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The Neonatal Withdrawal Inventory: A Simplified Score of Newborn Withdrawal

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ABSTRACT. A new method for the rapid assessment of neonatal withdrawal was tested. Three studies with 80 newborns compared the reliability, sensitivity and specificity of the Neonatal Withdrawal Inventory (NWI) with that of the Neonatal Abstinence Scoring System (NASS), a widely used neonatal withdrawal scale. Inter-rater reliability for raters assessing neonatal withdrawal with the NWI (range, 0.89-0.98) was superior to that demonstrated by the same raters using the NASS (range, 0.70–0.88). With the NASS as the standard, the sensitivity and specificity of the NWI were 100% at syndrome detection and treatment threshold levels. With use of the NWI, the severity of neonatal withdrawal could be accurately assessed in 10 minutes under case-blinded conditions. The NWI's advantages include brevity, ease of administration, and flexibility. The NWI's simplicity and accuracy commend its wider use as a clinical and experimental tool. *J Dev Behav Pediatr 19:89–93, 1998.* Index terms: *assessment, neonatal withdrawal.*

Within the first days of life, the majority of infants born to narcotic-dependent women experience a stressful withdrawal syndrome characterized by central nervous system (CNS) hyperirritability, gastrointestinal (GI) dysfunction, and autonomic symptoms.[1,2] The usual presentation of neonatal withdrawal includes tremors, increased muscle tone, crying, and associated behavioral distress. In many cases, it also includes hyper-reflexia, sweating, mottling, regurgitation, and diarrhea. Moderate-to-severe neonatal withdrawal poses an increased risk of morbidity[3] and is typically managed pharmacologically, with low doses of opiates (paregoric, tincture of opium) or barbiturates (phenobarbital).[4,5]

Clinical decisions concerning the initiation, modulation, and withdrawal of pharmacotherapy hinge on the objective and sensitive evaluation of withdrawal severity.[6] Likewise, the empirical evaluation of treatment agents and strategies requires reference to a reliable and valid measure of neonatal withdrawal severity. A dramatic (400%) escalation in the number of newborns requiring treatment for withdrawal in our nursery (unpublished data) and reports of significant increases in heroin use and potency across many cities in the United States [7,8] underscore the salience of efforts to achieve effective assessment and treatment of neonatal withdrawal. Our interest in this led to consideration of the strengths and weaknesses of extant withdrawal scoring methods and to the development of a new system for the rapid assessment of neonatal withdrawal.

The Neonatal Abstinence Scoring System (NASS) (Table 1),[9] a widely used withdrawal severity scale for newborns, is objective and comprehensive, but it is cumbersome. Though in use for more than 20 years, the NASS has never been formally evaluated from a strict research protocol. The measure consists of 32 items, each assigned a weight from 1 to 5 points. Point summation of observed features yields a total score, which represents the severity of neonatal withdrawal. The NASS's all-inclusiveness as a symptom roster insures its sensitivity as a withdrawal scale but undermines its usefulness. For example, one cannot easily monitor changes in the expression of withdrawal to investigate whether a treatment differentially affects CNS versus autonomic features over time or whether specific conditions of prenatal drug exposure, i.e. drug type, dose, or combinations, affect the patterns of postnatal withdrawal expression. Most important, standard administration of the NASS stipulates that scoring be conducted by the nurse tending an affected infant, a procedural limitation that precludes the possibility of blinded assessment of neonatal withdrawal. Empirical study of clinical issues is

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Table 1. The Neonatal Abstinence Scoring System

Signs and Symptoms	Score	Comments
High-pitched cry	2	
Continuous high-pitched cry	3	
Hyperactive Moro reflex	2	
Markedly hyperactive Moro reflex	3	
Mild tremors when disturbed	1	
Marked tremors when disturbed	2	
Mild tremors when undisturbed	3	
Marked tremors when undisturbed	4	
Increased muscle tone	2	
Generalized convulsion	5	
Frantic sucking of fists	1	
Regurgitation	2	
Projectile vomiting	3	
Frequent yawning	1	
Sneezing	1	
Nasal stuffiness	1	
Sweating	1	
Mottling	1	
Fever < 101° F	1	
Fever > 101° F	2	
Respiratory Rate > 60/min	1	
Respiratory Rate 60/min with retractions	2	
Excoriation of nose	1	
Excoriation of knees	1	
Excoriation of toes	1	
Sleeps < 1 h after feeding	3	
Sleeps < 2 h after feeding	2	
Sleeps < 3 h after feeding	1	
Poor feeding	2	
Loose stools	2	
Watery stools	3	
Dehydration	2	
TOTAL SCORE		

enhanced by assessment procedures that are independent of treatment activities, a condition that cannot be satisfied by the NASS.

Briefer neonatal withdrawal scales, e.g., the Neonatal Drug Withdrawal Scoring System (NDWSS)[10] and the Neonatal Narcotic Withdrawal Index (NNWI),[11] are also weighted-point indices that yield an objective score representing withdrawal severity. These measures can be readily administered by any clinician trained in their use and are somewhat easier to use than the NASS. When administered by anyone other than the infant's nurse/caregiver, however, both measures require accessing data from the infant's chart, a step that can introduce error, add time to the assessment procedure, and bias the assessment. More important, the NDWSS and the NNWI have not been empirically validated, a significant drawback to their usefulness as research, if not clinical, tools.

By integrating the structural and procedural advantages of the extant scoring approaches with our clinical experience, we developed a new system for assessing withdrawal severity. Design goals in constructing this new method included the following:

- sensitive and specific rating of withdrawal severity under case-blinded conditions;
- demonstrated reliability;
- ease of training;
- rapid and efficient applicability under clinical conditions; and
- modular design, allowing easy analysis of global presentation into CNS, autonomic, GI, and behavioral constituents.

The NWI scoring system consists of a standardized sequence of clinical care/assessment procedures, followed by evaluation of withdrawal severity with an eight-point checklist. The assessment procedures have the following characteristics:

- they are an integral aspect of the scoring system;
- they coincide with standard infant care activities;
- they take less than 10 minutes to complete; and
- they provide ample opportunity for direct assessment of withdrawal severity (Table 2).

The NWI (Fig.1) consists of the following seven prominent withdrawal signs:

- hypertonicity;
- tremor;
- hyperactive Moro reflex;
- sweating/mottling;
- repeated sneezing/yawning;
- regurgitation and diarrhea; and
- a behavioral distress scale anchored to specific observable referents, such as crying and fist-sucking.

Each of the signs is assigned a predetermined weight between one and four, as are the points along the behavioral distress continuum. The NWI represents the CNS, autonomic, GI, and behavioral features of withdrawal in an 8:3:4:4 ratio and

can be easily expressed as subtest scores. The greatest possible score is 19. The NWI can be administered by any physician, nurse, or assistant trained in its use, either according to a fixed schedule or as emerging clinical conditions warrant.

METHODS

To test the Neonatal Withdrawal Inventory scoring system, we compared its reliability, validity, and efficiency to that of the Neonatal Abstinence Scoring System, the most comprehensive and widely cited neonatal withdrawal severity scale. The study was approved by the Human Subjects Institutional Review Board of the University of Medicine and Dentistry of New Jersey / New Jersey Medical School.

Table 2. Assessment Procedures for the Neonatal Withdrawal Inventory

Observation of infant (1 min)
Unswaddling and gentle wakening
Determination of respiratory rate (1 min)
Measurement of axillary temperature
Inspection for signs of excoriation
Assessment of tone and Moro reflex
Diaper change
Reswaddling and positioning
Observation of infant (1 min)

Subjects

The study population consisted of 80 inborn neonates treated in the Intermediate Care Nursery at University Hospital, Newark, New Jersey between August 1995 and March 1996. Thirty infants participated in Study A, and 25 each participated in Study B and Study C. Their mean gestational age was 38 weeks (range, 35–40 wk); their mean postnatal age was 12 days (range, 2–30 d). The sample included no infants with congenital anomalies, intraventricular hemorrhage, or severe respiratory or metabolic disease; we also excluded infants small for gestational age. Sixty-seven of the 80 newborns were defined as *withdrawing* on the basis of positive postnatal heroin and/or methadone urine toxicologic test results and significant behavioral signs of withdrawal, i.e., 2 successive Neonatal Abstinence Scoring System (NASS) scores of 8 or more. According to existing nursery policy, all of the 67 infants were being treated for neonatal withdrawal with paregoric. At study time, withdrawal severity in this group ranged from marginal to severe (NASS scores of 2–12). Treatment dosing levels of infants in this group were equally broad, ranging from 2 to 12 drops of paregoric every 4 hours. Withdrawal was not adequately controlled in 3 of the 67 subjects at the 12-drop level, and these infants required supplemental treatment with phenobarbital (4–6 mg/kg · d). As per hospital policy, all mothers of narcotic-exposed infants were interviewed by a social worker and encouraged to avail them-

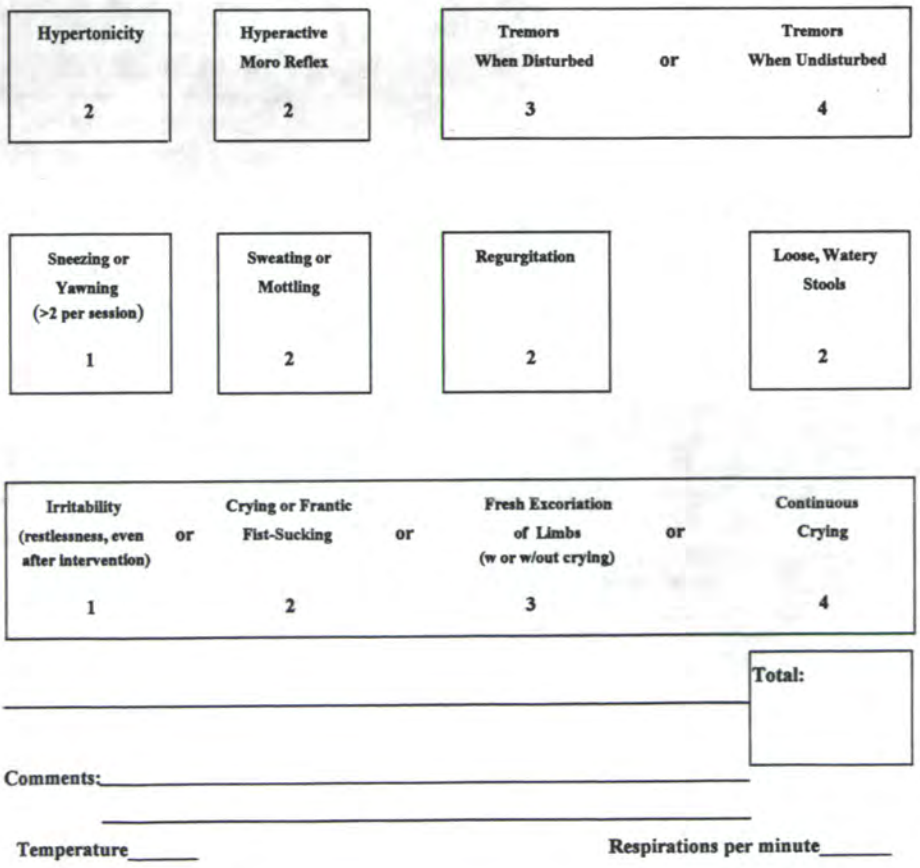

FIGURE 1. Neonatal Withdrawal Inventory.

selves of counseling and drug treatment. Thirteen control infants (Study B) were weight- and age-matched newborns receiving treatment for hyperbilirubinemia, anemia of prematurity, sepsis, and/or feeding difficulty in the Intermediate Care Nursery. These infants had urine toxicologic test negative for heroin and methadone.

Procedures

Three studies were conducted to test the Neonatal Withdrawal Inventory's (NWI) inter-rater reliability and to evaluate the method's sensitivity and specificity as an index of neonatal withdrawal at case identification and treatment threshold levels.

In Study A, four neonatal nurses (raters) experienced in administration and scoring of the Neonatal Abstinence Scoring System (NASS) were oriented to the NWI in a single 30-minute session. Experimental procedures permitting simultaneous administration of the NWI and the NASS were also described to the raters. These procedures were implemented to maximize the systematic observation of narcotic-withdrawing infants and to yield the highest possible levels of inter-rater reliability. The experimental scoring procedures were identical to the standard administration procedures for the NWI:

- observation of the infant, undisturbed in its bassinet, for 1 minute;
- unswaddling and gentle awakening (if necessary);
- determination of respiratory rate by counting chest expansions for 1 minute;
- measurement of axillary temperature;
- inspection of limbs and extremities for recent excoriation;
- assessment of muscle tone and Moro reflex;
- diaper change;
- reswaddling and positioning; and
- observation of the infant for 1 minute without intervention.

Evaluations of withdrawing infants (n = 30) with the NWI and NASS were conducted during the course of 10 nonsuccessive days, three infants per session. Evaluations were conducted 2 hours after feeding (between 0800 h and 1000 h). To minimize the risk of overstimulating infants, the hands-on aspect of assessment procedures, e.g., unswaddling, temperature taking, diapering, etc., was carried out by one rater each session, while the others observed. The rater performing the hands-on procedures changed daily, as decided by previous randomization. Raters did not speak during evaluation sessions except for announcement of infants' axillary temperature by the nurse carrying out the procedures. NWI and NASS score forms were presented in packets randomized for order from session to session and were completed independently by each rater. Raters' NASS and NWI scores for each infant were compared and reliability coefficients were calculated using Pearson's coefficient of correlation and Cronbach's alpha.

In Study B, an investigator performed blinded assessment of 25 newborns using the NWI to identify infants expressing signs of withdrawal. Twelve of the 25 newborns were assessed as narcotic withdrawing, whereas 13 newborns were asymptomatic/nonwithdrawing age- and weight-matched controls. NWI assessments were performed 2 hours after feeding (between 0800 h and 1000 h). The means of withdrawing and nonwithdrawing infants were calculated and the rates of identification using the NWI were described with measures of sensitivity and specificity and confirmed by the kappa statistic.

In Study C, an investigator assessed each of 25 narcotic-withdrawing infants with the NWI on 2 separate occasions, yielding 50 observations. Scoring was done blinded to the infants' withdrawal and treatment status and was performed 2 hours after feeding (between 0800 h and 1000 h) and within 30 minutes of the NASS scoring routinely and independently conducted by nursery staff. No infant was assessed more than once during a 24-hour period with the NWI. Individual (investigator) NWI scores and (nurse) NASS scores for each infant were bifurcated (< 8 or ≥ 8, values that represent the NASS and NWI thresholds for initiation of pharmacotherapy), and we compared the scores. The agreement between scores generated by the NWI and NASS was represented via descriptive measures of sensitivity and specificity and confirmed by the kappa statistic.

RESULTS

We used SAS/UNIX, 1993 (SAS Institute Inc., Cary, NC) software to conduct all of our statistical analyses. Administration and scoring of the Neonatal Withdrawal Inventory (NWI) required, on average, 9 minutes. Completion of the Neonatal Abstinence Scoring System (NASS) took an additional 5 minutes, using the procedures described.

In Study A, inter-rater reliability using the NWI to assess withdrawal severity ranged from 0.89 to 0.98 ($\bar{x}$ correlation = 0.93) by Pearson correlation. Inter-rater reliability for the NASS ranged from 0.70 to 0.88 ($\bar{x}$ correlation = 0.80) by Pearson correlation. Cronbach's alpha for the NWI and NASS was 0.98 and 0.93, respectively (Table 3).

In Study B, blinded scoring of infants with the NWI correctly identified all of the withdrawing neonates, with no false identifications. The 12 symptomatic newborns were correctly identified as withdrawing from narcotics ($\bar{x}$ NWI score = 7); none of the 13 control subjects ($\bar{x}$ NWI score = 1) were misidentified as narcotic-withdrawing neonates. The sensitivity and specificity of the NWI equaled 100%. (kappa = 1.0, standard error = 0.23).

In Study C, with NASS scores as the standard, we calculated the sensitivity and specificity of the NWI at treatment threshold levels (Table 4). Of the 29 observations yielding a NASS score less than 8 (i.e., do not treat pharmacologically), all of the 29 scored less than 8 with the NWI, i.e., the specificity was 100%. All of the 21 infants with NASS scores of 8 or more (i.e., treat pharmacologically), also scored 8 or more with the NWI, i.e., the sensitivity was 100% (kappa = 1.0, standard error = 0.14).

Table 3. Reliability of the Neonatal Abstinence Scoring System and the Neonatal Withdrawal Inventory

Instrument	Inter-rater (Pearson coefficient)	Cronbach's alpha
Neonatal Abstinence Scoring System	$\bar{x}$ = 0.80 (0.70–0.88)	0.93
Neonatal Withdrawal Inventory	$\bar{x}$ = 0.93 (0.89–0.98)	0.98

(N = 30) × (4 observers) = 120 observations.

Table 4. Sensitivity and Specificity of the Neonatal Withdrawal Inventory, with the Neonatal Abstinence Scoring System as the Standard

	NWI (+) (score ≥ 8)	NWI (−) (score < 8)
NASS (+) (score ≥ 8)	21	0
NASS (−) (score < 8)	0	29

NWI, Neonatal Withdrawal Inventory; NASS, Neonatal Abstinence Scoring System.
(N = 25) × (2) = (50 observations), kappa = 1.0, standard error = 0.14.

DISCUSSION

Our data suggest that withdrawal severity can be quickly and accurately assessed with the Neonatal Withdrawal Inventory (NWI). Inter-rater reliability using the NWI to assess withdrawal severity is very high, and the scoring system is highly sensitive and specific under case-blinded conditions, a significant advantage for empirical studies. The NWI does not require that withdrawal scoring be performed by an affected infant's nurse. Rather, it can be administered and scored in 10 minutes or less by any clinician trained in its use, making it a highly efficient and flexible diagnostic method. Concordance between the briefer NWI and the more comprehensive Neonatal Abstinence Scoring System is nearly perfect at treatment threshold levels.

Design features of the NWI, including the integration of simple but standardized administration procedures and a brief questionnaire, offer advantages over extant withdrawal severity scales. The NWI scoring system can be used by physicians, nurses, or other independent raters under case-blinded conditions, thereby allowing a measure of control that was previously lacking. Assessment of neonatal withdrawal with the NWI is based entirely on structured, contemporaneous observation, a feature that maintains the empirical salience of the measure while reducing potential sources of error. The compositional structure of the NWI is so simple that withdrawal severity can be easily analyzed into its central nervous system, autonomic, gastrointestinal, and behavioral parameters, thereby according investigators the ability to track these particular aspects of neonatal withdrawal across time and in response to various treatments.

The NWI represents empirical and practical advantages that commend it as a clinical and research tool. Consistent and broad use of the NWI might not only improve the clinical care of narcotic withdrawing infants but also assist in the elaboration of new approaches to the care of this group. The simplicity of the NWI and its standardized administration procedures make it particularly attractive to clinicians having limited experience with narcotic-withdrawing infants. Additional study is needed to evaluate optimal assessment and treatment strategies using the NWI and to assess its usefulness with other groups of drug exposed newborns.

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