accepted for its ease and simplicity, recognizing the use, limitations, and predictive abilities of Apgar scoring is also vital.[5,6] There are components

of the Apgar score that are subjective (color) and others that do not accurately reflect need for respiratory stabilization practices in the delivery room including use of continuous positive airway pressure or the physiological immaturity of a premature infant.[7] This subjectivity as well as lack of inclusion of provider care logically correlate inversely with the consistency of the Apgar score from one clinician to the next. Recent publications have shown significant variation in assigning color, respiratory component, and reflex irritability by providers and have called for an improved method in assessing response to resuscitation.[1,8,9] O'Donnell et al[10] found substantial variation in the perception of infant color following clinicians' assessment of video recordings of newborn births. Additionally, institutional variability

[1]Virginia Commonwealth University Medical Center, Richmond, VA, USA

Corresponding Author:
Shadi R. Jurdi, Virginia Commonwealth University Medical Center, Neonatal Intensive Care Unit, PO Box 980276, Richmond, VA 23298, USA.
Email: shadijurdimd@gmail.com

Table 1. Description of the Apgar and NRAS Scores.

Item	Apgar Score			Item	NRAS Score		
	0	1	2		0	1	2
Appearance (skin) (C1)	Blue/grey, pale (cyanosis)	Bluish extremities with body pink	Pink	Heart rate (C1)	Absent	<100	>100
Pulse (heart rate) (C2)	Absent	<100	>100	Cardiovascular support (C2)	No response to chest compressions	HR improves to >60 with chest compressions	No additional cardiovascular support
Grimace (reflex irritability) (N1)	No response	Grimace, weak cry when stimulated	Cry or pull away when stimulated	Reflex response (palmar grasp) (N1)	No grasp reflex	Incomplete grasp (partial flexion of fingers)	
Activity (muscle tone) (N2)	None	Arms and legs flexed	Active movement	Supplemental oxygen (R1)	>40%	≤40%	Room air (21%)
Respiration (R1)	Absent	Irregular/gasping	Good, crying	Respiratory support (R2)	PPV° with no spontaneous effort	CPAP or PPV° with irregular spontaneous effort	No additional respiratory support

Abbreviations: NRAS, Neonatal Resuscitation Adaptation Score; HR, heart rate; PPV°, positive pressure ventilation via either mask or endotracheal tube; CPAP, continuous positive airway pressure.

was identified with large differences noted particularly in respiration, muscle tone, and reflex scores.[11] Furthermore, interobserver variability has been noted using a variance component model for respiratory effort, muscle tone, reflex irritability, and color at 5 minutes of life.[12]

The "Expanded Apgar Score" by the American Academy of Pediatrics (Fetus and Newborn Committee) was proposed to reflect resuscitative interventions, but does not propose specific scores for resuscitative interventions leaving room for subjectivity, especially with the respiratory score component during resuscitation. Additionally, the *International Liaison Committee on Resuscitation* proposed changes in the Consensus on Resuscitation Science and Treatment Recommendation document that included the use of pulse oximetry as well as limiting the fraction of inspired oxygen delivered to a neonate based on oxygen targets.[13] Furthermore, continuous positive airway pressure is also recommended for use in the delivery room as studies have indicated reduced need for intubation and rate of mechanical ventilation particularly for the premature infant.[1,14,15] With the recent Neonatal Resuscitation Program (NRP) adopting these new recommendations, there is a need to incorporate these changes within the framework of neonatal resuscitation into a standardized and simple scoring system to assist in identification of neonatal health status as well as record need for resuscitation to address neonatal transition responses regardless of gestational age.[7]

The objective of this study was to develop and assess the interrater reliability of the Neonatal Resuscitation and Adaptation Score (NRAS; Table 1) as a quick and efficient tool in the delivery room to determine both the initial status as well as the need and response to resuscitation for both term and preterm infants.

Materials/Subjects and Methods

Development of the NRAS Tool

The NRAS was developed by the authors and the content validity reviewed for representativeness, clarity, and importance by an additional 2 neonatologists and 1 neonatal nurse practitioner. The tool uses 5 objective parameters of respiratory, cardiovascular, and neurological systems. Two parameters assessed the newborn's cardiovascular status, 2 measured the newborn's respiratory status, and 1 parameter, palmar grasp reflex, measured the neurologic of each newborn. Heart rate (C1) was used in NRAS as it is a quick and objective measure. The degree of cardiovascular support (C2) was used in order to not only assess response to resuscitation but also allow the provider to have additional information that may go overlooked by just utilizing the Apgar score. Supplemental oxygen (R1) and respiratory support (R2) were chosen due to their objectiveness and routine practice in current-day neonatal resuscitation. The Palmar (grasp) reflex (N1) was chosen as it is one of the earliest primitive reflexes to appear and can be easily assessed both in preterm and term neonates.[16-18]

Provider Utilization and Validation of NRAS

A prospective pilot study was conducted at Children's Hospital Of Richmond at VCU to study utilization and comparison of the NRAS to the Apgar score. Brief de-identified 15-second video snippets during 1 minute and 5 minutes of life of 5 neonates (ranging from 23 weeks to 40 weeks gestation) were sent via electronic format to neonatal health care providers who routinely use the Apgar score. Video recorded scenarios had no identifiers (MRN, date of birth, etc) visible during the recording

process. The gestational ages (weeks) of Case 1 to 5 were 23 weeks, 24 weeks, 27 weeks, 32 weeks, and 40 weeks, respectively. Each case demonstrated varying degrees of stabilization and/or resuscitation. The earliest gestation of 23 weeks was used given current institutional practice of 23 weeks being the earliest viable age. Each video included the degree of respiratory support, cardiovascular support (eg, current heart rate), pulse oximetry reading, and the percentage of inspired oxygen being delivered. For example, for patient 4 (32 weeks gestation) at 5 minutes, the text appeared above the patient indicating that he was breathing room air, pulse oximetry recorded as 96%, and a current heart rate of 151. For the NRAS videos an additional arrow popped up to indicate the palmar grasp being done as well as any additional cardiovascular support needed (eg, chest compressions were given between 1 and 5 minutes of life).

The videos were viewed by the providers twice. The health care providers were randomly divided into 2 groups: one group was asked to score the newborn in each video using the Apgar score and the alternate group was asked to score the newborn in each video using the NRAS scale. Following a 1-month washout period, the same scenarios were sent out to the same providers alternating the score group. An anonymous survey of participating health care professionals identified demographic characteristics of the providers including sex, age, NRP status, work status in the neonatal intensive care unit, and delivery room birth attendance frequency.

Institutional review board approval was obtained for all aspects of the study, and the health care providers participated voluntarily and gave implied consent. Confidentiality was maintained according to the Health Insurance Portability and Accountability Act regulations with regard to any information collected. Policy followed the VCU health System policy of Authorization to Interview and use Photographic, Digital, or Video Images on a Minor child, H-MR-07-07, and permission was obtained from the mother prior to delivery.

Statistical Analysis

The mean NRAS scores and Apgar scores were reported for each case and component, separately at 1 and 5 minutes. The interrater reliability was measured using the AC1 statistic as the AC1 is more robust than the more commonly used generalized kappa when the distribution of the trait prevalence is skewed.[20] This statistic was calculated separately for each component of the Apgar and NRAS tool over each case, separately at 1 and 5 minutes. Poor interrater reliability was found if the AC1 values were below 0.60. The coefficient of repeatability, which represents the expected difference

at the 5% level between 2 randomly selected measurements, was calculated for the overall Apgar and NRAS scores as an assessment of the reliability of the overall measure.[21] Linear mixed-effect models were used to calculate both the repeatability measurement and the intraclass correlation (ICC) between each of the raters, which describe how strongly the raters agreed with each other. Nonparametric bootstrap 95% confidence intervals (CIs) were calculated for each reliability statistics, based on 200 bootstrap samples. Furthermore, the AC1 values were calculated using the macro provided by Blood and Spratt.[22] All statistical analysis was performed using SAS 9.3.

Results

Thirty-nine providers, including 100% of the neonatologists, participated in the study with 17 (43%) completing both the NRAS and Apgar portions of the study to be included in the analysis. [19] Of the 17 that completed both the Apgar and NRAS surveys, 8 (47%) were resident physicians, 5 (29.4%) were neonatologists, 3 (17.6%) were neonatal transport nurses, and 1 (2.1%) was a neonatology ICU fellow. The median years of experience for this sample was 4.0 years (interquartile range = 3.0-11.0). Of all providers that participated in completing at least one survey, 19 (49%) of the providers indicated they were resident physicians, 8 (21%) were neonatal transport nurses, 5 (13%) were neonatologists, 4 (10%) were neonatal nurse practitioners, 3 (8%) were neonatology ICU Fellows.

Numerical summaries for the Apgar and NRAS tools are shown in Table 2. The tools show comparable trends; for newborns of younger gestational age (Cases 1-4), scores were lower compared to the scores of older infants (Cases 4 and 5). Numerical values of the total scores were typically larger for 1-minute Apgar scores than the corresponding NRAS scores for newborns with a very low gestational age, or less than 25 weeks. For instance, the 1-minute Apgar scores for Cases 1 and 2 (23 and 24 weeks, respectively) were 1.7 and 1.9, respectively, while the corresponding NRAS scores for Cases 4 and 5 (32 and 40 weeks) were larger at 3.8 and 3.2, respectively. Conversely, newborns of a higher gestational age of 32 and 40 weeks (Cases 4 and 5) tended to have lower Apgar scores compared to the corresponding NRAS score, regardless of whether the measurement was taken at 1 or 5 minutes. For these newborns, the Apgar scores ranged from 8.4 to 9.2, while the NRAS scores ranged from 9.7 to 9.8.

The interrater reliability estimates and 95% CIs, separately for each case and component, can be seen in Table 3 for the Apgar scores and in Table 4 for the NRAS

Table 2. Provider Assessment of NRAS and Apgar Scores Based on 5 Clinical Case Scenarios[a].

| | NRAS Scores | | | | | | | | | |
| | 23 Weeks | | 24 Weeks | | 27 Weeks | | 32 Weeks | | 40 Weeks | |
Item	1 min	5 min	1 min	5 min	1 min	5 min	1 min	5 min	1 min	5 min
R1	0.1	1.0*	0.1	0.0*	0.9	1.6	1.9	1.9	1.9	1.9
R2	0.1	0.6	0.0	0.1	0.9	1.0	2.0*	2.0*	2.0*	2.0*
C1	1.0	2.0*	1.0*	1.9	2.0*	2.0*	2.0*	2.0*	2.0*	2.0*
C2	1.9	1.9	1.9	1.0*	1.9*	1.9	1.9	1.9	1.9	1.9
N1	0.6	0.9	0.2	0.6	0.9	0.8	1.8	1.9	1.9	2.0
Overall	3.8	6.5	3.2	3.7	6.6	7.3	9.7	9.8	9.8	9.8

| | Apgar Scores | | | | | | | | | |
| | 23 Weeks | | 24 Weeks | | 27 Weeks | | 32 Weeks | | 40 Weeks | |
	1 min	5 min	1 min	5 min	1 min	5 min	1 min	5 min	1 min	5 min
C1	0.3	1.4	0.5	1.2	1.2	1.6	1.0	1.4	1.0	1.2
C2	1.0*	2.0*	0.9	2.0*	2.0*	2.0*	2.0*	2.0*	2.0*	2.0*
N1	0.1	1.0	0.1	0.2	0.5	0.9	1.8	1.7	2.0	2.0
N2	0.2	1.1	0.1	0.4	0.7	0.9	1.6	1.6	1.9	2.0
R1	0.2	0.9	0.1	0.3	1.1	1.2	2.0	2.0*	2.0*	2.0*
Overall	1.9	6.4	1.7	4.0	5.6	6.6	8.4	8.7	8.9	9.2

Abbreviation: NRAS, Neonatal Resuscitation Adaptation Score.
[a]Mean score separately by item and case for the Apgar score.
*Indicates items with perfect agreement.

Table 3. The Interrater Reliability Estimates and 95% CIs, Separately for Each Case and Each Apgar Component (N = 39)[a].

Case (Weeks)	Time	C1 (A)	C2 (P)	N1 (G)	N2 (A)	R1 (R)
1 (23)	1 min	0.39 (0.31, 0.65)	1.00 (—)	0.76 (0.55, 1.00)	0.62 (0.39, 0.84)	0.60 (0.31, 0.92)
	5 min	0.33 (0.31, 0.62)	1.00 (—)	0.43 (0.14, 0.76)	0.60 (0.36, 0.88)	0.11 (−0.02, 0.44)
2 (24)	1 min	0.31 (0.31, 0.49)	0.84 (0.62, 1.00)	0.84 (0.62, 1.00)	0.76 (0.55, 1.00)	0.84 (0.69, 1.00)
	5 min	0.46 (0.23, 0.76)	0.92 (0.69, 1.00)	0.60 (0.30, 0.84)	0.36 (0.31, 0.62)	0.53 (0.24, 0.84)
3 (27)	1 min	0.13 (−0.02, 0.44)	0.92 (0.76, 1.00)	0.20 (0.07, 0.47)	0.35 (0.16, 0.68)	0.22 (0.03, 0.60)
	5 min	0.36 (0.31, 0.62)	0.92 (0.69, 1.00)	0.17 (−0.00, 0.44)	0.30 (0.06, 0.67)	0.27 (0.08, 0.57)
4 (32)	1 min	0.92 (0.76, 1.00)	1.00 (—)	0.55 (0.34, 0.84)	0.36 (0.31, 0.62)	0.92 (0.73, 1.00)
	5 min	0.36 (0.31, 0.55)	1.00 (—)	0.49 (0.31, 0.76)	0.36 (0.31, 0.58)	1.00 (—)
5 (40)	1 min	0.67 (0.40, 0.92)	1.00 (—)	0.92 (0.76, 1.00)	0.84 (0.62, 1.00)	1.00 (—)
	5 min	0.55 (0.36, 0.84)	1.00 (—)	0.92 (0.76, 1.00)	0.92 (0.76, 1.00)	1.00 (—)

Abbreviation: CI, confidence interval.
[a]AC1 values and 95% CIs calculated at each time point for each case, separately by each component of the Apgar score.

scores. Each of the measures contains 1 item that is a highly reliable measure of the newborn's cardiovascular health with reliability scores almost uniformly near 1 and has no measures less than 0.60. The appearance component (C1) of the Apgar showed poor reliability with 3/5 reliability coefficients being below 0.60 at 1 minute and all coefficients below 0.60 at 5 minutes. In contrast, the NRAS cardiovascular support component (C2) had no reliability coefficients being below 0.60 at 1 minute and only 1 coefficient below 0.60 at 5 minutes.

Compared to the cardiovascular component, the respiratory components of both score tools had comparable reliability. Combining across the 1- and 5-minute scores, the respiration component (R1) of the Apgar score contained 4/10 reliability measures less than 0.60, compared to 1 item on each of the supplemental oxygen

Table 4. The Interrater Reliability Estimates and 95% CIs, Separately for Each Case and Each NRAS Component (N = 39)[a].

Case	Time	C1	C2	N1	R1	R2
1	1 min	0.93 (0.80, 1.00)	0.93 (0.80, 1.00)	0.12 (−0.01, 0.36)	0.87 (0.68, 1.00)	0.80 (0.56, 1.00)
	5 min	1.00 (—)	0.87 (0.68, 1.00)	0.23 (0.03, 0.51)	1.00 (—)	0.29 (0.15, 0.49)
2	1 min	1.00 (—)	0.87 (0.68, 1.00)	0.68 (0.46, 0.90)	0.87 (0.71, 1.00)	0.93 (0.80, 1.00)
	5 min	0.93 (0.80, 1.00)	0.22 (0.02, 0.58)	0.15 (0.03, 0.33)	1.00 (—)	0.80 (0.56, 1.00)
3	1 min	1.00 (—)	0.86 (0.66, 1.00)	0.01 (−0.03, 0.22)	0.87 (0.65, 1.00)	0.87 (0.68, 1.00)
	5 min	1.00 (—)	0.87 (0.68, 1.00)	0.32 (0.14, 0.62)	0.52 (0.22, 0.80)	0.93 (0.80, 1.00)
4	1 min	1.00 (—)	0.93 (0.80, 1.00)	0.68 (0.46, 0.93)	0.93 (0.80, 1.00)	1.00 (—)
	5 min	1.00 (—)	0.93 (0.80, 1.00)	0.80 (0.59, 1.00)	0.93 (0.80, 1.00)	1.00 (—)
5	1 min	1.00 (—)	0.93 (0.80, 1.00)	0.80 (0.62, 1.00)	0.93 (0.80, 1.00)	1.00 (—)
	5 min	1.00 (—)	0.93 (0.80, 1.00)	0.93 (0.80, 1.00)	0.93 (0.80, 1.00)	1.00 (—)

Abbreviations: NRAS, Neonatal Resuscitation Adaptation Score; CI, confidence interval.
[a]AC1 values and 95% CIs calculated at each time point for each case, separately by each component of the NRAS score.

(R1) and respiratory support (R2) components for the NRAS. There were no differences in items measuring neurologic impairment between the Apgar and NRAS scores. Combining across the 1- and 5-minute measurements, the grimace (N1) and activity components (N2) of the Apgar score and the grasp component (N1) of the NRAS each demonstrated equal 5/10 reliability estimates lower than 0.60.

The reliability coefficients for each of the components aggregated across cases can be seen in Table 5. Both the pulse rate component (C2) of the Apgar score and the heart rate component (C1) of the NRAS score showed excellent reliability with scores near 1. However, there appears to be a clear inferiority of the appearance component (C1) of the Apgar score when contrasted with the cardiovascular support component (C2) of the NRAS, with mean reliability coefficients being 0.47 for Apgar C1 versus 0.98 for NRAS C2. The appearance component has reliability coefficients of 0.47 and 0.44 at 1 and 5 minutes, respectively, while the cardiovascular support has reliability coefficients of 0.91 and 0.77 for the 1- and 5-minute measurements.

The respiratory components of the NRAS was superior in terms of the reliability across the cases compared to the Apgar scores. Of the 2 respiratory components at each of the 2 time points, no reliability coefficient falls below 0.77. In contrast, the respiration component (R1) of the Apgar was only 0.67 at 1 minute and 0.55 at 5 minutes. However, the reliability for the neurologic components of the Apgar score was superior compared to the NRAS neurologic component at 1 minute of life. At 1 minute, the grimace (N1) and activity (N2) reliability coefficients were 0.60 and 0.50, respectively, compared to the grasp component (N1) of the NRAS, which had a reliability coefficient of 0.40. However, this difference disappeared at 5 minutes with all 3 reliability coefficients having comparable values of approximating 0.44.

The repeatability coefficients for both the Apgar and NRAS scores are displayed in Table 6 for each case and time point. These coefficients ranged from 1.2 to 4.7 for the Apgar and 2.0 to 3.4 for the NRAS. For the extremely preterm newborns (Cases 1, 2, and 3 at 23, 24, and 27 weeks gestation, respectively), the NRAS was superior demonstrating higher degree of consistency as the repeatability coefficients were lower for the NRAS compared to the Apgar at 1 and 5 minutes except for the 5-minute score of Case 2 at 24 weeks gestation. The repeatability coefficients were similar for Case 4 (32 weeks gestation), and the Apgar score had higher consistency at 40 weeks gestation compared to the NRAS score.

The NRAS scores were nominally superior when assessing the aggregated scores. The repeatability coefficient are smaller for the NRAS at both 1 and 5 minutes, indicating increased reproducibility (Table 6). Provider scores with the Apgar score differed by 3 times the SD value while the NRAS scored differed by mean twice the SD value. Additionally the ICC values for the NRAS scores were higher at both the 1- and 5-minute time points. At 1 minute, the ICC value for the NRAS was 0.33 (95% CI = −0.06, 0.60), while the ICC value for the Apgar scores was 0.19 (95% CI = 0.07, 0.28). This continued at 5 minutes, with the ICC values for the NRAS being 0.35 (95% CI = −0.05, 0.54) compared to 0.19 (95% CI = 0.04, 0.32) for the Apgar scores.

Last, the evaluation of the importance, representativeness, and clarity of the 5 items from the NRAS score are displayed in Table 7. A Likert-type scale was used, with 5 being the highest possible score and 1 being the lowest. The cardiovascular and respiratory measures had high average scores (>4.3). These values indicate that the providers believed that the cardiovascular and respiratory measures were important, representative, and clear measures of the health of the newborn. However, the providers did not agree that the neurologic

Table 5. ACI Values and 95% Confidence Intervals for Each Time Point, Separately by Component but Aggregated Over All Cases for the Apgar and NRAS Tools.

	Apgar Components				
Time	CI (A)	C2 (P)	NI (G)	N2 (A)	RI (R)
I min	0.47 (0.19, 0.74)	0.94 (0.85, 1.00)	0.60 (0.30, 0.92)	0.50 (0.34, 0.81)	0.67 (0.24, 1.00)
5 min	0.40 (0.33, 0.51)	0.97 (0.92, 1.00)	0.45 (0.28, 0.76)	0.44 (0.27, 0.72)	0.55 (0.15, 1.00)

	NRAS Components				
Time	CI	C2	NI	RI	R2
I min	0.98 (0.94, 1.00)	0.91 (0.88, 0.93)	0.40 (0.12, 0.72)	0.85 (0.83, 0.93)	0.89 (0.82, 0.98)
5 min	0.99 (0.96, 1.00)	0.77 (0.50, 0.93)	0.44 (0.19, 0.93)	0.85 (0.64, 1.00)	0.77 (0.35, 1.00)

Abbreviation: NRAS, Neonatal Resuscitation Adaptation Score.

Table 6. Repeatability Coefficients and 95% Confidence Intervals for Each Case and Time Point of the Apgar and NRAS Tools[a].

		Repeatability Coefficient	
Case	Time	Apgar	NRAS
I	I min	3.4 (1.9, 4.6)	3.0 (2.2, 3.7)
	5 min	4.0 (3.0, 5.0)	2.6 (1.7, 3.2)
2	I min	2.2 (1.7, 2.7)	2.3 (1.2, 3.0)
	5 min	3.9 (2.3, 4.9)	2.8 (2.2, 3.4)
3	I min	4.7 (3.3, 6.1)	3.2 (2.0, 4.2)
	5 min	4.5 (3.4, 5.3)	3.4 (2.2, 4.2)
4	I min	2.4 (1.8, 2.8)	2.2 (0.8, 3.3)
	5 min	2.0 (1.2, 2.6)	2.1 (0.5, 3.3)
5	I min	1.2 (0.5, 1.6)	2.1 (0.5, 3.3)
	5 min	1.3 (0.8, 1.6)	2.0 (0.0, 3.3)
Overall	I min	2.7 (2.2, 3.2)	2.1 (1.7, 2.5)
	5 min	3.0 (2.4, 3.6)	2.1 (1.8, 2.4)

Abbreviation: NRAS, Neonatal Resuscitation Adaptation Score.
[a]Overall values combining all cases are provided at the end of the table.

Table 7. Evaluation of the Importance, Representativeness, and Clarity of the 5 Items From the NRAS Score, Scale 1 to 5, With 5 Being the Highest Possible Score.

	Importance	Representativeness	Clarity
CI	4.7	4.6	4.7
C2	4.3	4.4	4.4
NI	3.6	3.5	3.5
RI	4.4	4.4	4.6
R2	4.7	4.4	4.4

use of various degrees of respiratory support for all gestational ages.[13] The NRAS tool eliminates the subjective parameters of color and tone assessment within the Apgar tool providing instead clarifying respiratory support parameters. The NRAS tool is particularly suited for the increased care required of the preterm infant, which necessitates a score that can more effectively assist in the prediction of optimal transition as well as outcome risks. The evaluation of the NRAS tool identified greater degree of identification of respiratory support needed in the delivery for all gestational ages including the smallest of premature infants. The tool was easily performed with superior interrater reliability compared to the Apgar score in aggregate. A limitation of this study is that some may argue that the electronic video survey may not reflect a true delivery room experience. However, given the objective of assessing the Apgar and the NRAS the provider's responses validated their views of the usefulness of the tool. Additional limitations of this pilot are the evaluation of the NRAS within a small provider sample size. However, providers equally evaluated the Apgar and within the constraints of the clinical scenarios identified greater value of the NRAS in the infant who requires clinical support intervention or who is premature. These results require further validation in the clinical setting with additional providers.

measure was important, representative, or clear, as these average scores were around 3.5.

Discussion

Several challenges are faced by the clinician in documenting neonatal transition of the infant in the delivery room, especially for the premature infant. The Apgar score commonly has been used to provide an overview of the infant's postdelivery transition in the delivery room.[1] The Apgar score, however, has limitations with regard to neonatal resuscitation experiences and is limited in the assessment of the premature infant.[1,14,15] The NRAS tool was developed to address recent recommendations in delivery room care practices to reflect use of blended oxygen, oxygen level targeting, as well as

A final limitation that may have affected provider assessment of the NRAS neural component N1 (grasp) may include lack of provider observation of the grasp change within the video. This may have occurred due to the unfamiliar new observation that is not typically done by the providers in the delivery room. We received no feedback on this from the providers. Provider education may be needed in future studies regarding this component. Nevertheless, the neural components of the Apgar were also low indicating that this component may be more developmentally regulated compared to cardiac and respiratory components.

Development of score tools to assist the clinician in management or clinical assessment of neonatal transition has been required given the needed attention to changes and advancements in current treatment modalities that were not available during the development of the Apgar score. The NRAS tool outlined in this study has the potential to provide important information related to respiratory support provided postdelivery that are not available with the current Apgar score system. Using the NRAS, the information provided the clinician with information similar to an Apgar score with additional information related to the need for mechanical ventilator intervention and/or oxygen supplementation. This additional information may provide both useful short-term and potentially long-term information that can be incorporated in infant health responses important for later clinical interventions. The development of the NRAS and our associated findings support a greater need for objective tools in resuscitation assessment of infants, especially those of smaller gestation age, to determine transition status and health in the delivery room. The NRAS appears to be a viable tool to be further assessed in the clinical setting to examine its usefulness in providing information to the clinician related to severity of acute illness as well as may be of assistance in diagnosis of level of asphyxia compared to the Apgar score especially for postdelivery transition of preterm and term neonates.

Author Contributions

SRJ collected, analyzed and interpreted data and he was the primary author. AJ assisted with concept, data collection, writing and editing of paper. APS was responsible for statsitical analysis and calculations. He assisted in writing statistical analysis and results section. KDHM assisted in writing and editing of paper.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

References

1. American Academy of Pediatrics, Committee on Fetus and Newborn, American College of Obstetricians and Gynecologists, Committee on Obstetric Practice. The APGAR score. *Adv Neonatal Care*. 2006;6:220-223.
2. APGAR V. A proposal for a new method of evaluation of the newborn infant. *Curr Res Anesth Analg*. 1953;32:260-267.
3. Casey BM, McIntire DD, Leveno KJ. The continuing value of the Apgar score for the assessment of newborn infants. *N Engl J Med*. 2001;344:467-471.
4. Thompson CM, Puterman AS, Linley LL, et al. The value of a scoring system for hypoxic ischaemic encephalopathy predicting neurodevelopmental outcome. *Acta Paediatr*. 1997;86:757-761.
5. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33:159-174.
6. Jepson HA, Talashek ML, Tichy AM. The Apgar score: evolution, limitations, and scoring guidelines. *Birth*. 1991;18(2):83-92.
7. Perlman J, Kattwinkel J, Wyllie J, Guinsburg R, Velaphi S. Nalini Singhal; Neonatal ILCOR Task Force Group. Neonatal resuscitation: in pursuit of evidence gaps in knowledge. *Resuscitation*. 2012;83:545-550.
8. Bashambu MT, Whitehead H, Hibbs AM, Martin RJ, Bhola M. Evaluation of interobserver agreement of Apgar scoring in preterm infants. *Pediatrics*. 2012;130:e982-e987.
9. Hegyi T, Carbone T, Anwar M, et al. The Apgar score and its components in the preterm infant. *Pediatrics*. 1998;101(1 pt 1):77-81.
10. O'Donnell CP, Kamlin CO, Davis PG, Carlin JB, Morley CJ. Clinical assessment of infant colour at delivery. *Arch Dis Child Fetal Neonatal Ed*. 2007;92:F465-F467.
11. Rudiger M, Kuster H, Herting E, et al. Variations of Apgar score of very low birth weight infants in different neonatal intensive care units. *Acta Paediatr*. 2009;98:1433-1436.
12. O'Donnell CP, Kamlin CO, Davis PG, Carlin JB, Morley CJ. Interobserver variability of the 5-minute Apgar score. *J Pediatr*. 2006;149:486-489.
13. Escrig R, Arruza L, Izquierdo I, et al. Achievement of targeted saturation values in extremely low gestational age neonates resuscitated with low or high oxygen concentrations: a prospective, randomized trial. *Pediatrics*. 2008;121:875-881.
14. Morley CJ, Davis PG, Doyle LW, et al. Nasal CPAP or intubation at birth for very preterm infants. *N Engl J Med*. 2008;358:700-708.
15. Perlman JM, Wyllie J, Kattwinkel J, et al. Neonatal resuscitation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Science with Treatment Recommendations. *Pediatrics*. 2010;126:e1319-e1344.

16. Catlin EA, Carpenter MW, Brann BS 4th, et al. The Apgar score revisited: influence of gestational age. *J Pediatr*. 1986;109:865-868.

17. Allen MC, Capute AJ. The evolution of primitive reflexes in extremely premature infants. *Pediatr Res*. 1986;20:1284-1289.

18. Futagi Y, Toribe Y, Suzuki Y. The grasp reflex and moro reflex in infants: Hierarchy of primitive reflex responses. *Int J Pediatr*. 2012;2012:191562.

19. Donner A, Rotondi MA. Sample size requirements for interval estimation of the kappa statistic for interobserver agreement studies with a binary outcome and multiple raters. *Int J Biostat*. 2010;6:Article 31.

20. Gwet K. *Handbook of Inter-Rater Reliability: How to Estimate the Level of Agreement Between Two or Multiple Raters*. Gaithersburg, MD: STATAXIS Publishing; 2001.

21. Bland JM, Altman DG. Measuring agreement in method comparison studies. *Stat Methods Med Res*. 1999;8: 135-160.

22. Blood E, Spratt KF.Disagreement on agreement: two alternative agreement coefficients (Paper 186-2007). http://www2.sas.com/proceedings/forum2007/186-2007. pdf. Accessed July 17, 2015.