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Facial Expression as an Indicator of Pain in Critically Ill Intubated Adults During Endotracheal Suctioning

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Abstract

Background—Facial expression is often used to evaluate pain in noncommunicative critically ill patients.

Objectives—To describe facial behavior during endotracheal suctioning, determine facial behaviors that characterize the pain response, and describe the effect of patient factors on facial behavior during pain response.

Methods—Fifty noncommunicative patients receiving mechanical ventilation were video recorded during 2 phases (rest and endotracheal suctioning). Pain ratings were gathered by using the Behavioral Pain Scale. Facial behaviors were coded by using the Facial Action Coding System for 30 seconds for each phase.

Results—Fourteen facial actions were associated more with endotracheal suctioning than with rest ($z = 5.78$; $P < .001$). The sum of intensity of the 14 actions correlated with total mean scores on the Behavioral Pain Scale ($\rho = 0.71$; $P < .001$) and with the facial expression component of the scale ($\rho = 0.67$; $P < .001$) during suctioning. In stepwise multivariate analysis, 5 pain-relevant facial behaviors (brow raiser, brow lower, nose wrinkling, head turned right, and head turned up) accounted for 71% of the variance (adjusted $R^2 = 0.682$; $P < .001$) in pain response. The sum of intensity of the 5 actions correlated with total mean scores on the behavioral scale ($\rho = 0.72$; $P < .001$) and with the facial expression component of that scale ($\rho = 0.61$; $P < .001$) during suctioning. Patient factors had no association with pain intensity scores.

Conclusions—Upper facial expressions are most frequently activated during pain response in noncommunicative critically ill patients and might be a valid alternative to self-report ratings.

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Critically ill patients experience acute pain that may be associated with routine care or their underlying diseases.¹⁻⁵ Pain assessment is difficult in patients who cannot communicate their pain level by using speech, written notes, or eye or hand motions.^{3,6,7} Assessment of pain in these noncommunicative patients has no gold standard.⁸⁻¹³ Frequently used pain assessment tools¹⁰⁻¹⁵ consist of behavioral dimensions (facial expression, body movement, verbal response, ventilator compliance) but include a variety of facial descriptors that are used interchangeably (eg, wincing, frowning, grimacing)^{1,16-23} (Table 1). However, disagreement in rating the facial component has been reported.²⁴ In order to optimally evaluate pain, a comprehensive analysis of facial expression in critically ill noncommunicative patients is needed.

The Facial Action Coding System (FACS)^{25,26} is a comprehensive system for recognizing the muscular activity in facial appearances. Action units represent the movements of facial muscles, and units associated with pain in healthy volunteers have been identified²⁷⁻³⁷ (Table 2). Frequently reported pain-related facial actions include lowered brows, raised cheeks, tightened eyelids, a raised upper lip or opened mouth, and closed eyes.²⁶⁻³⁹ FACS has been used to understand facial expressions in infants, children, and adults, including the elderly, but little empiric evidence exists about use of the system in noncommunicative critically ill adults. Indeed, behaviors still cannot be associated with pain in noncommunicative patients. However, facial expression is commonly used to evaluate pain in these patients.

Therefore, the specific aims of this prospective study were to describe facial actions during endotracheal suctioning in noncommunicative critically ill patients, determine facial actions that may characterize the pain response, and describe the effect of patient factors (eg, age, sex, race, diagnosis, duration of endotracheal intubation, length of stay in the intensive care unit [ICU], use of analgesics and sedatives, sedation level, and severity of illness) on facial action during the pain response.

Methods

Setting and Sample

The sample consisted of 50 patients who were noncommunicative (unable to use speech, written notes, or eye or hand motions), intubated, and receiving mechanical ventilation in an adult surgical-trauma and a medical ICU at Virginia Commonwealth University Health System, Richmond, Virginia. Patients were excluded if they had persistent neuromuscular disorders, head trauma, or stroke or were receiving neuro-muscular blockers because these conditions might affect facial expressions and study measurements.

There is disagreement about ratings of facial behaviors during pain.

Measurement of Key Variables

Pain Level—Pain levels were measured by using the Behavioral Pain Scale (BPS)¹⁹ commonly used in intubated patients.^{7,19,40} An interrater reliability of $\kappa = 0.90$ between the principal investigator (M.R.) and another expert clinical nurse was established during routine patient care before the study began.

Facial Action—Facial actions were evaluated by using the FACS. FACS scores have been highly reliable in a variety of studies (Table 2) and indicate a distinct pattern of facial actions characteristic of pain.²⁷⁻³⁹ The basic elements of FACS action units can be reliably identified by trained FACS coders. Coding was performed by a certified FACS coder (M.R.). A second coder also certified in FACS coding established interrater reliability by scoring 10% of the randomly selected videos (246 frames) during the endotracheal

suctioning. Interrater reliability, determined by using the Ekman-Friesen formula,²⁶ was 0.88 with $\kappa = 0.70$, indicating strong agreement between the 2 raters.

Patients' Characteristics—Data on age, sex, race and ethnic background, diagnosis (reflecting type of critical illness and population; ie, surgical or medical), duration of endotracheal intubation, length of stay (from date of ICU admission to date of enrollment), and total amount of sedatives and analgesics used during the 24 hours before enrollment were collected from the medical records. Doses of opioids and benzodiazepines were converted to fentanyl and lorazepam equivalents, respectively, as described by Cammarano et al.⁴¹ Severity of illness was documented on the basis of the 24 hours before enrollment by using the Acute Physiology and Chronic Health Evaluation III.^{42,43}

Sedation level was measured by using the Richmond-Agitation Sedation Scale (RASS),⁴⁴ a 10-point scale, ranging from -5 (unarousable) to 0 (calm and alert) to +4 (combative). The scale has been validated against a visual analogue scale of sedation and agitation and tested for interrater reliability in adult ICUs.⁴⁴⁻⁴⁶ Interrater reliability ($\kappa = 1.0$) was established between the principal investigator (M.R.) and another expert clinical nurse during routine patient care before the study began.

Endotracheal Suctioning—Endotracheal suctioning was used to elicit a pain response because of its validity as a noxious event.^{1,47-54} In a recent study,⁵ 755 patients who could self-report pain indicated greater pain during endotracheal suctioning (mean, 4.0; SD, 3.3) than before suctioning (mean, 2.1; SD, 2.8). The most frequently observed pain behavioral responses during endotracheal suctioning were grimace (52%), clenched fists (24%), rigidity (23%), and wince (22%).

Procedures

The study was approved by the appropriate institutional review board, and consent for participation in the study was obtained from each patient's legally authorized representative. Routine suctioning was performed by the nursing staff according to each patient's clinical need.

Video recordings for FACS coding were obtained by using a digital camcorder (Canon GL2) zoomed to the patient's face and neck. The videos were analyzed at a later time for 2 phases: when the patient appeared most comfortable (baseline) and during the endotracheal suctioning. The time segment for FACS coding was standardized to 30 seconds for each phase. This time frame was based on preliminary findings that suctioning episodes in this setting ranged from 6 to 28 seconds (mean, 13.33; SD, 4.8). On the basis of the criteria established by the developers of FACS,²⁶ each 30-second phase was coded separately for all possible action units for their frequency of occurrence, duration of expression (in seconds), and intensity of expression (on a 5-point scale). The BPS and RASS scores were recorded at baseline and during the endotracheal suctioning.

Data Analysis

Data were analyzed by using Observer XT 8.0 Software (Noldus Information Technology) and JMP 10.0 Statistical Software (SAS Institute). Descriptive statistics and the Wilcoxon signed rank test were used to determine the relationship between action units activated during baseline and those activated during endotracheal suctioning. Stepwise multivariate analysis was used to develop a model that best described the FACS pain score based on pain-relevant facial action units.^{32-33,36,37} Spearman rank correlation values were used to describe the relationship between BPS scores, RASS scores, and patient factors on facial action during the pain response for $\alpha < 0.05$.

Results

Patients' Characteristics

The sample consisted mostly of men and was evenly divided between African Americans and whites. The mean age was 52.5 years (Table 3). The primary reason for ICU admission was respiratory failure. Patients from the 2 ICUs did not differ in demographic characteristics (Table 3). A moderate correlation was detected between age and score on the Acute Physiology and Chronic Health Evaluation III ($\rho = 0.39$; $P = .005$). An inverse relationship was detected between age and fentanyl equivalents ($\rho = 0.53$; $P < .001$). Patients with longer duration of intubation had longer lengths of stay in the ICU than did patients with shorter durations ($\rho = 0.78$; $P < .001$).

Pain Level

According to BPS scores, pain level was higher during endotracheal suctioning than at baseline ($F_{99} = 123.89$; $P < .001$). At baseline, the facial expression component of the BPS indicated that 92% of the patients ($n = 46$) had "relaxed" facial expressions, and the overall mean BPS score was 3.28. During endotracheal suctioning, 46% of the patients had facial expressions that were "partially tightened" 24% had "fully tightened expressions," and 18% were "grimacing"; the total mean BPS score was 6.36. Total mean BPS scores correlated with total mean RASS scores ($\rho = 0.60$; $P < .001$).

Description of Facial Actions

The Wilcoxon signed rank test indicated that activation of 14 action units differed significantly between baseline and endotracheal suctioning (Table 4). The Figure illustrates the action units activated at baseline and during endotracheal suctioning.

Facial Actions and Pain Response

The 14 facial actions varied in frequency, duration, and intensity of correlation with total mean scores on the BPS (Table 5). For example, the frequency, duration, and intensity of brow lower (action unit 4) had moderate to strong correlation with the total mean BPS scores. Results of the Spearman rank correlation were $\rho = 0.30$ for frequency ($P = .03$), 0.63 for duration ($P < .001$), and 0.74 for intensity ($P < .001$). Patients tended to turn their heads more to the right side of the bed, and the frequency, duration, and intensity of this finding had a positive correlation with total mean BPS scores. Endotracheal tubes were located on the right side of the mouth in 27 patients, on the left side in 18, and in the middle in 3. Two patients had a tracheostomy. More patients tended to turn their heads to the right (32%) than to the left (22%). No significant relationship was detected between location of the endotracheal tube and head turning. However, frequency, duration, and intensity of cough correlated with head movement (action units 52, 53, and 57; $\rho = 0.35$ ($P = .01$), 0.30 ($P = .04$), and 0.49 ($P < .001$).

In order to evaluate which action units were predictors of pain, all 14 action units were entered into a stepwise model. The final model included 5 pain-relevant facial action units that accounted for 71% of the variance (adjusted $R^2 = 0.682$) for prediction of pain response ($F_{49} = 21.99$; $P < .001$). These action units included inner brow raised, brow lower, nose wrinkle, head turn right, and head turn up. Per the convention established by Prkachin and Solomon,³⁷ intensities were added to define the FACS pain intensity score (Table 6).

On the basis of the 5-point intensity scale used to code each action unit, the possible FACS pain intensity score ranged from 0 to 25. The score was higher during the endotracheal suctioning than at baseline (mean difference = 42.22; $z = 7.67$; $P < .001$). In addition, the score was strongly correlated with the mean BPS score ($\rho = 0.72$; $P < .001$) and the facial

expression component of the BPS ($\rho = 0.61$; $P < .001$) during endotracheal suctioning. Likewise, the sum of intensities of the 14 action units was highly correlated with mean BPS scores ($\rho = 0.71$; $P < .001$) and with the facial expression component of the BPS ($\rho = 0.67$; $P < .001$) during the endotracheal suctioning.

Facial Action and Patient Factors

No association was detected between FACS pain intensity scores and patient factors. However, the FACS pain intensity scores and RASS values had a strong correlation ($\rho = 0.55$; $P < .001$). Likewise, the sum of the intensity scores of the 14 action units was strongly correlated with RASS values ($\rho = 0.59$; $P < .001$) during endotracheal suctioning.

Discussion

This study was the first one in which comprehensive video analysis was used to measure specific facial muscle activity in noncommunicative critically ill patients during a type of endotracheal suctioning known to elicit a pain response. We also investigated the relationship among facial expression, pain level, sedation level, and other patient factors. About half of the patients were adequately sedated, with light to moderate levels of sedation, and able to briefly awaken with eye contact or movement to voice but were unable to follow commands.

Facial Actions During Pain Response

Prkachin and Solomon³⁷ identified 4 core facial actions that provide the majority of pain information: brow lower, orbit tightening, nose wrinkling, and eye closure. Various methods (ie, experimental pain or clinical pain; Table 2) have been used to test these expressions in healthy volunteers. Our study extended that research by determining facial expression in noncommunicative critically ill patients and using endotracheal suctioning as the noxious stimulus. We found activation of similar facial actions, specifically brow lower, orbit tightening, nose wrinkling, and eye closure. However, we also found that brow raiser, mouth opening, head position, and nasal dilatation often occurred during suctioning.

Core Facial Actions in Noncommunicative Critically Ill Patients

Brow Lowering and Orbit Tightening (Action Units 4 and 6 Plus 7)—Facial expression of pain occurred most often in the upper part of the face (brow lower and orbit tightening), especially for duration and intensity. These action units highly correlated with descriptors included in the facial domain of the BPS. Specifically, action units 4 and 7 occurred most often with higher intensity for levels 2 and 3 of the facial expression domain. Of note, level 4 (grimace) was recently defined as “folded cheek,”⁵⁵ which includes several action units that were not visible in our patients because of the tape used to secure tubes around the mouth and cheeks. Further studies are need to test these action units to describe the relationship between folded cheek and grimace in various populations.

Nose Wrinkle (Action Unit 9)—Although nose wrinkle is generally a common expression of pain reported in otherwise healthier patients, this action unit occurred infrequently and was not strongly associated with endotracheal suctioning. However, detection of nose wrinkle was often compromised because the visibility of the nose bridge was obscured by the tape holding a nasogastric tube or the endotracheal tube in place. Therefore further studies are warranted to confirm if these expressions occur in patients who do not have securing devices around the mouth and nose.

Eye Closure (Action Unit 43)—Most people close their eyes when they experience pain.²⁶⁻³⁹ The assumption in FACS coding is that the eyes are generally open and then close

as a pain response. However, Hadjistavropoulos et al³² reported that eye closure varied as a function of activity in patients who kept their eyes open to maintain balance while performing physiotherapy activities. In our study, most of the patients had their eyes closed at onset and during the 30-second coded segment. The intensity of eye closure was unchanged because this action unit is coded on basis of the degree of upper eyelid lowering at maximum intensity when eyes are closed for more than 2 seconds. We scored patients at a level 3 (fully tightened) on the facial domain of the BPS if we noted muscles around the eyes contracted as the eyelids were closing or already closed. Of note, level 3 (fully tightened; eg, eyelid closing) is described in FACS coding as a forced contraction of the eyelids and not just eye closure, which closely resembles action units 6 and 7 and not action unit 43.²⁵ We found no relationship between eye closure (action unit 43) and level 3 or 4 of the facial expression component of the BPS. Whether eye closure or opening is associated with pain or arousal warrants further studies.

Facial muscle actions during pain in the critically ill were similar to normal volunteers.

Additional Facial Actions in Noncommunicative Critically Ill Patients

Brow Raiser (Action Units 1 Plus 2)—Raising of the inner and outer parts of the brows in response to pain is not commonly reported in healthy volunteers. Obviously, a poor correlation between BPS scores and descriptors not included in the BPS makes sense. The facial domain of the BPS was constructed on the basis of previous findings obtained in awake volunteers,¹⁹ a situation that would explain why brow raiser was not included in the BPS descriptors. Therefore, brow raising may have been an arousal effect and may not be associated with pain response. This facial expression warrants further study.

Mouth Opening (Action Units 25 Plus 26)—Lip parting and jaw drop have been reported in many studies.^{26,27,30-35} Although not considered a core facial expression of pain,³⁷ mouth opening occurred frequently in our study. Of note, most of our patients had their mouth open because of the presence of an endotracheal tube. However, confirming that the degree of mouth opening was due to a pain response or cough and respiratory distress caused by endotracheal suctioning is difficult.

Nose wrinkle, seen in healthy adults during pain, was not strongly associated with pain here.

Head Position (Action Units 52 Plus 53 and 57)—Interestingly, head position (turn right, turn up, and forward) has not been described as an expression of pain in previous studies, but it occurred frequently during endotracheal suctioning in our study. All of the patients in our study were supine with the head of the bed elevated 30° and tended to move their head back or side to side during endotracheal suctioning. Even though head position was moderately correlated with pain level, this finding may have been patients' attempts to get away from the suctioning procedure and may not necessarily represent a pain response. Head movements are often the only possible movements for ICU patients immobilized in bed. Therefore, head position may require observations with other pain stimuli.

Facial Actions During Pain and Patient Factors

Our findings are also consistent with those of previous studies in which frequency, duration, and intensity of facial expression did not differ by sex^{29,56-59} or age.³⁶ Patients who had greater levels of arousal showed greater intensity of facial expression. Therefore, concluding that these facial expressions occurred in response to pain or were an effect of arousal is difficult, and further study is warranted.

Limitations

We used only one endotracheal suctioning condition, had no stimulus control, and assumed that patients had no pain at baseline. These factors may limit our findings in determining facial behaviors that may characterize the pain response. However, suctioning is comparable to other noxious procedures that cause pain in critically ill patients^{47,53}; in our study, the suctioning might have had an arousal effect.

The data collection and video coding were done by the principal investigator, who was highly qualified and trained in FACS coding. Biasing effects were minimized by recording the BPS scores and coding the FACS at separate times and by coding each action unit individually for all possible action units.

Conclusion

Our findings suggest that facial expressions of pain do not diminish in noncommunicative critically ill patients. Actions in the upper part of the face (brow raiser, brow lower, and orbit tightening) are the most frequently activated expressions and might be a valid alternative to self-report ratings in noncommunicative critically ill patients. The FACS pain intensity scores could be used to measure pain and to standardize pain evaluation. However, caution must be taken in interpreting our findings because we cannot state whether or not they are associated with response to pain or are a response due to arousal. Further studies are needed to confirm our findings in a larger sample with a different level of sedation to account for a possible arousal effect and during different nociceptive procedures to determine a possible cough or respiratory distress effect. Further studies should validate our data so that clinicians can focus on facial expressions that are most likely to reflect pain in noncommunicative critically ill patients.

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Figure.
Facial action units (AUs) during baseline and noxious procedure.

Table 1

Pain measurement tools and facial behavior descriptors for noncommunicative patients

Scale/reference	Facial behavior descriptors and scoring	Score
Behavioral Pain Rating Scale (BPRS)	Does not frown forehead or grimace	0
Mateo and Krenzischek ¹⁷ (1992; English version)	Slight frowning and grimacing	1
	Moderate frowning and grimacing	2
Persson and Ostman ¹⁸ (2004; Swedish version)	Constant frowning and grimacing	3
The Pain Assessment and Intervention	Grimacing, frowning, wincing	
Notation (PAIN) algorithm	Drawn around mouth and eyes	
Puntillo et al ¹⁶ (1997)	Wrinkled forehead	
	Teary/crying	
Behavioral Pain Scale (BPS)	Relaxed	1
Payen et al ¹⁹ (2001)	Partially tightened (eg, brow lowering)	2
	Fully tightened (eg, eyelid closing)	3
	Grimacing (eg, folded cheeks)	4
Nonverbal Pain Scale (NVPS)	No particular expression or smile	0
Odhner et al ²⁰ (2003)	Occasional grimace, tearing, frowning, wrinkled forehead	1
	Frequent grimace, tearing, frowning, wrinkled forehead	2
Pain Behavior Assessment Tool (PBAT)	Grimace	
Puntillo et al ¹ (2004)	Frown	
	Wince	
	Eyes closed	
	Grin/smile	
	Eyes wide open with eyebrows raised	
	Unable to assess	
	Looking away in opposite direction of the pain	
	Mouth wide open to expose teeth and tongue	
	Clenched teeth exposing slightly open mouth	
	None	
	Other	
Critical-Care Pain Observation Tool (CPOT)	Relaxed, neutral: no muscular tension observed	0
Gélinas et al ²¹ (2006; French version)	Tense: presence of frowning, brow lowering, orbit tightening, and levator contraction	1
Gélinas, et al ²² (2007; English version)	Grimacing: all of the preceding facial movements plus eyelid tightly closed	2

Table 2

Studies of facial action units associated with pain in adults

Study	Population	Procedure	Action units ^a
Craig and Patrick ²⁷ (1985)	72 college students; mean age 18.65 (SD, 1.58) y	Cold pressor test	6, 7, 10, 12, 25, 26, 27, 43, 45
Patrick et al ²⁸ (1986)	30 women; age range, 17-28 y	Electric shock	4, 6, 10, 45
Prkachin ²⁹ (1992)	41 college students; mean age 20 (SD, 2.02) y	Electric shock, cold pressor test, mechanical pressure, muscle ischemia	4, 6, 7, 9, 10, 43
Wilkie ³⁰ (1995)	43 adult outpatients with lung cancer	Activity protocol—sit, walk, stand, recline	4, 6, 7, 9, 10, 20, 26, 27, 43
Hadjistavropoulos et al ³¹ (2000)	58 frail elders with cognitive impairment after hip replacement; mean age 76.6 (SD, 8.1) y	Sit, stand, walk, and recline	1, 2, 4, 6, 7, 9, 10, 12, 17, 18, 20, 24, 25, 26, 27, 43, 45
Hadjistavropoulos et al ³² (2002)	82 patients after surgical knee replacement; mean age 73.1 (SD, 7.6) y	Reclining, standing, knee bending	1, 2, 4, 6, 12, 17, 18, 20, 24, 25, 26, 43, 45
Kunz et al ³³ (2004)	40 college students; mean age 24 (SD, 3.2) y	Electrical shock and mechanical pressure	1, 2, 4, 6, 7, 9, 10, 12, 17, 25, 26, 27, 45
Lints-Martindale et al ³⁴ (2007)	27 patients with Alzheimer disease; mean age 78 (SD, 4) y; 36 patients with no cognitive impairment; mean age 78 (SD, 4) y	Electrical-thermal and mechanical pressure	4, 7, 25, 26, 43, 45, 61, 62, 63, 64, 73
Kunz et al ³⁵ (2007)	42 patients with dementia; mean age 76.7 (SD, 7.3) y; and 54 healthy controls; mean age 74.2 (SD, 5.6) y	Mechanical pressure	1, 2, 4, 6, 7, 9, 10, 17, 25, 26, 27, 45
Kunz et al ³⁶ (2008)	40 college students; mean age 24.1 (SD, 3.2) y and 61 elderly students; mean age 72.3 (SD, 5.6) y	Electrical shock and mechanical pressure	1, 2, 4, 6, 7, 9, 10, 12, 14, 25, 26, 27, 43, 45
Prkachin and Solomon ³⁷ (2009)	129 patients with shoulder pain; mean age 42.23 (SD, 14.48) y	Passive range of motion	4, 6, 7, 9, 10, 12, 20, 25, 26, 27, 43

^a See Table 4, Ekman and Friesen,²⁵ and Ekman et al²⁶ for explanations of the numbers.

Table 3

Characteristics of sample and major variables (N = 50)

Variable	Frequency	%
Sex ^a		
Male	26	52
Female	24	48
Ethnicity ^a		
Black or African American, not Hispanic	24	48
White, not Hispanic	24	48
American Indian or Alaskan native	1	2
Asian	1	2
Intensive care unit ^a		
Medical	27	54
Surgical/trauma	23	46
Diagnosis or reason for admission		
Respiratory failure	25	50
Surgery	12	24
Transplant	4	8
Motor vehicle accident	5	10
Septic shock	2	4
Other	2	4
Endotracheal tube suctioning ^b		
Once	42	84
Twice	8	16

	Mean	SD	Range
Age, ^a Y	52.5	17.2	18-85
Duration of intubation, ^c d	5.1	3.9	1-17
Stay in intensive care unit, ^d d	5.74	3.7	1-17
Suctioning duration, s	13.33	8.1	5.99-28.13
Score on Acute Physiology and Chronic Health Evaluation III	92.8	26.0	37-140
Opioids ^e			
Fentanyl, µg	1662.12	1316.51	0-4910
Morphine, mg	1.86	10.77	0-75
Hydromorphone, mg	1.96	10.66	0-72
Fentanyl equivalents unit, mg	1.78	1.56	0-8.4

	Mean	SD	Range
Benzodiazepine ^e			
Lorazepam, mg	1.02	4.00	0-20
Midazolam, mg	53.48	66.58	0-268
Lorazepam equivalents unit, mg	18.85	23.07	0-89.33
Other ^e			
Propofol, mg	659.5	1689.0	0-8304
Dexmedetomidine, µg	113.0	578.3	0-3600

	Median	IQR	Range
Score on Behavioral Pain Scale ^f			
Baseline	3.0	3-3	3-5
Procedure	6.0	5-8	3-11
Score on Richmond Agitation-Sedation Scale			
Baseline	-3.0	-4 to -1	-5 to + 2
Procedure	-2.5	-4 to -1	-5 to + 2

Abbreviation: IQR, interquartile range.

^aNo significant difference.

^bNumber of times suctioning was performed during 30-second segment.

^cFrom day of intubation to the time of study enrollment.

^dFrom day of admission to intensive care unit to the time of study enrollment.

^eTotal dosage given in past 24 hours.

^f $P < .001$.

Table 4

Activation of facial action units during baseline and noxious procedure (N = 50)

		No. of times activated		Wilcoxon test (rank sum)			
Facial action unit				Score, mean difference	Standard error of difference	Z	P ^b
Name ^a	Number	Baseline	Procedure				
Upper part of face							
Inner brow raised	1	2	31	13.22	3.79	3.49	<.001
Outer brow raised	2	2	20	7.14	3.15	2.27	.02
Brow lower	4	8	88	37.1	5.30	6.99	<.001
Upper lid raised	5 ^c	0	5	0.98	1.00	0.98	.33
Cheek raised	6	3	25	12.04	3.70	3.25	.001
Lid tightened	7	29	141	29.06	5.49	5.29	<.001
Eyes closure	43	56	82	10.14	3.88	2.61	.009
Blink	45	17	48	8	3.50	2.29	.02
Head position							
Head turn left	51	9	10	3.88	3.49	1.11	.27
Head turn right	52	3	20	9.98	3.50	2.85	.004
Head turn up	53	3	43	23.46	4.62	5.08	<.001
Head tilt left	55 ^c	0	1	0.98	1.00	0.98	.33
Head forward	57	1	11	8	3.02	2.65	.008
Eye position							
Eyes right	62 ^c	0	2	0.98	1.00	0.98	.33
Eyes up	63 ^c	0	7	2.98	1.71	1.74	.08
Lip parting and jaw opening							
Lips parted	25	36	62	14.54	5.29	2.75	.006
Jaw drop	26	18	41	9.58	4.93	1.94	.05
Lower part of face							
Nose wrinkle	9	0	15	10.98	3.15	3.49	<.001
Lower lip depress	16 ^c	0	2	1.98	1.41	1.41	.16
Chin raiser	17	1	23	11.1	3.39	3.28	.001
Lip pucker	18	1	8	5	2.57	1.95	.05
Lip stretcher	20 ^c	1	9	3.04	2.19	1.39	.17
Lip presser	24 ^c	1	3	1.98	1.97	1.01	.31
Miscellaneous							
Tongue show	19 ^c	1	3	1.98	1.97	1.01	.31
Jaw clencher	31 ^c	0	1	0.98	1.00	0.98	.33

Facial action unit		No. of times activated		Wilcoxon test (rank sum)			
		Baseline	Procedure	Score, mean difference	Standard error of difference	Z	P ^b
Name ^a	Number						
Blow	33 ^c	0	1	0.98	1.00	0.98	.33
Puff	34 ^c	0	1	0.98	1.00	0.98	.33
Nasal dilatation	38	0	32	7.98	2.73	2.92	.004
Head shake back and forth	84 ^c	0	1	0.98	1.00	0.98	.33
Total number of action units activated		192	736	43.06	5.78	7.45	<.001

^aPain-related action units are marked in boldface as reported in previous studies.

^bSignificant results are marked in boldface.

^cAction units occurring in 5% or less for all 50 patients in the 2 phases were eliminated from subsequent consideration because of the rarity of occurrence.

Table 5

Spearman's rank correlation of facial action units and score on Behavioral Pain Scale for frequency, duration, and intensity during noxious procedure (endotracheal suctioning)

Facial action unit		Frequency		Duration		Intensity	
Name	Number	Correlation	P	Correlation	P	Correlation	P
Inner brow raised	1	0.29	0.4	0.29	0.4	0.35	0.1
Outer brow raised	2	0.19	.19	0.20	.16	0.22	.12
1/2 combined ^a	1/2	0.24	.09	0.26	.06	0.37	.009
Brow lower	4	0.30	.03	0.63	<.001	0.74	<.001
Cheek raised	6	0.27	.06	0.33	.02	0.40	.004
Lid tightened	7	0.15	.29	0.35	.01	0.40	.004
6/7 combined ^a	6/7	0.24	.09	0.39	.005	0.41	.003
Eye closure (AU 43)	43	0.02	.91	-0.22	.12	-0.02	.92
Lips parted (AU 25)	25	0.35	.01	0.23	.11	0.40	.004
Jaw drop (AU 26)	26	0.26	.07	0.23	.10	0.34	.02
25/26 combined ^a	25/26	0.38	.006	0.22	.12	0.40	.004
Nose wrinkle (AU 9)	9	0.08	.59	0.09	.55	0.15	.29
Chin raiser (AU 17)	17	0.16	.28	0.17	.23	0.16	.27
Nasal dilatation	38	-0.01	.97	-0.01	.95	-0.02	.89
Head turn right	52	0.34	.02	0.33	.02	0.36	.01
Head turn up	53	0.15	.29	0.26	.06	0.24	.09
Head turn forward	57	0.15	.30	0.16	.26	0.14	.35
52/53/57 combined ^a	52/53/57	0.31	.03	0.34	.01	0.28	.05
Sum of action units		0.39	.004	0.49	<.001	0.71	<.001

^aFollowing a precedent established by Ekman and Friesen,²⁵ action units were combined to form 1 variable (eg, if both action units occurred 1 time each, the combined variable was given a frequency of 2). Action units 25 and 26 were combined because they represent varying degrees of mouth opening. Action units 1 and 2 represent varying degrees of eyebrow rising and action units 6 and 7 represent degrees of eye orbit tightening. Action units 52, 53, and 57 represent gross movement of the head.

Table 6

Facial Action Coding System pain intensity score

	Facial action unit						Total score
	AU 1 Inner brow raised	AU 4 Brow lower	AU 9 Nose wrinkle	AU 52 Head turn right	AU53 Head turn up		
Pain intensity score	3	+	5	+	4	+	3
							5
							20