Validity of the Modified Richmond Agitation–Sedation Scale for Use in Sedated, Mechanically Ventilated Swine

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A valid and reliable scale for assessing level of sedation would facilitate appropriate sedation management in a porcine intensive care unit (ICU) model. The Richmond Agitation–Sedation Scale (RASS) is used often for human ICU patients. The purpose of this study was to estimate the content validity of the modified RASS for use in sedated, mechanically ventilated swine. The modified RASS includes descriptors specific for swine. A content validity assessment form was developed with 4 items and 5 response choices to assess the modified RASS for relevancy, sufficiency, clarity, and representativeness. The modified RASS and content validity assessment form were emailed to 23 veterinarians with experience in the care of swine or other large animals; participants judged the extent to which the modified RASS is valid for assessing sedation in mechanically ventilated critically ill swine. The criterion for acceptable validity evidence was a content validity index (CVI) of 0.80 or greater. Eight (67%) of 12 veterinarians who responded to the invitation to participate completed the assessment form. The item CVI varied from 0.50 to 0.88; scale CVI was 0.66. Because these values did not meet the a priori criterion, we concluded that the modified RASS does not have sufficient evidence of content validity for use with swine. The reliability of the modified RASS will be tested in the porcine ICU model, and experience with its use in swine will inform refinement of the scale descriptors for repeat assessment of content validity.

Abbreviations: CVI, content validity index; ICU, intensive care unit; RASS, Richmond Agitation-Sedation Scale.

Because their genetics, anatomy, and physiology are similar to those of humans,[15] pigs are used to investigate disease processes that affect humans. Pigs can be maintained in an ICU for as long as 7 d,[13] making a swine model attractive and feasible for the study of critical illness and sedation assessment. In the human ICU, sedation scales such as the Richmond Agitation–Sedation Scale (RASS) [26] typically are used by nurses to guide sedation in mechanically ventilated patients.[22] Although sedation assessment tools, such as visual analog scales[27] and others[9,18] have been developed for use in veterinary patients, we were unable to locate a sedation assessment scale with established validity or reliability for use with animals. The purpose of the current study was to estimate the content validity of a modified RASS for use with sedated, mechanically ventilated swine.

Researchers in the Preclinical Critical Care Laboratory at the University of Texas Health Science Center at Houston School of Nursing developed and tested a comparative preclinical intensive care unit (ICU) research model with swine for clinical ICU studies.[13] This model is being refined continuously, with the goal of creating a close analog to a human ICU. Research protocols are approved by the University of Texas Health Science Center at Houston IACUC. The swine are intubated with oral endotracheal tubes, placed on mechanical ventilators, aseptically instrumented with indwelling catheters while under anesthesia, and placed on clinical ICU beds. To maintain survival in the ICU, meticulous nursing care is provided 24 h daily by registered nurses with ICU experience. The ICU nurses titrate continuous intravenous sedation by using an infusion pump to effect light-to-moderate sedation throughout the 7-d ICU stay. In previous work,[13] nurses monitored the pig's muscular activity, jaw tone, pedal reflexes, spontaneous breathing rate, blood pressure, and heart rate as indicators of the level of sedation and adjusted the sedation dose accordingly.

Because sedation assessment may vary widely among practitioners,[8] it is unlikely that the pigs consistently are sedated to the target level and may be under- or oversedated at various times during the ICU stay. Assessment of sedation in swine according to a scale, as is done for humans in the ICU,[24-26] may allow different practitioners to assess sedation in a similar, consistent way, thereby minimizing under- and oversedation. To make the porcine ICU a high-fidelity model of human ICU care, sedation in swine should be assessed in a similar way as for humans, provided that measuring instruments are valid, reliable, and facilitate adequate sedation.

In contrast to anesthesia, which is defined as the loss of consciousness, sedation is defined as a decreased level of consciousness,[1] and accurately assessing patients' level of consciousness is important to prescribe and administer medications safely.[3] Several sedation scales include consciousness in the scoring system.[9,24-26] Descriptors of consciousness across scales vary from hyperactive to hypoactive states and include: combative,[26] agitated,[24-26] restless,[24,26] alert,[9,26] calm,[25,26] tranquil,[24] drowsy,[26] sedated, unarousable,[25,26] and unresponsive.[9]

Content validity describes how well the content included in an instrument reflects the concept being measured as assessed by a panel of persons with expertise related to the concept. The use of 5 to 10 experts is recommended for the assessment.[20] The content experts use a content validity assessment form to score evaluation of the instrument. The content validity as-

sessment form should include response choices that allow the content expert to rate the instrument's relevance, clarity, and representativeness on a continuum from 'not adequate' to 'very adequate.'[11] The content validity index (CVI) is used to quantify the content validity estimate of an instrument. The item CVI is calculated by adding the numbers per item (in this case, the response choice) rated as adequate (a score of 3 on the content validity assessment form) and very adequate (a score of 4) and dividing the sum by the number of content experts who rated the item. The scale CVI can be calculated as the average of the item CVI for all items on the scale that achieved ratings of adequate or very adequate.[23] The CVI for each item or the entire scale (or both) is reported. The number of items scored as 3 or 4 and the number of content experts determine real compared with chance agreement at the 0.05-level of significance for both item and scale CVI.[20] A scale CVI of 0.80 or greater is considered acceptable evidence of content validity.[5,21] Presenting both item and scale CVI provides the most useful information, because every item may not meet the CVI criterion, yet the scale can have an acceptable CVI overall. An argument can be made that the scale CVI alone reflects adequate scale content validity; however, the item CVI shows where disagreement occurred among the raters.

Desirable properties of a sedation scale for use in the porcine ICU are validity (the scale measures sedation on a continuum from undersedated to oversedated), reliability (multiple raters assign highly similar scores when assessing the same level of sedation), ease of use, and rapid administration. Taking care of sedated, mechanically ventilated swine and humans is demanding in both physical and time-consuming ways. A sedation scale that is difficult to understand and takes more than a few minutes to administer is impractical, in that its use would interfere with clinical care and implementation of research protocols. We assessed 5 sedation scales,[9,18,24-26] 4 of which are one-item scales, with various response choices scored subjectively against the desirable properties. Estimates of validity and reliability have been reported for only the scales used with human patients; no psychometric evidence was found for the scales used with animals. Negative correlation coefficients reflect opposite scoring directions of the scales, and validity estimates that were originally reported as R^2 were converted here to correlation coefficients (r) for ease of comparison among values.

The RASS has acceptable reliability estimates for mechanically ventilated, sedated humans. The interrater reliability estimate among 5 different raters was $\kappa = 0.73$ (95% confidence interval, 0.71 to 0.75).[26] Estimates of validity were demonstrated by using several approaches. RASS scores correlated with experts' neuropsychiatric assessments of level of consciousness (r, not reported; $P < 0.001$),[10] the Glasgow Coma Scale score ($r = 0.91$, $P < 0.001$; $r = 0.79$, $P < 0.0001$),[10,26] and the Ramsay scale ($r = -0.78$, $P < 0.0001$).[26] Face validity was estimated at 92% when critical care nurses were surveyed regarding applicability of the RASS to the critically ill human population; the nurses ranked statements on a Likert-type scale.[10]

Of the 5 sedation scales we considered,[9,18,24-26] we selected the RASS as the instrument for potential use in the porcine ICU because it has most of the desired properties. The RASS has been noted for its ease of use, rapid administration, and acceptable validity and reliability estimates with sedated, mechanically ventilated patients.[10,26] In addition, the scale appears to be appropriate for use in the porcine ICU (that is, has face validity).

Materials and Methods

A descriptive design was used to estimate content validity of the modified RASS (Figure 1) .Veterinarians with experience in the care of swine and other large animals were asked to determine the extent to which the modified RASS is valid for assessing sedation in mechanically ventilated critically ill swine. An expert was defined as a veterinarian who has published about or actively worked with swine or other large animals for at least 3 y. Veterinary experts with experience in clinical and academic laboratory settings were identified from publications, Internet-based searches, and recommendations from veterinarians or senior researchers in related fields. Preselection interviews were not performed. The study was conducted by electronic mail.

Instruments. The RASS[26] was developed to subjectively assess the dynamic phenomenon of level of consciousness in human ICU patients to prevent complications of under- and oversedation. It is a one-item measurement scale with 10 response choices. A score can vary from +4 (combative) to −5 (unarousable). A score of 0 or greater indicates a patient is not sedated. A score of −2 or −3 represents light or moderate sedation, respectively (the target sedation level in the porcine ICU).

The RASS[26] was modified to include descriptions and procedures specific for swine in the porcine ICU (Figure 1). For example, the description for combative was changed to "attempts to stand or get out of bed or is a danger to self or staff"; scores of +2 and +3 were modified to reflect pig–ventilator dyssynchrony; and procedures for application of physical stimuli were modified to include stimulation of the coronary band of the hoof, tip of ear, and tail.

A content validity assessment form was developed with 4 items and 5 response choices to evaluate the modified RASS for relevancy, sufficiency, clarity, and representativeness with respect to sedation assessment. The 5 response choices were: 1, not at all; 2, somewhat; 3, adequate; 4, very adequate; and 5, cannot judge. The fifth response choice was added to give the reviewer the choice of not judging an item and was not used in the calculation of the item or scale CVI. A section at the bottom of the form was included for comments, recommended additions, and recommended omissions.

Data collection and analysis procedures. A cover letter, information about the study, the modified RASS, a content validity assessment form, and instructions for its completion were mailed electronically to 23 veterinarians across the United States who met sample eligibility criteria. The cover letter addressed why the expert was selected, purpose of the study, and requirements for participation. Information provided included the definition of sedation (decreased level of consciousness), target population for use of the modified RASS (domestic farm pigs [*Sus scrofa*] 4 to 6 mo of age and weighing approximately 70 kg), instrument administration procedures, training procedures for users of the modified RASS, interpretation of scores, the purpose of content validity assessment, and directions for completing the content validity assessment form. IACUC approval was not needed because no animals were involved in the content validity assessment.

The experts' responses for each item were recorded in a spreadsheet. The CVI for each item was calculated by adding the number of scores of 3 and 4 for each item and dividing the value by the number of content experts that rated the particular item. The CVI for the entire scale was calculated as the proportion of individual item CVI with a rating of 3 or 4. Item and scale CVI were evaluated against the a priori criterion for acceptable content validity evidence (0.80). The experts' comments, recom-

Modified RASS (Richmond Agitation–Sedation Scale)

Score	Term	Description
+4	Combative	Attempts to stand or get out of bed; danger to self or staff
+3	Very agitated	Vigorous limb/head movement that could dislodge tube(s) or catheter(s), pig–ventilator dyssynchrony with high-pressure alarm activation
+2	Agitated	Frequent non-purposeful limb movement, resistance to movement, and/or pig–ventilator dyssynchrony
+1	Restless	Anxious or fearful; may have chewing reflexes, but movements not vigorous
0	Alert and calm	Eyes open spontaneously, looks at nurse and environment, no resistance to movement
−1	Drowsy	Not fully alert, but has sustained (more than 10 s) awakening, with eye contact, to voice
−2	Light sedation	Briefly (less than 10 s) awakens with eye contact to voice
−3	Moderate sedation	Any movement (but no eye opening) to voice
−4	Deep sedation	No response to voice, but any movement to physical stimulation
−5	Unarousable	No response to voice or physical stimulation

Scoring Procedure

1. Observe pig. Is pig alert and calm (score 0)?
   Does pig have behavior that is consistent with restlessness or agitation (score +1 to +4 using the criteria listed above, under Description)?

2. If pig is not alert, in a loud speaking voice talk to the pig and check if pig opens eyes and looks at speaker. Repeat once if necessary.
   Pig has eye opening and eye contact, which is sustained for more than 10 s (score −1).
   Pig has eye opening and eye contact, but this is not sustained for 10 s (score −2).
   Pig has any movement in response to voice but no eye opening (score −3).

3. If pig does not respond to voice, physically stimulate the pig by rubbing the sternum or pinching the coronary band of the hoof, tip of ear, or tail.
   Pig has any movement to physical stimulation (score −4).
   Pig has no response to physical stimulation (score −5).

Figure 1. Modified RASS (Richmond Agitation–Sedation Scale). Modified from reference 26.

mended additions, and recommended omissions to improve the validity of the modified RASS were collected and summarized. Comments specific to improvement of particular scores and descriptions of the modified RASS were placed in a checklist to be used in future modification and testing of the instrument.

Results

Twelve (52%) of the 23 invited veterinarians responded to the request to serve as a content expert. Eight (67%) of the 12 respondents completed the content validity assessment form. Of the remaining 4, 3 said they did not feel qualified to complete the form, and one replied that time constraints prevented participation. The item CVI for relevance, sufficiency, clarity, and representativeness were 0.63, 0.50, 0.88, and 0.63, respectively. The total-scale CVI was 0.66. Three experts (38%) offered positive comments on the applicability of the scale to swine, and 2 (25%) questioned its applicability. Three experts (38%) offered comments suggesting lack of familiarity with a porcine ICU model, and one expert (13%) stated that the scores for sufficiency and representativeness would be increased from 2 to 3 if the scale incorporated recommended changes. Recommended additions to modified RASS scores included adding the presence of the chewing reflex to score +3, resistance to touch to score +2, increased tail swishing to score 0, any movement to voice to score −2, positive palpebral and pedal reflexes to score −4, and negative palpebral and pedal reflexes to score −5. One expert recommended removing the term 'bed' from score +4; another expert recommended removing score +4 entirely.

Discussion

To our knowledge, the modified RASS is the first subjective animal sedation scale that has undergone empirical content validity testing. Such a scale has the potential for valid and reliable sedation assessment that can guide sedation management to minimize discomfort during veterinary care and research on animals. Although the modified RASS received some favorable feedback in the comments, 3 item-CVI values and the total scale CVI fell below the a priori criterion for acceptable evidence of content validity. The item CVI for clarity was the only item that met the criterion.

Several explanations may underlie the finding of inadequate content validity. One is that the modified RASS is not valid for the assessment of sedation in a porcine ICU. Content validity addresses how well the scale items reflect the content domain and is easier to achieve when the domain is well understood and clearly articulated. Veterinarians who work with anesthetized animals and ICU clinicians who work with sedated patients may not appreciate differences between the concepts of anesthesia (that is, loss of consciousness) and sedation (that is, decreased level of consciousness). The RASS complicates this distinction by purportedly measuring sedation and agitation. Furthermore, validity evidence for the RASS was obtained by correlating RASS scores with Ramsay Scale scores and Glasgow Coma Scale scores; neither of the comparison scales has independent evidence for being a valid measure of sedation. Because the RASS measures agitation, the scale may be inappropriate for measuring sedation and guiding adjustment of sedative medications. However, level of consciousness represents a continuum from unconsciousness (that is, anesthetized) to mania. Light and moderate sedation, the target sedation levels in the porcine ICU, represent a narrow band of this continuum. Extreme ends of the continuum include behaviors such as an unarousable state at one end and agitation and combativeness at the other end.

Other explanations for inadequate content validity evidence for the modified RASS include minimal use of subjective assessment scales (and psychometric testing thereof) in the animal sciences and unfamiliarity with the intended use of the modified RASS. Perhaps psychometric testing is not as common for instrument development in veterinary medicine as it is for human instrument development, which may explain why we were unable to locate animal sedation scales with estimates of validity and reliability.

Assessment of validity and reliability are different processes; content validity is the first step in instrument development or modification,[21] and content validity testing is the focus of the current study. Classical test theory principles[7,21] guided psychometric testing of the modified RASS. A scale must be both valid and reliable to measure the concept of interest, such as sedation. Validity is the extent to which a scale measures what it is intended to measure. For example, a scale that measures pain would not be a valid measure of sedation. The instrument could be reliable (for example, 2 raters could consistently assign similar scores), but the scores would not represent level of sedation. Reliability was not tested in this study. However, the validity and reliability of the RASS have been assessed in specialty-ICU patients with cardiac, surgical, neurosurgical, medical, and trauma diagnoses.[26] Because the RASS has acceptable estimates of validity and reliability in diverse ICU populations, is easy to use, and is rapidly administered, we hypothesized the RASS would have adequate validity evidence for use with swine in the porcine ICU model.

Several issues influence the use of the RASS with swine. Available literature suggests that the RASS has been tested only with humans. No validity and reliability estimates are available for existing subjective animal sedation scales,[9,17,18] and estimation of construct validity for the RASS with existing animal sedation scales is challenging because the comparison instrument must have independent evidence of validity and reliability.[21] Another issue related to the use of the RASS is the scoring; the rater could omit a minus sign on data entry into the medical or research record. It is difficult to distinguish between inadequate content validity evidence for the modified RASS and incomplete understanding of its intended use by the veterinarians who participated in this study. The modified RASS uses descriptors specific to swine in a porcine ICU for up to 7 consecutive days, and comments from more than one third of the experts suggested lack of familiarity with a comparative porcine ICU model and long-term sedation. For example, one of the experts recommended removing 'bed' from the modified RASS descriptions, yet placement of the animal in a clinical ICU bed is one of the unique features of the porcine ICU model. One way to address some of these issues would be to test validity evidence of the other scales we assessed,[9,18,24,25] modified for use in swine.

The Ramsay scale[24] is the most widely used scale to measure the dynamic phenomenon of level of consciousness in human ICU patients.[16] It has 6 response choices that are quick and easy to assess. This scale was first tested on 30 ICU patients with such diagnoses as acute respiratory failure, head injury, and postcardiac surgery.[24] ICU-based studies have demonstrated substantial[19] estimates of interrater reliability for the Ramsay scale as evidenced by $\kappa = 0.94$ (level of significance not provided)[10] and $\kappa = 0.88$, $P < 0.001$.[25] Construct validity was estimated by correlating this scale with the RASS ($r = −0.78$, $P < 0.0001$)[26] and the Bispectral Index XP ($r = −0.89$, $P < 0.001$).[4]

The Sedation–Agitation Scale was developed to measure the dynamic concept of sedation to prevent complications associated with agitation in critically ill adults.[25] The scale has

7 response choices. A 10-wk study was conducted with adult critically ill patients in various specialty ICUs to determine validity and reliability estimates; most (71%) of the patients were intubated. The estimate of interrater reliability was $\kappa = 0.92$, and construct validity (compared with the Ramsay scale) was $r = -0.91$ ($P < 0.001$).[25] Additional studies demonstrated lower construct validity estimates of the Sedation–Agitation Scale with a visual analog scale for sedation ($r = -0.77$, $P < 0.001$)[3] and the Bispectral Index ($r = 0.66$ to 0.69, $P < 0.001$).[6]

Other authors[9] used a scale with 4 response choices to assess anesthesia with halothane in 63 male Sprague–Dawley rats. No validity or reliability estimates were reported for this scale. Investigators in another study[17] used this scale to measure sedation in rats but did not report evaluation of the psychometric properties. A 5-item scale with 4 response choices[18] was devised to assess sedation in sheep. These authors did not report validity or reliability estimates. Compared with another previous scale,[9] this scoring system appears more complicated because it involves subjective assessments of the 5 items with a numerical rating scale from 0 to 10, depending on absent, mild, moderate, or severe levels of each item.

It is unclear whether sedation or anesthesia was the objective in some animal studies that used traditional sedation assessment of animals. Several authors[2,12,14] implied that sedation or anesthesia was assessed but were unclear about the assessment methods. Although some researchers reported that animal subjects in their ICU model were sedated, the report suggests that the subjects were maintained closer to an anesthetized than sedated state.[12] Deep sedation was maintained for 3 wk in a canine ICU model by using pentobarbital at 5 to 12 mg/kg/h, which prevented spontaneous respiration.[12] Although animal sedation may have been the goal in that study, loss of spontaneous respiration occurs at the extreme end of the continuum of loss of consciousness, closer to an anesthesia state than a sedation state.

For the reasons discussed, veterinarians who are not acquainted with an ICU delivery system, such as the porcine ICU at the University of Texas Health Science Center at Houston School of Nursing, may have difficulty in assessing the content validity of a scale that reflects descriptions of swine in an ICU environment for up to 7 d—a time period that exceeds the length of most swine research protocols. A minimum of 5 experts is recommended for content validity testing to control for chance agreement in responses;[20] 8 experts participated in the current study, thus exceeding the minimum sample size requirement. Seven of the 8 experts would have needed to score all items as 3 or 4 to meet the a priori criterion for evidence of content validity beyond the 0.05-level of significance; this proportion was not attained for relevance, sufficiency, and representativeness of the modified RASS scoring system for valid assessment of sedation level in a porcine ICU.

Reliability will be tested and recommendations from the experts in this study will be used to revise the modified RASS for repeated assessment of content validity. If acceptable estimates for content validity and reliability for the modified RASS are obtained, use of the modified RASS can be recommended for the assessment of sedation of sedated, mechanically ventilated swine in similar settings. After species-specific modification of score descriptions, validity and reliability testing of the modified RASS could be performed with other animal models.

In conclusion, item- and scale-CVI values for the modified RASS did not meet the a priori criterion. The item CVI was acceptable for clarity but not for relevance, sufficiency, and representativeness. Therefore, the modified RASS does not have sufficient evidence of content validity for its intended purpose. A subjective sedation assessment scale for sedated, mechanically ventilated swine that is both valid and reliable would facilitate sedation delivery and animal comfort in ICU settings and other contexts where the objective is sedation rather than anesthesia. A scale such as the modified RASS, with evidence of acceptable validity and reliability, would facilitate the administration of the targeted level of sedation and reduce the likelihood of under- or over-sedation. Because research done with swine has benefited human health in many ways, generation of a sedation scale for swine based on research with humans could provide a valid and reliable guide for optimal sedation delivery that ensures ethical and comfortable care of research swine.

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