4 Sedation Scales and Discharge Criteria: How Do They Differ? Which One to Choose? Do They Really Apply to Sedation?

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Introduction

Assessing the depth of sedation in children is critically important to determine whether the goals of sedation are met without exposing the patient to the risk of adverse outcomes. In a clinical model of pediatric sedation [1], the patient's state can range from fully awake undergoing a painful procedure without sedation or analgesia to apnea, hypoxia, and death from oversedation (Fig. 4.1). Clearly, having the sedated child's state in the goal zone is important, and objective tools to assess sedation depth are necessary to standardize depth of sedation. Additionally, having objective assessment scales available to rate a child's readiness for discharge from a sedation recovery area is also important, as premature discharge may lead to adverse events and even death [2–4]. This chapter will review commonly used pediatric sedation scales, focusing on procedural sedation. Then methods of sedation assessment using processed EEG will be reviewed and compared to pediatric sedation scales. Finally, commonly used scales to assess recovery from sedation and readiness for discharge from sedation will be discussed.

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Sedation Scales

The Joint Commission, American Academy of Pediatrics, and the American Society of Anesthesiologists have recently revised their definitions of the levels of pediatric sedation [5, 6] (Table 4.1, Fig. 4.2). The four levels of sedation are now minimal, moderate, deep, and general anesthesia. The previously used term "conscious sedation" has been eliminated because it was misleading, and inapplicable particularly in pediatric patients who can change rapidly from minimal to deep levels of sedation. Any assessment of levels of sedation needs to take these basic considerations into account.

Sedation scales are indeed necessary for pediatric procedural sedation, particularly when practiced by nonanesthesiologists. For example, Reeves et al. [7] studied 16 children undergoing propofol sedation for bone marrow aspiration by nonanesthesiologists, and found that for all children, their level of consciousness, motor activity score, and bispectral index score was consistent with either deep sedation or general anesthesia at some point during the procedure. In a large pediatric procedural cohort, Cravero et al. assessed 49,836 propofol sedations. Complications were noted in 5.92% of patients, including an airway or pulmonary complication in 1.17%, yet there was no assessment of depth of sedation reported [8]. Sedation scales are essential to minimize complications from sedation. They can provide early warning of sedation that is

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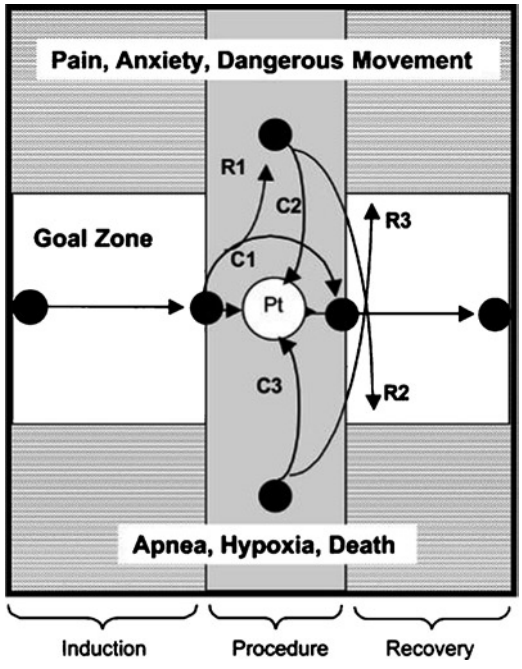

Fig. 4.1 A working model of pediatric sedation. The *x*-axis is the time of phase of sedation. The *y*-axis is the depth of sedation, ranging from inadequate to oversedation. A sedation scale should be able to accurately assess the depth of sedation and maximize the chance that the patient is in the goal zone. The *black dots* are the patient at a single point in time, ranging from preprocedure, through intra and postprocedure. (**c**) designates the work done by the provider to counteract the adverse effects of sedation or accomplish a task. C1 is the procedure control loop, C2 the procedural pain and anxiety control loop, and C3 the sedation-related respiratory depression control loop. R1 is the undesired side effects of therapeutic action: R1 undersedation and pain; R2 oversedation, and R3 rescue from oversedation. (From Cravero et al. [1], reprinted with permission from Wolters Kluwer Health)

Table 4.1 American Academy of Pediatrics/Joint Commission/American Society of Anesthesiologists Definitions of Levels of Sedation

Minimal sedation (anxiolysis): A drug-induced state during which patients respond normally to verbal commands. Although cognitive function and coordination may be impaired, ventilatory and cardiovascular functions are unaffected
Moderate sedation (previously called conscious sedation or sedation/analgesia): A drug-induced depression of consciousness during which patients respond purposefully to verbal commands either alone or accompanied by light tactile stimulation. No interventions are required to maintain a patent airway, and spontaneous ventilation is adequate. Cardiovascular function is usually maintained
Deep sedation: A drug-induced depression of consciousness during which patients cannot be easily aroused but respond purposefully after repeated or painful stimulation (*note*: reflex withdrawal from a painful stimulus is not considered a purposeful response). The ability to independently maintain ventilatory function may be impaired. Patients may require assistance in maintaining a patent airway and spontaneous ventilation may be inadequate. Cardiovascular function is usually maintained
General anesthesia: A drug-induced loss of consciousness during which patients are not arousable, even to painful stimulation. The ability to independently maintain ventilatory function is often impaired. Patients often require assistance in maintaining a patent airway, and positive pressure ventilation may be required because of depressed spontaneous ventilation or drug-induced depression of neuromuscular function. Cardiovascular function may be impaired

Source: Data from American Society of Anesthesiologists. ASA Standards, Guidelines and Statements, October 2007. Available at www2.asahq.org/publications/p-106-asa-standards-guidelines-and-statements.aspx

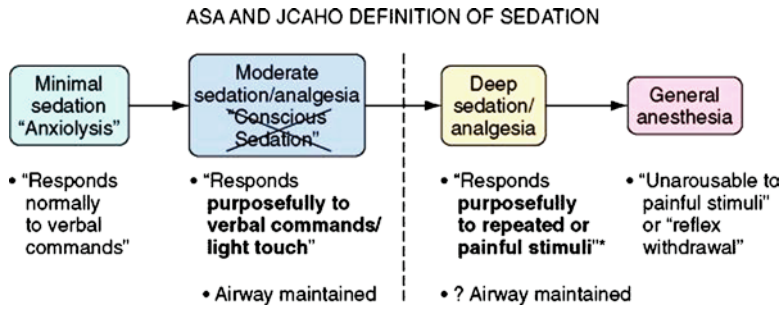

Fig. 4.2 The sedation continuum. A patient may readily pass from a light level of sedation to deep sedation or general anesthesia. Healthcare providers must be prepared to increase vigilance and intensity of monitoring consistent with the depth of sedation. One should consider all children younger than the age of 6 years as deeply sedated because "conscious sedation" in this age group for most children is an oxymoron. (*ASA, American Society of Anesthesiologists; JCAHO, Joint Commission on Accreditation of Healthcare Organizations*.) (Reproduced and used with permission from Kaplan et al. [6])

deeper than intended and allow the practitioner to intervene proactively, instead of having to rescue the patient from an episode of hypoxemia from airway obstruction or apnea. The ideal sedation scale would be applicable to children of all ages, easy and rapid to administer to allow repeated objective assessment, and correlate both with depth of sedation necessary for successful completion of the procedure and with adverse effects of sedation, i.e., airway obstruction, hypoxemia, hypotension, and bradycardia. It would be validated against other accepted scales, and also an objective method of assessment such as a processed EEG technique. And, it would be further validated in very large numbers of patients to determine whether the scale correlates with outcomes. Unfortunately, no such ideal sedation scale exists. However, there are a number of objective and semiobjective methods, some validated, to assess depth of sedation. This chapter will review the currently available and utilized sedation scales and assessment methods.

The Ramsay Scale

The Ramsay Sedation Scale (RSS) was described by Ramsay and colleagues in 1974 for the purpose of monitoring sedation with alphaxalone/alphadolone [9] (Table 4.2). It has been validated by several methods including a modified Glasgow Coma Scale and the Sedation Agitation Scale [10]. The Ramsay scale was one of the earliest sedation scales, and although not strictly validated in children, it is one of the most widely used scales for assessing and monitoring pediatric sedation in daily practice, as well as in clinical research. RSS spans the continuum of sedation but does not clearly separate purposeful from nonpurposeful responses.

Table 4.2 Ramsay Scale

Level	Characteristics
1	Patient awake, anxious, agitated, or restless
2	Patient awake, cooperative, orientated, and tranquil
3	Patient drowsy, with response to commands
4	Patient asleep, brisk response to glabella tap or loud auditory stimulus
5	Patient asleep, sluggish response to stimulus
6	Patient has no response to firm nail-bed pressure or other noxious stimuli

Source: Data from Ramsay et al. [9]

A later modification of the Ramsey scale more clearly coincides with the AAP and Joint Commission guidelines (Table 4.3) [6]. A score of 2–3 is anxiolysis, 4–5 is moderate sedation, 6 is deep sedation, and 7–8 is general anesthesia.

The Observer's Assessment of Alertness/Sedation Scale and Modified Observer's Assessment of Alertness/Sedation Scale

The Observer's Assessment of Alertness/Sedation scale (OAA/S) [11] was developed to measure the alertness of adult subjects who are sedated with benzodiazepines. It assesses consciousness level in four areas: responsiveness, speech, facial expression, and eyes (Table 4.4). The OAA/S was validated in 18 healthy males 19–44 years of age, who received intravenous midazolam, initial dose 0.035 mg/kg, followed by additional doses of 0.015 mg/kg every 60–90 s until one of two levels of sedation was reached, light or heavy. A placebo group was also used, and two raters determined the depth

Table 4.3 Modified Ramsay Sedation Scale with American Academy of Pediatrics/Joint Commission/American Society of Anesthesiologists Designation

Score	Characteristics
1	Awake and alert, minimal or no cognitive impairment
2[a]	Awake but tranquil, purposeful responses to verbal commands at conversation level
3[a]	Appears asleep, purposeful responses to verbal commands at conversation level
4[b]	Appears asleep, purposeful responses to verbal commands but at louder than usual conversation level or requiring light glabellar tap
5[b]	Asleep, sluggish purposeful responses only to loud verbal commands or strong glabellar tap
6[c]	Asleep, sluggish purposeful responses only to painful stimuli
7[d]	Asleep, reflex withdrawal to painful stimuli only (no purposeful responses)
8[d]	Unresponsive to external stimuli, including pain

Source: Data from Ramsay et al. [9]
[a] Minimal
[b] Moderate
[c] Deep
[d] GA, general anesthesia

Table 4.4 The Observer's Assessment of Alertness/Sedation Scale

Assessment Categories				
Responsiveness	Speech	Facial expression	Eyes	Composite score level
Responds readily to name spoken in normal tone	Normal	Normal	Clear, no ptosis	5 (Alert)
Lethargic response to name spoken in normal tone	Mild slowing or thickening	Mild relaxation	Glazed or mild ptosis (less than half the eye)	4
Responds only after name is called loudly and/or repeatedly	Slurring or prominent slowing	Marked relaxation (slack jaw)	Glazed and marked ptosis (half the eye or more)	3
Responds only after mild prodding or shaking	Few recognizable words	–	–	2
Does not respond to mild prodding or shaking	–	–	–	1 (Deep sleep)

Source: Data from Chernik et al. [11]

of sedation using the OAA/S and 100 mm visual analog scale (VAS) rating patients from 0 (very sedated) to 100 (completely alert). Each subject was tested three separate times in a crossover design to assess the OAA/S reliability, criterion, and construct validity. The scale was found to be reliable with high correlations between raters, to have strong criterion and behavioral validity with consistently decreasing scores for placebo, light and heavy sedation. The construct validity among the four components was also strong, as was the validity for subsequent administration to the same subject in the crossover phase. Finally, the investigators also used two performance tests, the Digit Symbol Substitution Test, and the Serial Sevens Subtraction Test to compare to OAA/S scores and again found strong correlation.

Despite this thorough validation of the OAA/S in adult patients, and its use in several sedation research studies in children [12, 13], the OAA/S has not been separately validated in children. The OAA/S has been used in the validation of the University of Michigan Sedation scale [14], and in assessments of the reliability of the bispectral index monitor in children [15].

The Modified Observer Assessment Sedation Score (MOAA/S) uses only the responsiveness category of the OAA/S. This category was separately validated in the original study [11] but as with the OAA/S has not been separately validated in children.

The COMFORT Scale

The COMFORT Scale is a physiologically based scale that was originated and validated in children receiving intensive care, and as such is not completely applicable to the procedural sedation environment [16] (Table 4.5). It was tested and validated in 37 ventilated pediatric patients, and inter-rater agreement and internal consistency were very strong. Criterion validity, assessed by comparison with concurrent global ratings of PICU nurses, was also high. It is included here as an example of such a physiologically based scale. An added dimension is the assessment of pain or discomfort. Generally, a COMFORT score between 18 and 26, with each area scored as 2–3, is desirable to signify appropriate levels of sedation in the ICU setting. It is clear that this scale is complex and will require several minutes to assess, and as such is more applicable for ICU care where the scale is performed no more frequently than every hour. In the context of most procedural sedation this scale will be inappropriate.

The University of Michigan Sedation Scale

The University of Michigan Sedation Scale (UMSS) is an assessment tool that has been shown to be valid when compared to the OAA/S scale and other scales of sedation (Table 4.6) [14]. It is a level of consciousness tool that readily

Table 4.5 The COMFORT Score

Domain	Characteristics	Score
Alertness	Deeply asleep	1
	Lightly asleep	2
	Drowsy	3
	Fully awake and alert	4
	Hyper-alert	5
Calmness/agitation	Calm	1
	Slightly anxious	2
	Anxious	3
	Very anxious	4
	Panicky	5
Respiratory response	No coughing and no spontaneous respiration	1
	Spontaneous respiration with little or no response to ventilation	2
	Occasional cough or resistance to ventilator	3
	Actively breathes against ventilator or coughs regularly	4
	Fights ventilator; coughing or choking	5
Physical movement	No movement	1
	Occasional slight movement	2
	Frequent slight movement	3
	Vigorous movement limited to extremities	4
	Vigorous movement including torso and head	5
Blood pressure	Blood pressure below baseline	1
	Blood pressure consistently at baseline	2
	Infrequent elevations of 15% or more (1–3 observations)	3
	Frequent elevations of 15% or more (more than 3 episodes)	4
	Sustained elevation ≥15%	5
Heart rate	Heart rate below baseline	1
	Heart rate consistently at baseline	2
	Infrequent elevations of 15% or more (1–3 observations)	3
	Frequent elevations of 15% or more (more than 3 episodes)	4
	Sustained elevation ≥15%	5
Muscle tone	Muscle totally relaxed	1
	Reduced muscle tone	2
	Normal muscle tone	3
	Increased muscle tone and flexion of fingers and toes	4
	Extreme muscle rigidity and flexion of fingers and toes	5
Facial tension	Facial muscles totally relaxed	1
	Facial muscle tone normal; no facial muscle tension evident	2
	Tension evident in some facial muscles	3
	Tension evident throughout facial muscles	4
	Facial muscles contorted and grimacing	5

Source: Data from Ambuel et al. [16]

Table 4.6 University of Michigan Sedation Scale (UMSS)

Score	Characteristics
0	Awake and alert
1	Minimally sedated: tired/sleepy, appropriate response to verbal conversation and/or sound
2	Moderately sedated: somnolent/sleeping, easily aroused with light tactile stimulation or a simple verbal command
3	Deeply sedated: deep sleep, arousable only with significant physical stimulation
4	Unarousable

separates patients into the sedation categories defined by the AAP, ASA, and Joint Commission. It does not explicitly rate pain, and does not include an assessment of vital signs. In a study of 32 children aged 4 months to 5 years undergoing CT scanning with oral chloral hydrate, 50–75 mg/kg, Malviya et al. [14] validated the UMSS by comparing the scores assessed every 10 min before, during, and after the procedure by the clinical sedation nurse, with assessments made

by trained, blinded observers of the videotaped assessments, which were edited and viewed in random order. UMSS was compared to a 10-point visual analog scale (VAS) and the OAA/S. One hundred and sixty-four observations were made, and the UMSS showed an excellent correlation with VAS ($r=0.955$) and OAA/S ($r=0.929$), $p<0.0001$ for both. There was excellent inter-rater agreement between sedation nurse and trained observers at UMSS 0 and 1, and good agreement at UMSS 3 and 4, as well as excellent agreement in a test–retest scenario where 75 videotaped observations were rescored at a later date. Thus it would appear that the UMSS meets several of the requirements for the ideal sedation scale, in that it is validated, rapid to administer, and allows repeated observations. A problem it shares with other scales is the need to arouse the patient to make an assessment; this is not possible during a procedure such as an MRI scanning sequence, and may be undesirable if the patient remains aroused after the assessment.

Dartmouth Operative Conditions Scale

The Dartmouth Operative Conditions Scale (DOCS) [1] was designed by three pediatrician/anesthesiologists, and then refined by videotaping 12 common procedures which included MRI, CT scan, voiding cystourethrogram, cardiac catheterization, fracture reduction, and bone marrow biopsy (Table 4.7). DOCS was created as a research tool to evaluate the conditions and responses to sedation [1]. The Dartmouth scale was validated by videotaping 95 procedures with sedation provided by a variety of providers including radiology nurses, pediatricians, pediatric residents, cardiologists, oncologists, and anesthesiologists. The scale allows quantification of children based on observable behavior. It rates level of sedation in four areas: pain or stress, movement, consciousness, and sedation side effects (Fig. 4.1). In this manner the completeness of the quality of sedation can be assessed comprehensively. Inter- and intra-rater reliability, construct validity, and criterion validity were all excellent. DOCS correlated well with the modified COMFORT score when video clips of procedural sedation were shown to 10 different healthcare providers.

The Dartmouth scale is a well-validated tool. It is best suited for research because of its comprehensive nature but nonetheless applicable to routine use for procedural sedation. Assessment of this scale at frequent intervals allows for careful tracking of state of sedation, effectiveness of sedation, uncontrolled side effects, and the timing of induction of sedation and recovery. This data can be helpful in quantifying the quality of sedation and best practices.

Modified Aldrete Score as a Sedation Scale

The Modified Aldrete Score has been in widespread use as a postanesthesia recovery score for many years and is detailed further in the latter part of this chapter (Table 4.8). Because of its

Table 4.7 The Dartmouth Operative Conditions Scale

Patient state	Observed behaviors/points			
Pain/stress	Eyes closed or calm expression: 0	Grimace or frown: 1	Crying, sobbing, or screaming: 2	–
Movement	Still: 0	Random little movement: 1	Major purposeful movement: 2	Thrashing, kicking, or biting: 3
Consciousness	Eyes open: 0	Ptosis, uncoordinated, or "drowsy": −1	Eyes closed: −2	–
Sedation side effects	SpO_2 <92%: −1	Noise with respiration: −1	Respiratory pauses >10 s: −1	BP decrease of >50% from baseline: −1

Source: Data from Cravero et al. [1]

near universal use for this purpose it is familiar to many sedation practitioners, and although not designed specifically for this purpose, it has been applied as a sedation scale during the procedure itself, as well as through recovery until discharge for procedural sedation in children. This score has not been independently validated neither in children nor for procedural sedation.

Processed EEG Monitors: The Bispectral Index

Several investigators have studied whether the Bispectral Index (BIS, Aspect Corporation, Newton, MA), a single-lead processed EEG that uses a proprietary algorithm to assign a number from 100 (completely awake) to 0 (isoelectric EEG), is meant to objectively assess the depth of sedation or anesthesia (Fig. 4.3). The appeal of processed EEG methods is that they are continuous, objective, and do not require awakening of the patient for assessment. Limitations of BIS include that the sensor, when applied to the forehead, must be secured with firm pressure to yield a valid signal, and this in itself may awaken the patient. Its ferromagnetic electrode array is not compatible with MRI magnetic fields. Malviya et al. [17] pooled data from four studies comparing UMSS to BIS values for 3,373 observations for 248 children aged 1 month to 18 years. The patients underwent a variety of diagnostic and therapeutic procedures, with a number of different agents including chloral hydrate, midazolam, pentobarbital, propofol, ketamine, and opioids. There was a moderate inverse correlation between BIS and UMSS in all age groups; however, there was not a difference between BIS values and UMSS 3 and 4 (moderate and deep sedation) in all age groups, and UMSS 0 and 1 (awake vs. light sedation) in infants. Furthermore, there was a poor correlation between BIS and UMSS with ketamine or opioid use. The authors concluded that BIS values must be interpreted with caution during procedural sedation in infants and children, with particular attention needed to the age of patient and agents used.

Mason et al. [18] compared BIS values immediately after an MRI or CT scan in 86 children greater than 1 year of age undergoing sedation with pentobarbital as a sole agent, who had achieved Ramsay scores of 4 or 5 (moderate or deep sedation). There was no significant difference between the sedation scores and BIS values (63 ± 12 and 64 ± 15 for RSS 4 and 5, respectively, $p = 0.64$). There was a wide variation in BIS values of 31–90. The authors concluded that the BIS had limited ability to distinguish moderate from deep sedation levels.

These studies and other data suggest that BIS has limited utility in assessing sedation level in children [19]. This is due to several factors, including the age-related developmental differences in the EEG between infants, children, and adults; and the different values achieved with similar levels of sedation with different agents [20].

Other Sedation Scales

There are a number of additional sedation scales, such as the Harris, modified Glasgow Coma Score, Cambridge, Bloomsbury, Neurobehavioral Assessment Scale, Sedation-Agitation Scale, PRST (pressure, rate, sweat, tearing), Vancouver Sedative Recovery Scale, Motor Activity Assessment Scale, and many others [10]. These scales are largely not applicable to pediatric procedural sedation because they were designed either for adult or for pediatric ICU care, and many have not been validated. None were designed primarily for procedural sedation. Most also measure physiologic variables as part of the assessment, and thus are long and cumbersome to apply for procedural sedation.

Objective, Physiologically Based Sedation Scales

As is evident from the discussion above, the ideal sedation scale for pediatric patients undergoing procedural sedation does not exist at this time. Limitations of all scales include the inherent subjectivity in assessing the patient's response to verbal or tactile stimulation, which is included in most of the scales. In addition, the arousal of the patient necessary for assessment can interfere with both

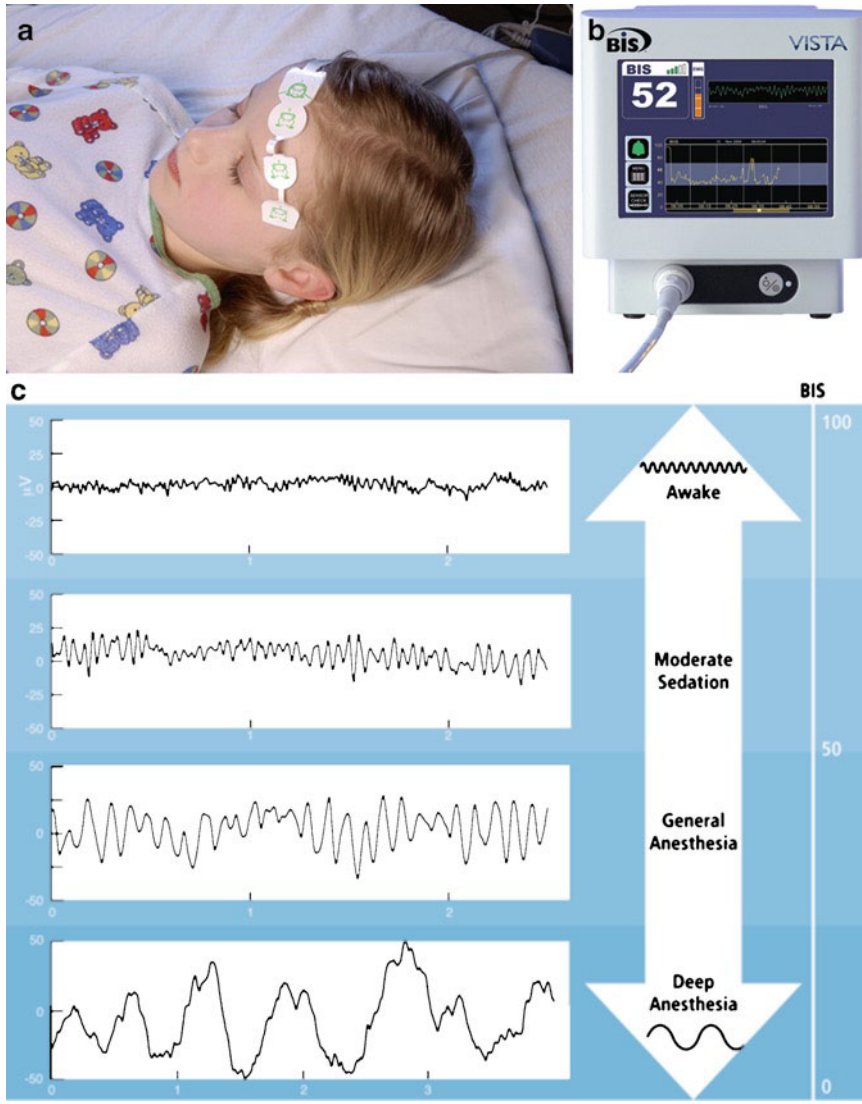

Fig. 4.3 (**a**) The Bispectral Index® (BIS) pediatric sensor. A one-channel EEG monitor with reference electrode applied to the forehead. (**b**) The BIS® monitor displays a single processed EEG number from 0 to 100, as well as the raw EEG waveform, and signal strength indicator. (**c**) The sedation continuum using the BIS algorithm. See text for details. (Images used by permission from Nellcore Puritan Bennett LLC, Boulder CO, doing business as Covidien)

the sedation level itself, and interrupt the procedure. Also, many scales have not been validated, and interobserver reliability is thus in question. Finally, the ability to discriminate safe from dangerous levels of sedation, i.e., deep sedation from general anesthesia, is limited and has not been demonstrated for most of the scales, or for processed EEG monitoring, and thus the goal of preventing airway and cardiovascular complications is also problematic using current schema.

Green and Mason [21] have advocated a reformulation of the sedation continuum. Instead of basing the scale on subjective or semiobjective criteria, scales based on objective physiologic monitoring would be devised. The reformulated sedation continuum would be based on an objective means of assessing and stratifying sedation risk. The tool would be identified as the Objective Risk Assessment Tool for Sedation (ORATS) and would guide training, credentialing and quality

New levels (as yet unnamed)	Escalating risk of serious adverse event	Physiological monitoring parameters (singular or combination)[a]	Recommended sedationist skill set	Recommended resources[b]
1	≤1:10,000	Consistent with normal awake pattern and frequency	Ability to observe and interpret the agreed-upon physiological monitoring parameters	Appropriate for risk level
2	1:1,000	← Objective monitoring predicts this level of risk	Skills appropriate for maintaining sedation at this risk level and for rescuing from the subsequent level	Appropriate for risk level
3	1:100	← Objective monitoring predicts this level of risk	Skills appropriate for maintaining sedation at this risk level and for rescuing from the subsequent level	Appropriate for risk level
4	≥1:10	← Objective monitoring predicts this level of risk	Skills appropriate for maintaining a patient at this risk level	Appropriate for risk level

Fig. 4.4 Objective Risk Assessment Tool for Sedation (ORATS). Preliminary sample schematic for an Objective Risk Assessment Tool for Sedation (ORATS). The choice of four levels here is arbitrary and for illustration purposes only; the final tool would contain the minimum number of discrete levels with independent predictive value.
[a]Focused research would be required to validate the specific variables, parameters, and thresholds that predict the progressive levels of serious adverse event risk. Evaluation of capnography, for example, could include but not be limited to evaluation of waveform, frequency, pattern and/or numerical value on inspiration or expiration.
[b]To be determined at each level by consensus panel and would include but not be limited to recommendations on adjuvant personnel, intravenous access, availability of rescue medications and airway equipment

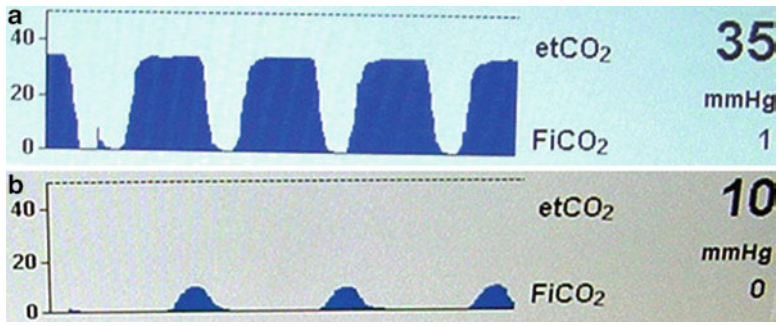

Fig. 4.5 (**a**) Normal capnograph in a sedated patient, obtained with divided nasal cannula. Respiratory rate of 16, and end-tidal CO_2 of 35 mmHg with full "area under the curve" waveform with long plateau signifies unobstructed airway and adequate tidal volumes in this patient. (**b**) Capnograph from a patient with significant respiratory depression. Respiratory rate is 10 per minute, and end-tidal CO_2 is only 10 mmHg, likely signifying small tidal volumes

indicators of sedation providers and sedation outcome respectively. This ORATS tool would be used in conjunction with a Comfort Assessment Tool for Sedation (CATS) which reconfigures the existing sedation continuum to reflect and follow the degree of comfort (Fig. 4.4) [22].

The scale includes capnography as one of the objective tools for assessment. Capnographic monitoring may provide an objective, valuable tool to follow sedation depth as well as warn of potential or existent compromise. Because most sedation-related adverse events begin with airway and ventilatory problems, capnography would be able to detect abnormalities, i.e., upper airway obstruction from lax pharyngeal muscle tone and tongue resulting in cessation of airflow, at its earliest occurrence (Fig. 4.5). This is substantially before arterial desaturation is detected by pulse oximetery, or bradycardia or hypotension from prolonged hypoxia. Portable capnographic monitoring is easily performed via widely available divided nasal cannulae made in infant, pediatric, and adult sizes, and can be used in all situations, including the MRI suite [23]. Indeed, capnography

monitoring for procedural sedation has been demonstrated to improve safety in children. Lightdale et al. [24] reported 174 moderate sedations in children for gastrointestinal endoscopy procedures, with half receiving capnographic monitoring and an intervention protocol and the other half blinded capnography with only rescue intervention, in a prospective randomized study design. Eleven percent of patients in the intervention arm had SpO_2 <95% for greater than 5 s, versus 24% in the control arm ($p<0.03$).

Potential capnographic criteria for increasing levels of sedation would include age-appropriate respiratory rate determined by the capnograph (slower means deeper sedation), significant decreases in end-tidal CO_2 values (signifying smaller tidal volumes or partial airway obstruction, or in worst case scenario low cardiac output), or complete absence of end-tidal CO_2, associated with complete airway obstruction. Specific, focused research would be required to stratify levels of risk based on capnographic and other parameters. A multidisciplinary effort would be required to develop updated guidelines.

Recovery and Discharge Scales

The concept of postanesthesia recovery after a surgical procedure has been expanded to procedural sedation, and scales originally designed to assess anesthesia recovery readiness for discharge to a hospital ward (Aldrete, Steward – see below) have also been expanded to include recovery from sedation, and readiness for discharge to home after procedural sedation without a painful operative procedure, e.g., an outpatient brain MRI for assessment of seizure disorder or developmental delay. Obviously the requirements for discharge can be very different in these two circumstances. The outpatient should be able to resume quiet "normal" activities before discharge from sedation, i.e., spontaneous wakefulness, eating, voiding, drinking, and ambulating with assistance. The inpatient may not need to meet all these requirements. This raises the question of whether these types of recovery scales have ever been validated for the purpose of discharge readiness, and in the case of the postanesthesia recovery scales, they have not. Besides assessing readiness to resume "normal" activities, the purpose of discharge and recovery scales is to prevent adverse events. Respiratory and cardiac events, including death, have occurred after premature discharge following procedural sedation [2]. These events have mostly occurred when a long lasting (long half-life) sedative such as chloral hydrate has been given. This can result in the child being unable to spontaneously unobstruct his or her airway.

Table 4.8 The modified Aldrete Scale

Domain	Response	Points
Activity	Able to move four extremities voluntarily or on command	2
	Able to move two extremities voluntarily or on command	1
	Unable to move extremities voluntarily or on command	0
Respiration	Able to breathe deeply and cough freely	2
	Dyspnea or limited breathing	1
	Apneic	0
Circulation	BP ± 20% of preanesthetic level	2
	BP ± 20–49% of preanesthetic level	1
	BP ± 50% of preanesthetic level	0
Consciousness	Fully awake	2
	Arousable on calling	1
	Not responding	0
O_2 saturation	Able to maintain SpO_2 >92% on room air	2
	Needs O_2 inhalation to maintain SpO_2 >90%	1
	SpO_2 <90% even with O_2 supplement	0

Source: Data from Aldrete [26]

The Aldrete score was introduced in 1970 [25], validated in adults, and quickly became the standard for PACU discharge from surgery for both adults and children. It rates five domains: activity, respiration, circulation, consciousness, and color. A point score of 0, 1, or 2 is given in each domain for a maximum score of 10 (Table 4.8). With the introduction of pulse oximetry, the score was modified to include SpO_2 instead of color [26]. Because of its familiarity, it has been used as a score for discharge from sedation as well. A score of 9 or 10 is standard to determine readiness for discharge.

The Maintenance of Wakefulness Test was devised to assess daytime somnolence in patients with sleep disorders [27, 28]. Polysomnography is used to measure the time taken for an adult patient to fall asleep in a dark, quiet room, after they have been instructed to stay awake. The Modified Maintenance of Wakefulness Test (MMWT) is a new modification of the original test, which was devised to help determine discharge readiness in children [29]. The MMWT requires visual observation to measure the duration of time from patient awakening to falling asleep. Malviya et al. studied 29 infants receiving either chloral hydrate or midazolam/diphenhydramine oral sedation for echocardiogram [29]. The modified wakefulness test was combined with the UMSS sedation scale (see above) to devise new, modified discharge criteria, which were compared with the standard hospital sedation discharge criteria. A UMSS of 0 or 1 (awake or minimally sedated), combined with a modified wakefulness test (MMWT) of 20 min, was required to meet these criteria. These data were compared with the Bispectral Index, with a value of 90 or higher signifying adequate wakefulness for discharge. Standard discharge criteria were stable vital signs, oxygen saturation, and level of consciousness compared to presedation baseline. The patient must be able to maintain a patent airway, manage oral secretions independently, or demonstrate the ability to swallow or demonstrate a gag reflex. In addition, the patient must be able to move or ambulate safely consistent with their presedation baseline. Combining the MMWT and UMSS criteria correctly identified 88% of infants with BIS >90, compared with only 55% of children assessed as "street ready" according to usual hospital discharge criteria [29]. In addition, time in recovery to discharge was only 16 ± 13 min using the standard discharge criteria versus 75 ± 76 min ($p \leq 0.007$) using the revised criteria. This study reveals that many children discharged using standard criteria may indeed not truly be back to their baseline status, and thus be potentially at risk for delayed complications. These more objective discharge criteria would need to be studied in a much larger group of patients to determine whether late complications were truly reduced.

Table 4.9 The Steward simplified postanesthetic recovery score

Domain	Level	Points
Consciousness	Awake	2
	Responding to stimuli	1
	Not responding	0
Airway	Coughing on command or crying	2
	Maintaining good airway	1
	Airway requires maintenance	0
Movement	Moving limbs purposefully	2
	Nonpurposeful movements	1
	Not moving	0

Source: Reprinted from Steward [30], with kind permission of Springer Science + Business Media

Steward [30], citing the difficulty of assessing patient color (pulse oximetry was not available at the time), and the sometimes inconsistent relationship of blood pressure to recovery from anesthesia, proposed a simplified score (Table 4.9). The original publication was a short description of the scale, and its rationale, but there was no actual patient data attempting to validate it as had been done in the original Aldrete Score paper. Despite its use in a number of pediatric studies [31, 32] it has not been independently validated.

Table 4.10 summarizes the sedation, recovery, and discharge scales which have been reviewed and include parameters assessed, utility in various phases of the sedation process, strengths and limitations.

A Practical Approach to Sedation Scales and Discharge Scores

Synthesizing the concepts presented in this chapter, and considering the demands of a busy sedation service that must be efficient as well as safe. I propose a practical approach to sedation scales, recovery and discharge scores. If moderate or deep sedation by a nonanesthesiologist is planned (the vast majority of pediatric sedations, as only older children undergoing nonpainful procedures, will undergo minimal sedation), one suggested approach is to use a validated simple level of consciousness scale (Ramsay, UMSS, or Aldrete).

Table 4.10 Characteristics of sedation and recovery/discharge scales

Scale	Parameters measured	Sedation, recovery, or discharge scale	Strengths	Limitations	Validated?	References
Ramsay Sedation Scale	Level of consciousness	S, R, D	Simple	No physiologic parameters, must awaken patient	Adults	[6, 9, 10]
OAA/S	Responsiveness, speech, facial expression, eyes	S, R, D	Well validated, relatively simple	No physiologic parameters, must awaken patient	Adults	[11–13]
Modified OAA/S	Responsiveness only	S, R, D	Simple	No physiologic parameters, must awaken patient	Adults	[11]
COMFORT	Alertness, agitation, and multiple physiologic parameters	S	Comprehensive, well validated	Very complex, time consuming, not appropriate for routine procedural sedation	Children	[16]
UMSS	Level of consciousness	S, R, D	Relatively simple	Does not rate pain or physiologic parameters, must arouse patient	Children	[14]
Dartmouth	Pain, movement, consciousness, physiologic parameters	S	Comprehensive, rates pain and movement	Relatively complex	Children	[1]
Modified Aldrete	Activity, respiration, circulation, consciousness, oxygen saturation	S, R, D	Widespread use and familiarity	Not designed as a sedation scale	Adults	[25, 26]
Modified Maintenance of Wakefulness	Maintenance of alertness	R, D	Simple	Requires at least 20 min to administer	Children	[29]
Steward	Consciousness, airway, movement	S, R, D	Simple	No assessment of oxygen saturation	No	[30]
Bispectral Index®	Processed electroencephalogram	S, R, D	Semiobjective; one simple number reported	Continuous, no need to awaken patient	Adults, incomplete validation in young children; not compatible with MRI	[17–19]
Capnography-based	End-tidal CO_2	S, R	Objective; sensitive indicator of respiratory depression/obstruction	Many artifacts; equipment not always available	Adults and children, as monitor	[21–24]

S sedation phase; *R* recovery phase; *D* discharge phase; *OAA/S* Observer's Assessment of Alertness/Sedation Scale; *UMSS* University of Michigan Sedation Scale

Assess every 15 min at a minimum, or when a change in level of sedation occurs, i.e., after an additional dose of sedative. In addition to standard monitoring with continuous ECG and SpO_2, document automated oscillometric blood pressure measurement at least every 5 min. The sedation and recovery personnel must be familiar with the patient's baseline heart rate, blood pressure, respiratory rate and oxygen saturation, as well as the age-related normal ranges. Follow end-tidal CO_2 monitoring via a divided nasal cannula for moderate sedation and beyond, if logistically and practically feasible. The sedation scale need not be assessed if it would arouse the patient and interrupt the procedure, on a patient who has not exhibited any signs of oversedation, i.e., hypotension or respiratory depression. In this way, the frequent physiologic monitoring is used instead of a more extensive and difficult to administer scale that scores the vital signs, i.e., COMFORT scale. The recovery and discharge score could be a modified Aldrete score of 9 or 10, a UMSS of 0 or 1, or a modified wakefulness test of 20 min. It may be simplest to use the same scale for both the sedation and the recovery phases, i.e., the Ramsey, UMSS, or modified Aldrete could be used throughout. The exact tests and scales are determined by institutional preferences.

Whatever scales are decided upon, they are not a substitute for well-trained sedation practitioners exercising skill and vigilance, combined with continuous physiological monitoring to ensure the best outcomes.

Conclusions

Regular use of sedation, recovery, and discharge scales for pediatric procedural sedation is essential, given the wide variety of practitioners involved, as well as the variety of procedures and agents. Uniform assessment will minimize oversedation and complications, but also ensure that adequate levels of sedation and analgesia are achieved. In addition, only by more objective measurement of sedation will hospitals and departments have accurate data to improve the quality and outcomes of their programs. In the future, more objective physiologically based scales, utilizing capnography, should be devised. Any research on new agents or approaches must be validated using sedation scores that are objective and allow scientific comparison of different methods.

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