Development of a Two-Dimensional Sedation Rating Scale for Critically Ill Adults

Craig Weinert, MD, MPH; and Lisette McFarland, BS

Study objectives: To develop and evaluate an observer-rated instrument, the Minnesota Sedation Assessment Tool (MSAT), which is a measure of arousability, spontaneous muscle activity, and global sedation quality of mechanically ventilated adults.

Design: Paired raters assessment for reliability testing and observational design for validation testing.

Setting: Medical and surgical ICUs at a university-based hospital.

Participants: Ninety-four intubated patients in ICUs and 93 ICU staff nurses.

Interventions: None.

Measurements and results: The MSAT had very good overall reliability between raters, with the arousal scale (κ = 0.85) having slightly better agreement than the motor activity scale (κ = 0.72). The instrument had good coverage, very few missing values, and very good correlation with visual analog scales. The MSAT arousal scale had moderate correlation (ρ = 0.68) with the analogous scale of a previously validated sedation instrument, the Vancouver Interaction and Calmness Scale. The correlation was weaker (ρ = -0.41) between the MSAT motor activity scale and the calmness subscale, probably because of their dissimilar constructs. Both MSAT scales demonstrated convergent validity, whereas predictive validity was demonstrated in both a hypothetical scenario and in actual clinical practice for the MSAT arousal scale only. A patient’s spontaneous motor activity was not associated with future sedative administration, with the possible exception of a more-sedated patient subgroup.

Conclusions: The MSAT combines the efficiency of a single-item response format while permitting the separate reliable measurement of distinct observable characteristics of intubated patients. The level of consciousness of intubated patients influences the future administration of sedative medications. Spontaneous motor activity is less important in determining subsequent sedative use but may be useful as a comparative measure of patients’ kinesiologic state during critical illness.

Key words: anesthesia and analgesia; artificial respiration; critical illness; intensive care

Abbreviations: CI = confidence interval; MSAT = Minnesota Sedation Assessment Tool; RASS = Richmond agitation-sedation scale; VAS = visual analog scale; VICS = Vancouver Interaction and Calmness Scale

The administration of sedative medications to mechanically ventilated adults in ICUs is a common practice. To facilitate communication between caregivers and to standardize practice, numerous observer-rated sedation scales have been developed. Many sedation scales have excellent interrater reliability and concurrent criterion validity (ie, they correlate with other sedation scales measured concurrently). Construct validity has been supported by showing that scale levels are associated with prior sedative medication exposure.
logic measures of cardiopulmonary stress or brain activity, or nurses’ opinions as to whether additional clinical interventions are necessary. Only one scale has demonstrated predictive criterion validity, which is the association between a subject’s present state (as measured by a scale) and the occurrence of future events experienced by that person.

A limitation of some commonly used sedation scales, such as the Ramsay sedation scale, the Sedation Agitation Scale, the Richmond Agitation and Sedation Scale (RASS), and the Motor Activity and Agitation Scale, is that a single number is used to characterize distinct behaviors, which precludes the separate reporting of domains such as level of consciousness and agitation. If behaviors such as agitation, arousal level, and visual attention influence the decisions of caregivers to administer more or less sedative medication, then single-item instruments could lead to information loss. This problem, which has been noted by other investigators, was addressed successfully in the Vancouver Interaction and Calmness Scale (VICS), which uses two summed rating scales.

The focus of our research has been on discovering the characteristics associated with sedation adequacy, and to describe the pharmacoepidemiology of sedative practice and its effects on post-ICU recovery. Therefore, our objective was to develop an instrument that could measure at least two relevant domains that likely are associated with sedative exposure, yet retain a low response burden. The scale should not have a single “optimal” level (ie, every scale level could be appropriate for certain patients at specific times during their ICU stay), and values for a general ICU population should range across the entire scale. We wished to test the scale using methods of convergent construct validity as well as two forms of criterion validity (ie, concurrent and predictive). During scale development, as a secondary aim, we also planned analyses to better understand how caregivers judge overall sedation quality.

**Materials and Methods**

The development of the Minnesota Sedation Assessment Tool (MSAT) was performed in four phases. First, we held five focus groups with ICU nurses, and concluded that nurses’ choices about sedation therapy are influenced by the anatomic distribution of patients’ spontaneous motor activity and level of consciousness. We also concluded that while caregivers may be able to establish the presence of pain, anxiety or delirium, they have difficulty in determining whether these conditions were the causes of a patient’s agitation.

Second, we drafted the MSAT as a two-domain instrument, with raters selecting a single item in each subscale. We used neutral language to minimize bias, whereby responders tend to choose levels that imply a desirable state such as “cooperative, oriented, and tranquil.” We pretested the assessment procedure, response format, and number of levels by asking 21 critical care physicians and 22 nurses to rank MSAT sedation levels in 12 hypothetical sedation scenarios. From these results, we modified the MSAT to have a motor activity scale with four levels and an arousal scale with six levels.

Motor activity was conceptualized as a subject’s observed spontaneous activity (ie, not in response to commands or tactile stimulation), and the ordered levels of motor activity correspond to the anatomic distribution of muscle groups. “No movement” (excepting respiratory activity) is the lowest level of motor activity, increasing to “distal limb” (ie, hand/foot/head movement), to “proximal lower or upper extremity” movement, and up to the highest level of “central truncal movement.” Whether the motor activity is appropriate or not (eg, agitation) does not influence the scoring of the motor activity scale. As such, the motor activity scale is not an agitation measure but a quantification of spontaneous muscle activity in intubated patients. Although derived from the empirical observation of ICU patients, the ordered anatomic distribution is analogous to a severity rating for neurologic conditions such as stroke or seizures. We chose this specific construct because although agitation-related events can have severe clinical consequences, agitation prevalence, as measured by sedation scales, is relatively uncommon (eg, in two large studies, only 5 to 10% of all assessments were in the “agitated” range).

The arousal scale is a hierarchic level of consciousness/alertness measure based on eye opening and roughly corresponds to the “sedation” or “alertness” part of other sedation scales. If the subject’s eyes are open, the rater chooses between “eye tracking” and “no eye tracking.” Otherwise, a two-step (ie, auditory then tactile) stimulation protocol is performed with scoring determined by the stimulus intensity required for eye opening or other bodily movement. Cognitive function, attention, or interactivity is not assessed in the arousal scale. The MSAT administration procedure is located in the Appendix.

The third phase was to estimate the interrater reliability of the MSAT using nonresearch registered nurses who had a minimal amount of MSAT training. Testing was performed in the adult medical and surgical ICUs at Fairview-University Medical Center, the primary teaching hospital of the University of Minnesota Medical School. There were no other standardized sedation assessments or therapeutic algorithms in use during the reliability study.

Rater subjects were all receiving mechanical ventilation, and the current sedative medication dose or severity of illness were not exclusion criteria. The university institutional review board approved the study, and we obtained the required informed consent from family members. We randomly paired 18 registered nurses from the ICU for the duration of the reliability study, and rater pairs were brought into the subject’s room without notice and independently scored the motor activity level by passively observing spontaneous motor activity for 30 s. Then, if necessary, a randomly selected rater performed the stimulation procedure for the arousal scale with both raters independently scoring the response. Subjects could be assessed up to three times but only on separate days to increase the independence of the observations. We estimated interrater consistency with intraclass correlation coefficient and \( \kappa \) statistic. A value of \( \kappa > 0.75 \) was considered to be excellent agreement, \( \kappa = 0.4 \) to 0.75 was considered to be good, and \( \kappa < 0.4 \) was considered to be poor.

After the reliability testing phase, we modified the MSAT such that nurses could select a single-word descriptor (eg, “adequate,”...
“oversedated,” or “undersedated”) that, in their opinion, best described the overall sedation quality in the previous 4 h. Raters could consider patients’ clinical status, planned depth of sedation, oxygenation, ventilator synchrony, and hemodynamic data that were not specifically assessed by the MSAT. MSAT scores are presented without summing, for example, as “2.4.A” (motor activity, 2; arousal, 4; sedation quality, A [adequate]).

Phase four was scale validation, and three hypotheses were tested. First, domains of spontaneous motor activity and arousal level should correlate with visual analog scale (VAS) lines anchored at “motionless,” and “very active” and “completely unresponsive-alert,” respectively. Second, MSAT domains should correlate with those of a previously validated two-domain sedation scale, the VICS. We hypothesized that the correlation between the VICS interaction scale and the MSAT arousal scales would be greater than the correlation of the VICS calmness scale and the MSAT motor activity scale because the constructs are slightly different in the latter comparison. Third, the MSAT scales should have predictive validity. First, we determined whether the motor activity or arousal scales were associated with nurses’ sedative medication interventions in the 90 min after the assessment. Second, in both a hypothetical scenario and in actual care delivery, we tested whether future sedation treatment depended on the presence of a discrepancy between the MSAT assessments and the nurses’ stated sedation goal for that patient. For example, patients with a sedation goal of “light” or “no sedation” who exhibited low levels of arousal or motor activity should be more likely to have their sedation decreased over time compared to patients with the same sedation goal who exhibited higher arousal or motor activity levels. Nurses’ sedation goals were dichotomized into deep/moderate or light/none as were the MSAT arousal levels (ie, 1, 2, 3 or 4, 5, 6) and motor activity level (ie, 1, 2 or 3, 4). Each patient assessment then was allocated to one of the following three categories: excess sedation (the actual MSAT level was lower than the nurses’ goal); insufficient sedation (the actual MSAT level was higher than the nurses’ goal); or at-goal sedation (the MSAT level was equal to the nurses’ goal).

After patient enrollment in the validation study, nurses indicated the patient’s current sedation goal (ie, deep, moderate, light, no sedation, or do not know), performed an MSAT assessment (the motor activity observation period was increased to the 10-min interval prior to the assessment), and then responded to the following hypothetical scenario. Assume that the patient was receiving a continuous medication or a bolus of an IV with the median. Validation testing occurred from September 2001 to April 2002 and examined patients who previously had consented to participate in an observational study of post-ICU outcomes.

We used χ² analysis to determine whether the distribution of these categories differed across the six ordered categories of the “strongly agree” to “strongly disagree” future medication question described previously. We similarly tested for an association (Fisher exact test) among the three MSAT goal categories and actual medication changes in the subsequent 90 min. The Spearman ρ statistic was used to describe the correlation between MSAT values and corresponding VAS values.

Results

During a 2-month interval in 2001, 35 subjects were recruited for MSAT reliability testing. Subjects had a mean (± SD) age of 51 ± 15 years, 18 were men, and 34% were admitted to the ICU after surgery. The reason for intubation was postoperative (11 patients), COPD exacerbation, pneumonia, aspiration, or pulmonary edema (15 patients), and sepsis, cardiac arrest, or other (9 patients). A total of 50% of patients were enrolled within 2 days of ICU admission, and 75% were enrolled within 6 days. The sample was severely ill with an ICU mortality rate of 29% and a mean ICU length of stay of 21 ± 20 days. A total of 63% of subjects had three assessments, 23% had two assessments, 11% had one assessment, and one subject inadvertently had four assessments.

The 18 nurse raters had an average of 10 years of ICU experience and performed 91 paired MSAT assessments. In 87% of the assessments, the subject had received therapy with either a benzodiazepine or an opiate in the previous 48 h, and in 46% of the assessments the patient was receiving a continuous sedative infusion. Table 1 shows that most subjects’ motor activity during the 30-s observation period was rated at the lowest level (motionless), whereas the arousal levels were more evenly distributed across all six levels.

Table 1—Ninety-One Paired Ratings of MSAT Motor Activity and Arousal Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Score</th>
<th>Rater 1 Score</th>
<th>Rater 2 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>Motor activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rater 2</td>
<td>1 50</td>
<td>4 1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>23 3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1 1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Arousal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rater 2</td>
<td>1 20</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>12 1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>2</td>
<td>16</td>
</tr>
</tbody>
</table>
For the motor activity scale, the intraclass correlation coefficient between raters was 0.81 (95% confidence interval [CI], 0.73 to 0.87) and κ = 0.72 (95% CI, 0.59 to 0.84), with perfect agreement in 87% of assessments. For the arousal scale, the intraclass correlation coefficient was 0.96 (95% CI, 0.94 to 0.97) and κ = 0.85 (95% CI, 0.77 to 0.93), with perfect agreement in 88% of assessments. Agreement was slightly improved for both scales if subjects were not receiving a continuous infusion of a sedative during the assessment, but the results were not statistically different.

For the validation phase, 75 nurse raters performed 100 assessments of 59 subjects. No nurse rater contributed more than three assessments. Twenty-six patients had one rating, 24 had two ratings, and 9 had three ratings. The first assessment was performed at a median of 5 days after intubation, and 51% of assessments were performed while the subject was receiving a continuous sedative infusion. Figure 1 demonstrates that as the motor activity observation period was extended to 10 min, the distribution was shifted toward higher levels compared to observations in the reliability phase. For instance, using rater 1 as the “gold standard” in the 30-s assessment (Table 1), 57% of observations were rated at level 1, 33% at level 2, 6.7% at level 3, and 3.3% at level 4. With the 10-min observation, 38% were rated at level 1, 43% at level 2, 12% at level 3, and 7% at level 4. There was little difference in the arousal scale distribution between the two samples. The validation sample received ratings across the entire range of both scales with MSAT arousal levels of 5 (ie, eyes open without tracking) and 3 (ie, eyes open after shoulder shake) observed least frequently.

Two percent of MSAT assessments (2 of 100 assessments) had missing data, whereas 21% of the VICS assessments were incomplete because of at least one missing value or “not applicable” values from a total of 10 possible items (21 of 100 assessments). Counting all VICS items, 60 of 1,000 items were missing or not applicable. Missing values occurred mostly in the interaction subscale as raters thought that statements such as “information communicated by the patient is reliable” or “patient cooperates” were uninterpretable or not applicable for their heavily sedated patient. The VICS interaction scale distribution had a right skew (median, 12; interquartile range, 8 to 21) whereas the Calmness scale had a more pronounced left skew (median, 25; interquartile range, 20 to 29), suggesting that the study sample was, on average, calm but not very interactive.

The correlation between the MSAT motor activity scale and a VAS anchored at “motionless” and “very active” was moderate (ρ = 0.64; p < 0.001), whereas the correlation between the MSAT arousal scale and a VAS anchored at “completely unresponsive” and “alert” was higher (ρ = 0.80; p < 0.001). The correlation between the MSAT motor activity scale and the VICS calmmness scale (ρ = -0.41; p < 0.001) was statistically significant but, as hypothesized, weaker than the MSAT arousal scale-VICS interaction scale correlation (ρ = 0.68; p < 0.001). The presence of a continuous infusion of sedative medication did not significantly affect the MSAT-VICS correlation. Excluding the 15 assessments with level 1 on the Ramsay scale (not a measure of level of consciousness), the correlation between the MSAT arousal scale and the Ramsay scale was strong (ρ = -0.80; p < 0.001).

Figure 2 shows that as the VICS interaction scale score increased there was a corresponding increase in the MSAT arousal scale level, but there was minimal separation between MSAT arousal scale levels 2 to 3 or 4 to 5. Similarly (Fig 3), patients at level 4 on the MSAT motor activity scale had a wide range of VICS calmmness scale scores, with a mean value greater than motor activity level 3, suggesting that the spontaneous movement of truncal muscles can occur in patients with a wide range of calmness.

The nurses judged the overall sedation quality as undersedated in 6% of assessments, oversedated in 9% of assessments, and adequately sedated in 85% of assessments. Table 2 shows that patients who were judged to be oversedated had significantly lower motor activity and arousal levels compared to patients judged to be undersedated, which supports the convergent validity of the MSAT.

There was a statistically significant association in the hypothesized direction between the MSAT arousal score and nurses’ actual sedation therapy during the subsequent 90 min (Table 3). Patients

![Figure 1. Distribution of MSAT motor scores (four levels) and arousal scores (six levels) in the validation sample. Black bars = arousal scale; gray bars = motor activity scale.](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/22019/ on 06/27/2017)
with lower arousal scores (ie, 1, 2, and 3 [less arousable]) were more likely to have their medication dosages decreased compared to increased (21% vs 12%, respectively). Similarly, the group with arousal scores in the top half of the scale (ie, 4, 5, and 6 [more arousable]) was much more likely to have their sedative medication dosages increased in the subsequent 90 min rather than decreased (20% vs 2%, respectively). This supports the predictive utility of the MSAT arousal scale.

Table 4 shows that 18% of assessments had an arousal level below the nurses’ desired sedation goal (ie, excessive sedation), 66% were at the desired level, and 17% had an arousal level greater than the goal (ie, insufficient sedation). Patients with arousal levels lower than the goal were more likely to have their nurses disagree that additional medications should be administered. Similarly, patients with arousal levels higher than the goal were more likely to have their nurses agree that additional medications should be administered. The association between discrepancy category and the actual sedative interventions within 90 min was in the hypothesized direction but did not reach statistical significance (data not shown; p = 0.10 [Fisher exact test]).

The relationship between the motor activity scale and subsequent sedative therapy was less consistent compared to that with the arousal scale (Table 5). In the group with motor scores in the lower half of the scale (ie, 1 and 2 [no movement or distal movement only]), about the same proportion of subjects had their medication dosages increased as decreased.

---

**Figure 2.** Association between the MSAT arousal scale and the VICS interaction scale. □ = mean values; horizontal bars = ± 1 SD. Higher VICS interaction scale values represent a more interactive patient.

**Figure 3.** Association between the MSAT motor activity scale and the VICS calmness scale. □ = mean values; horizontal bars = ± 1 SD. Higher VICS calmness scale values represent a calmer patient.

---

**Table 2—Relationship Between MSAT Motor Activity or Arousal Level and Inadequate Sedation Quality**

<table>
<thead>
<tr>
<th>MSAT Level</th>
<th>Increase (n)</th>
<th>No Change† (n)</th>
<th>Decrease (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor activity</td>
<td>Subjects judged oversedated</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Subjects judged undersedated</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Arousal</td>
<td>Subjects judged oversedated</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Subjects judged undersedated</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Relationship between distribution of MSAT scale levels and quality of sedation (undersedated or oversedated) significant at p < 0.002 by Fisher exact test for both scales.

---

**Table 3—Relationship Between MSAT Arousal Scale and Future Sedative Therapy**

<table>
<thead>
<tr>
<th>MCC</th>
<th>Increase (n = 16)</th>
<th>No Change† (n = 70)</th>
<th>Decrease (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHAS (n = 42)</td>
<td>Patients</td>
<td>No</td>
<td>In MCC</td>
</tr>
<tr>
<td></td>
<td>In LHAS category</td>
<td>31%</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>within each MCC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UHAS (n = 54)</td>
<td>Patients</td>
<td>No</td>
<td>In MCC</td>
</tr>
<tr>
<td></td>
<td>In UHASC within each MCC</td>
<td>69%</td>
<td>60%</td>
</tr>
</tbody>
</table>

*AS = arousal scale; LHAS = lower half of arousal scale; UHAS = upper half of arousal scale; MCC = medication change within 90 min category.
†One patient did not have an arousal rating performed.
And in the group with greater motor activity, 22% of subjects had their medication dosages increased vs 6% who had them decreased. Post hoc, we repeated the analysis only for patients with a nurse-rated sedation goal of moderate or deep (41 patients), reasoning that there may be an interaction (ie, spontaneous motor activity may influence sedative decisions only in more sedated patients), and found that 14% of subjects in the lower motor activity group had their medication dosages increased, whereas 50% of subjects in the high motor group had their medication dosages increased (p = 0.09 [Fisher exact test]).

Table 6 shows that a motor activity level below the nurses’ desired sedation goal was found in 44% of assessments, at the desired level was found in 49% of assessments, and greater than the goal was found in 7% of assessments. There was no association in the hypothesized direction between the discrepant groups and nurses’ agreement with the hypothetical scenario (Table 6) or actual sedation decisions (data not shown).

**Table 4—Relationship Between Arousal Score-Goal Discrepancy and Agreement to Administer Additional Sedation**

<table>
<thead>
<tr>
<th>Score-Goal Relationship</th>
<th>Strongly Agree</th>
<th>Moderately Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Moderately Disagree</th>
<th>Strongly Disagree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arousal level lower than goal</td>
<td>2 (12)</td>
<td>2 (12)</td>
<td></td>
<td></td>
<td>2 (12)</td>
<td>11 (65)</td>
<td>17 (100)</td>
</tr>
<tr>
<td>Arousal level at goal</td>
<td>6 (10)</td>
<td>6 (10)</td>
<td>7 (11)</td>
<td>1 (2)</td>
<td>16 (25)</td>
<td>27 (43)</td>
<td>63 (100)</td>
</tr>
<tr>
<td>Arousal level greater than goal</td>
<td>4 (25)</td>
<td>3 (19)</td>
<td>4 (5)</td>
<td>2 (13)</td>
<td>1 (6)</td>
<td>2 (13)</td>
<td>16 (100)</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>3</td>
<td>19</td>
<td>40</td>
<td>96</td>
</tr>
</tbody>
</table>

*Values given as No. (%). Relationship between three ordered levels of arousal state-goal discrepancy and six categories of agreement with hypothetical future medication administration significant at p = 0.01 (by Fisher exact test). Test for linear trend was significant at p < 0.004.

**Table 5—Relationship Between MSAT Motor Activity Scale and Future Sedative Therapy**

<table>
<thead>
<tr>
<th>MCC</th>
<th>MAS</th>
<th>Increase (n = 16)</th>
<th>No Change (n = 71)</th>
<th>Decrease (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHMAS (n = 79) Patients No.</td>
<td>12</td>
<td>58</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>In MCC</td>
<td>15%</td>
<td>73%</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>In MAS category within each</td>
<td>75%</td>
<td>82%</td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>UHMAS (n = 18) Patients No.</td>
<td>4</td>
<td>13</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>In MCC</td>
<td>22%</td>
<td>72%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>In MAS category within each</td>
<td>25%</td>
<td>18%</td>
<td>10%</td>
<td></td>
</tr>
</tbody>
</table>

*MAS = motor activity scale; LHMAS = lower half of motor activity scale; UHMAS = upper half of motor activity scale. See Table 3 for abbreviation not used in the text.

(15% vs 11%, respectively). And in the group with greater motor activity, 22% of subjects had their medication dosages increased vs 6% who had them decreased. Post hoc, we repeated the analysis only for patients with a nurse-rated sedation goal of moderate or deep (41 patients), reasoning that there may be an interaction (ie, spontaneous motor activity may influence sedative decisions only in more sedated patients), and found that 14% of subjects in the lower motor activity group had their medication dosages increased, whereas 50% of subjects in the high motor group had their medication dosages increased (p = 0.09 [Fisher exact test]).

Table 6 shows that a motor activity level below the nurses’ desired sedation goal was found in 44% of assessments, at the desired level was found in 49% of assessments, and greater than the goal was found in 7% of assessments. There was no association in the hypothesized direction between the discrepant groups and nurses’ agreement with the hypothetical scenario (Table 6) or actual sedation decisions (data not shown).

**DISCUSSION**

The development of sedation scales occurred rapidly in the last decade, responding to the need for precise medication titration to guide clinical or trial protocols and to standardize communication. Because they were designed for frequent clinical use, with two recent exceptions, sedation scales have not used the psychometric technique of summated rating scales that permits the more precise measurement of a single construct with superior responsiveness, but at the cost of greater respondent burden. The MSAT was designed to combine the low rater burden of a single-item response format while separating the level of consciousness assessment from spontaneous movement of intubated adult ICU patients. The arousal domain of the MSAT had good correlation with other validated scales, and this report, along with others, shows that minimally trained raters can reliably measure the level of consciousness of critically ill intubated patients. Scores from the arousal domain correlated better with other scales than did the motor activity scale. This is likely because the arousal domain is very similar to the sedation domains of other scales, whereas the motor activity scale is somewhat dissimilar to the agitation and calmness constructs assessed in other instruments. In fact, the lower correlation of the motor activity scale with other calmness scales and the lack of association with future sedative therapy across the entire sample support its distinctiveness as a construct distinguishable from agitation. Our data also suggest that nurses regard spontaneous motor activity as influential in changing sedative therapy only in more deeply sedated patients. There is no observer-rated instrument used in ICU patients that is available for use as a criterion to support the validation of the motor activity scale. Correlating
motor activity values with data obtained from accelerometers placed on the limbs of ICU patients would be a potential method for validating the scale.

Scoring for the MSAT was not normally distributed, which is similar to data obtained using the RASS (in two studies, 5% and 10% of observations scored in the top 30% of the scale\textsuperscript{5,6}), the Motor Activity Assessment Scale (3% of observations were in the top 28% of the scale\textsuperscript{7}), and the sedation-agitation scale (approximately 0%\textsuperscript{8}, 2%\textsuperscript{18} and 16%\textsuperscript{4} of observations were in the top 28% of the scale). These results suggest that many sedation scales have either a floor effect (ie, observations accumulate in an overly coarse lowest rank) or have too many higher level categories that are relevant to very few patients.

Similar to other sedation scales such as the RASS,\textsuperscript{5} the MSAT uses eye opening to rate subjects. This preference may be due to the established prognostic utility of eye opening in assessing coma after traumatic brain injury\textsuperscript{19} or to the relative accessibility of the visual organs compared to other body areas in a restrained and intubated patient. However, Figure 2 suggests that eye opening alone does not always indicate a high level of consciousness, as there was no difference in the mean VICS interaction score for patients rated at arousal levels of 5 (ie, eyes open but not tracking) or 4 (ie, eyes closed but open to verbal command). Similarly, the lack of separation between arousal level 3 (ie, opens eyes only to tactile stimulation) and level 2 (ie, no eye opening but some other movement to tactile stimulation) suggests that patients who require physical stimulation to generate a response of any kind are at equally low interaction levels.

Patients who were considered oversedated had lower activity levels on scales for both arousal and motor activity, but future sedative decision making in our study was determined more by arousal level than by motor activity. A recent study\textsuperscript{16} summed the measures of consciousness and comprehension into a “consciousness” domain, and agitation, ventilator synchrony, and facial grimacing into a “tolerance” domain. In that study, the correlation with prior sedative doses was higher with the consciousness domain, which supports our conclusion that the arousability of patients is the predominant factor in determining sedative administration. Because there are so many reasons why caregivers administer sedative medications to ICU patients,\textsuperscript{12,20} determining the relative importance of other clinical factors that lead to more or less sedative intervention is an important research goal. We hypothesize that the importance of these factors will differ for heavily sedated patients compared to minimally sedated patients.

Researchers developing sedation scales have generally emphasized their utility in short-term clinical decision making, but investigators should begin to use sedation scale data in longitudinal study designs to determine whether specific ICU conditions or exposures affect post-ICU outcomes. For instance, future investigations could determine whether the motor activity scale predicts the recovery of physical function\textsuperscript{21} and ambulation capacity. Another hypothesis is that longitudinal scores on the MSAT arousal scale predict the degree of ICU amnesia, which, in turn, may affect the incidence of post-traumatic stress disorder.\textsuperscript{22}

Because the MSAT also produces a summary “sedation adequacy” score that “controls” for patients’ severity of illness and incorporates nurses’ clinical judgments, the MSAT could be used as a ICU quality-improvement measure. For instance, administrative staff could set a goal for reducing the proportion of assessments rated as either undersedated or oversedated (15% in this study), implement an intervention, and then follow the monthly summary reports of sedation adequacy to monitor the success of the intervention.

Administrators have to evaluate several criteria in choosing which sedation scale is appropriate for clinical use in their unit, including purpose, brevity, and consistency. The MSAT would probably not be a good choice for units with a high proportion of minimally sedated patients. Similarly, using sedation-

---

**Table 6—Relationship Between Motor Activity Score-Goal Discrepancy and Agreement to Administer Additional Sedation**\textsuperscript{a}

<table>
<thead>
<tr>
<th>Score-Goal Relationship</th>
<th>Strongly Agree</th>
<th>Moderately Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Moderately Disagree</th>
<th>Strongly Disagree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor level less than goal</td>
<td>4 (9)</td>
<td>5 (12)</td>
<td>3 (7)</td>
<td>10 (23)</td>
<td>21 (49)</td>
<td>43 (100)</td>
<td></td>
</tr>
<tr>
<td>Motor level at goal</td>
<td>7 (15)</td>
<td>6 (13)</td>
<td>6 (13)</td>
<td>2 (4)</td>
<td>9 (19)</td>
<td>18 (38)</td>
<td>48 (100)</td>
</tr>
<tr>
<td>Motor level greater than goal</td>
<td>1 (17)</td>
<td>2 (33)</td>
<td>1 (17)</td>
<td>3</td>
<td>41</td>
<td>97</td>
<td></td>
</tr>
</tbody>
</table>

Values given as No. (%). Relationship between three ordered levels of motor activity state-goal discrepancy and six categories of agreement with hypothetical future medication administration not significant at p = 0.31 by Fisher exact test.
agitation scales on a fixed schedule to record agitation episodes would likely underestimate the true incidence of agitation. Caregivers often intervene quickly with potent medications to eliminate almost any level of agitation, and, therefore, a short-lived agitation episode that occurred between a scheduled 4:00 PM and 8:00 PM sedation assessment would be missed.

In summary, our data support the reliability of the MSAT, and we show, in some instances, that specific types of validity depend on the sedation status of the patient. We suggest that the MSAT and other recently developed sedation scales that describe the state of an ICU patient can have both clinical and research applications.

APPENDIX

Procedure for Scoring the MSAT

1. Record the highest level of unstimulated spontaneous motor activity observed in the last 10 min.
2. Walk to the right shoulder and observe eye opening and/or tracking.
3. If no eye opening, call first name and "open your eyes!"
4. If no eye opening yet, shake right shoulder firmly and call first name and "open your eyes!"
5. Choose the arousal scale category appropriate for the patient's response to procedures 2 to 4.
6. Judge the current quality of the sedation therapy as "adequate," "oversedated," or "undersedated." Use any clinical information available to you in addition to the scale levels.

Motor Activity Scale

4. Movement of central muscle group (back or abdominal muscles).
3. Movement of proximal limbs (hip or shoulder).
2. Movement of distal limbs or head and neck muscles.
1. No spontaneous movement.

Note: Disregard respiratory efforts, cough, swallowing, eye movement, or isolated tiny muscle contractions.

Arousal Scale

6. Eyes open spontaneously with tracking.
5. Eyes open spontaneously but not tracking.
4. Eyes closed but open to sound of voice.
3. Eyes closed but open to shoulder shake plus sound of voice.
2. Eyes stay closed, but other patient movement observed in response to stimulation.
1. Eyes stay closed and no patient movement is observed in response to stimulation.

ACKNOWLEDGMENT: The authors thank the ICU nurses at Fairview-University Medical Center who participated in the MSAT reliability and validation studies.

REFERENCES