Original Article

Behaviors Indicative of Pain in Brain-Injured Adult Patients With Different Levels of Consciousness in the Intensive Care Unit

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Abstract

Context. Many brain-injured patients are unable to self-report their pain during their hospitalization in the intensive care unit (ICU), and existing behavioral pain scales may not be well suited.

Objectives. The objectives of this study were to describe and compare behaviors in brain-injured patients with different levels of consciousness during nociceptive and nonnociceptive care procedures in the ICU and to examine interrater agreement of individual behaviors as well as discriminative and criterion validation of putative pain behaviors.

Methods. Brain-injured ICU patients were observed using a 40-item behavioral checklist before and during soft touch (i.e., nonnociceptive procedure), turning, and other care procedures (nociceptive) by pairs of trained raters. When possible, patients self-reported their pain on a 0–10 visual thermometer. Patients were classified into unconscious (Glasgow Coma Scale, $3<GCS\leq8$), altered consciousness ($9\leq GCS\leq12$), or conscious ($13\leq GCS\leq15$).

Results. A sample of 147 patients participated (65 conscious, 56 altered consciousness, and 26 unconscious). Active behaviors (e.g., face expressions and body movements) were more frequent in conscious patients. High-percentage interrater agreement (80%–98%) was obtained for most behaviors. The total number of active behaviors was significantly higher during turning and other nociceptive procedures compared with rest (Wilcoxon = 9.873, $P< 0.001$) and soft touch (Wilcoxon = 9.486, $P< 0.001$) regardless of levels of consciousness. The strongest predictors of pain intensity ($n = 33$) were grimace, mouth opening, orbit tightening, eye weeping, and eyes tightly closed; these behaviors were moderately correlated with self-reported pain intensity (Spearman rho = 0.47).

Conclusion. These findings may guide the revision of existing pain scales to make their content more suited for this population. J Pain Symptom Manage 2019;57:761–773. © *2018 American Academy of Hospice and Palliative Medicine. Published by Elsevier Inc. All rights reserved.*

Key Words

Pain, behaviors, assessment, critical care, brain-injured

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Introduction

A common barrier to adequate pain management is the failure to assess pain.[1] Measurement of pain in the brain-injured intensive care unit (ICU) patient is particularly challenging owing to the brain injury itself, altered levels of consciousness (LOC), mechanical ventilation, and administration of sedatives that can jeopardize the patient's ability to self-report. In previous studies with brain-injured ICU patients, between 29% and 70% of patients could self-report pain,[2–5] indicating that alternative measures are needed to assess pain in this vulnerable population.

Behavioral scales such as the Critical-Care Pain Observation Tool (CPOT)[6] and the Behavioral Pain Scale/Non-Intubated (BPS/BPS-NI)[7,8] have been proposed as alternative measures to self-report for use in nonverbal ICU adults[9,10]; however, they may not be valid for brain-injured patients who may or may not express some specific pain behaviors.[2,4,11] In a CPOT validation study with brain-injured ICU patients ($n = 79$), some items (i.e., grimace, muscle rigidity) were rarely observed during painful procedures (≤20%) and were targeted for possible revision in future scale adaptation to improve the CPOT's validity for pain assessment in these patients.[3]

In ICU patients with traumatic brain injury (TBI),[2] non-TBI,[4] and elective brain surgery,[12] more behaviors were observed during turning compared with rest. Brow lowering, body movements toward the pain site, and moaning were observed more frequently in brain-injured patients who were conscious,[2,4] and grimace was only found in a small proportion of them (≤25%).[2,12] Regardless of LOC, muscle rigidity was observed in <20% of TBI and elective brain surgery patients[2,12] and was more frequent (32%–48%) in non-TBI patients.[4] Face flushing and/or eye weeping were newly described in TBI and non-TBI patients and appeared more frequent in patients with a lower LOC.[2,4,12] These studies focused on homogeneous patient groups and included only turning as a nociceptive procedure. Further research is needed to describe pain behaviors in a heterogeneous group of brain-injured ICU patients during various procedures to assist with further revisions of behavioral pain scales for this population.

Objectives

This study aimed to 1) describe and compare behaviors in brain-injured patients with different LOC during standard ICU care procedures (nociceptive vs. nonnociceptive), 2) examine interrater agreement for the presence/absence of behaviors, and 3) examine the discriminative and criterion validation of behaviors for pain assessment in this patient group. An exploratory objective was to compare behaviors across different diagnoses (i.e., TBI or non-TBI) and brain injury localizations.

Methods

Design

A prospective cohort observational design was used.

Sample and Setting

Patients were eligible if they were over 18 years old, in the ICU for less than four weeks after brain injury (traumatic or not), had a score >3 on the Glasgow Coma Scale (GCS),[13] and were above −5 (unarousable) on the Richmond Agitation Sedation Scale (RASS).[14] Patients were excluded if they sustained a spinal cord/brainstem/cerebellar injury; had peripheral neuropathologies, cognitive deficits/psychiatric conditions (e.g., psychosis), and epilepsy diagnosis; received neuromuscular blocking agents; and had suspected brain death. Recruitment took place using convenience sampling in two neuroscience ICUs of a university-affiliated health care center in Montreal, Canada.

Procedures

Following institutional ethical approval, the nursing staff identified eligible patients and solicited their interest to be approached by the research team. Whenever possible, informed consent was obtained from patients, otherwise from their representatives. A first data collection set was obtained for all patients who were observed with a behavioral checklist before and during turning,[2,4] other common standard care nociceptive procedures (e.g., endotracheal suctioning),[15] and soft touch of the patient's forearm[16] (nonnociceptive procedure). These observations were repeated in a second data collection set and on a different day for a subgroup of patients experiencing a change in LOC during their ICU stay. Behavioral assessments lasted one minute at rest and during soft touch, and for the duration of the nociceptive procedure. Patients' face and body were video-recorded. One rater completed the behavioral checklist at the bedside, whereas the other viewed the video independently. After completing the checklist, the research staff asked capable patients to report the presence or absence of pain verbally (yes/no) or using signs (e.g., head nodding) and to rate their pain intensity using the 0–10 Faces Pain Thermometer (FPT) visual format.[17] The rater viewing the videos was blinded to patients' self-reported pain.

Measures

The Behavioral Checklist and Raters' Training. A behavioral checklist was created and described in a previous publication.[2] Sixty individual behaviors from the

CPOT,[6] the Behavior Observation Tool,[18] and a pilot study[19] were included. A shortened version comprising 30 active and 10 neutral behaviors was used in this study (Table 1). Some behaviors of the initial checklist were merged (i.e., eye opening and wide eye opening, guarding and splinting, resistance and strong resistance, verbal complaints and protests words), and several were removed as they were observed in one or two patients (i.e., flailing, raising shoulders, startling, screaming mastication, chewing, jaw tightening, biting lip, decortication, decerebration, pulling on restraints, seeking attention, striking at staff, climbing out of bed, and shaking).

Ten raters (a clinical research coordinator, three nurses, six nursing students) completed a 90-minute training provided by the principal investigator (C. G.) as previously described.[2,19]

The Faces Pain Thermometer. The FPT consists of a vertical thermometer graded from 0 (no pain) to 10 (worst possible pain) including six faces adapted

Table 1
The Behavioral Checklist

Behavioral Categories	Behavior	Behavior Description
Face—active behaviors		
	Brow lowering	Lowering of the eyebrows and wrinkling of forehead
	Eyebrow elevation	Action of elevating eyebrows
	Orbit tightening	Muscles around eyes become tense
	Eye opening	Opening of the eyelids
	Eye closing	Closure of the eyelids
	Eyes tightly closed	Lids are shut tightly (wrinkling visible on side of eyes)
	Eye weeping	Tearing of the eyes
	Levator contraction	Wrinkling or lifting of the upper lip and cheek tightening
	Mouth opening	Mouth opening to expose teeth and tongue
	Biting tube	Pressing teeth on tube; exposing teeth with opened mouth
	Face flushing	Sudden reddening of the face
	Grimace	A sharp contortion of the face generally accompanied with brow lowering, orbit tightening or eyes tightly closed, levator contraction with either mouth opened or clenched teeth (or biting tube)
Face—neutral behaviors		
	No tension	No visible contraction in the face
	Closed eyes	Eyelids are shut (not tightly)
	Opened eyes	Eyelids are open (not widely)
	Open mouth	Mouth is open
	Smile	Upward curling at corners of mouth; showing teeth
Body—active behaviors		
	Cautious movements	Reaching or moving slowly
	Try to reach pain site	Reaching toward the pain site
	Guarding pain site	Act of touching for the purpose of protecting pain site
	Rubbing pain site	Act of touching the pain site in a back and forth movement
	Upper limb flexion	Action of bending the upper limbs at the elbow
	Lower limb flexion	Action of bending the lower limbs at the knee
	Upper limb extension	Action of extending the upper limbs at the elbow
	Lower limb extension	Action of extending the lower limbs at the knee
	Restlessness	Nonpurposeful, continuous movement
	Defensive grabbing	Reaching out to grasp
	Attempting to sit up	Lifting torso from the bed with the upper limb
	Pulling tubes	Pulling on tubes or catheters
Body—neutral behavior		
	Doesn't move	Laying in bed in a normal position, very still
Muscle rigidity—active behaviors		
	Resistance	Patient tries to control or resist the passive movement of flexion and extension of the upper limb
	Clenching fists	Tight squeezing of the hands
Muscle rigidity—neutral behavior		
	No resistance	Passive movement of flexion and extension of the upper limb is done smoothly
Compliance with mechanical ventilator—active behaviors		
	Alarms activated but stop	Alarms are activated but stop spontaneously
	Coughing	Exhaling air from the lungs with a sudden sharp sound
Compliance with mechanical ventilator—neutral behaviors		
	Easy ventilation	Smooth ventilation and breathing, no alarm
Vocalization—active behaviors		
	Moaning	Low, soft indistinguishable sounds
	Verbal complaints of pain	Words used to object (e.g. stop, no, do not) or to describe pain (e.g., it hurts, ouch)
Vocalization—neutral behaviors		
	No vocalization	No sounds
	Normal speaking	Talk in normal tone

from the work of Prkachin.[20] The scale demonstrated good convergent ($r = 0.80$ to 0.86 with a descriptive rating scale) and discriminative validation across rest and turning ($t = 5.10$, $P < 0.001$) with adult ICU patients.[17]

Demographic and Medical Variables. Demographic (sex, age, ethnicity) and medical variables (ICU admission diagnosis, mechanical ventilation, analgesics and sedatives, cause and severity of TBI (Injury Severity Score or ISS[21]), brain injury localization, APACHE II,[22] GCS,[13] and RASS[14] scores) were extracted from medical charts. An adapted GCS score was calculated for mechanically ventilated patients.[23] GCS and RASS scores documented less than two hours before data collection were used in analysis. The trained research staff screened patients for delirium using the Confusion Assessment Method–Intensive Care Unit.[24]

Data Analysis

Data analysis was performed using the SPSS version 22 software (SPSS Inc., Chicago, IL). Interrater agreement regarding the presence or absence of behaviors between two trained raters was examined using percentage of agreement, an appropriate approach with nominal data.[25]

Patients were classified as unconscious ($3<GCS\leq8$), altered ($9\leq GCS\leq12$), or conscious ($13\leq GCS\leq15$).[13] Frequencies of behaviors were calculated before and during soft touch, turning, and other nociceptive procedures. Behaviors were considered present if one of the two raters reported them. Nonparametric tests (McNemar's and Pearson's chi-square) were conducted for comparisons of nominal variables. The Holm-Bonferroni method was used to correct for multiple pairwise comparisons (smallest $P = 0.017$).

A total score was calculated for each procedure by adding each active behavior present ($n = 30$) and omitting neutral behaviors (e.g., no movement). Discriminative validation was examined by comparing total scores at rest, during soft touch, turning, and other nociceptive procedures using the Wilcoxon signed-rank test. Criterion validation was determined by examining the relationship between patients' self-reported pain on the 0–10 FPT and the total score using the Spearman's rank-order correlation coefficient. The Mann-Whitney *U* test was used to compare the total score between patients reporting the presence and those negating pain during turning. The most predictive behaviors of patients' self-reported pain intensity were identified using multiple linear regression. Patients who were Confusion Assessment Method–Intensive Care Unit positive were excluded from criterion validation as delirium can lead to unreliable self-reports of pain.

Results

A total of 194 patients or proxies were approached, 29 refused (14 because of video recording, nine for feeling overwhelmed, and six did not provide a reason), and 165 provided written consent. Eighteen patients were lost (15 discharged before and three withdrew during data collection), and 147 were included (Table 2). Of note, 45 TBI patients from our sample were included in a previous report[2] describing some behaviors during turning only. In this study, patients were also observed during soft touch and other nociceptive procedures (endotracheal suctioning [$n = 16$], external ventricular drain removal [$n = 3$], subcutaneous injection [$n = 3$], dressing change [$n = 3$], catheter insertion [$n = 3$], and blood work [$n = 1$]).

Patients were mostly men ($n = 96$, 65.3%) and admitted to the ICU after a TBI ($n = 94$, 63.9%). The distribution of patients according to LOC was not significantly different between TBI and non-TBI patients (chi-square (2) = 3.38, $P = 0.185$). Equianalgesic doses of opioids administered (mg of morphine)[26] within four hours of data collection were not significantly different across the unconscious (median = 8.00, interquartile range [IQR] = 7), altered (median = 6.00, IQR = 6.00), and conscious (median = 3.50, IQR = 5.83) patients (Kruskal Wallis (2) = 4.075, $P = 0.130$). The same was true for TBI (median = 8.00, IQR = 6.00) and non-TBI (median = 6.00, IQR = 5.50) patients (Mann-Whitney = 140.50, $P = 0.533$). Most conscious patients did not receive analgesics or sedatives within four hours of the first data collection ($n = 49$, 75.4%), whereas close to half of unconscious patients received continuous analgesics (i.e., fentanyl) and sedation (i.e., propofol, midazolam) ($n = 12$, 46.2%) (Pearson chi-square (8) = 39.12, $P < 0.001$). There were no significant differences for the second data collection set ($n = 43$).

Interrater Agreement

Percentages of interrater agreement were calculated during turning of the first data collection set (Table 3). Very high percentages (92%–98%) were obtained for behaviors such as grimace, clenching fists, and most body items, whereas the lowest percentage was for cautious movements (68%).

Comparison of Behaviors Between Patients of Different LOC

In the first and second data collection sets, the most frequently occurring behaviors during turning were brow lowering (46%/49%), eye opening (42%/35%), cautious movements (40%/42%), moaning (31%/33%), and coughing for those mechanically

Table 2
Sample Characteristics

Variables	All Patients During the Initial Data Collection ($n = 147$)	Subsample of Patients With a Second Data Collection ($n = 43$)
Age (mean, SD)	55.65 (19.51)	51.77 (18.21)
Sex (n, %)		
Male	96 (65.3)	32 (74.4)
Female	51 (34.7)	11 (25.6)
Ethnicity (n, %)		
White	118 (80.3)	34 (79.1)
Black	6 (4.1)	2 (4.7)
Asian	5 (3.4)	1 (2.3)
Hispanic	2 (1.4)	—
First nation	10 (6.8)	5 (11.6)
Other	2 (1.4)	—
Missing	4 (2.7)	1 (2.3)
Diagnosis (n, %)		
Traumatic brain injury	94 (63.95)	29 (67.4)
Nontraumatic brain injury	53 (36.05)	14 (32.6)
Aneurysm	33	8
Stroke	19	6
Brain abscess	1	—
Cause of traumatic brain injury (n, %)		
Fall	52 (55.3)	14 (48.3)
MVA[a] (passenger)	16 (17.0)	6 (20.7)
Assault	10 (10.6)	6 (20.7)
MVA (bike driver)	5 (5.3)	—
MVA (pedestrian)	5 (5.3)	1 (3.4)
Other	6 (6.4)	2 (6.9)
Traumatic brain injury severity (n, %)		
Mild	20 (21.2)	2 (6.9)
Moderate	29 (30.9)	6 (20.7)
Severe	43 (45.7)	21 (72.4)
Missing	2 (2.1)	—
Injury localization (n, %)		
Frontal only	26 (17.7)	9 (20.9)
Frontal and other	48 (32.7)	13 (30.2)
Other without frontal	38 (25.9)	8 (18.6)
Diffuse/basal ganglia	35 (23.8)	13 (30.2)
Level of consciousness (n, %)		
Unconscious	26 (17.7)	4 (9.3)
Altered	56 (38.1)	11 (25.6)
Conscious	65 (44.2)	28 (65.1)
APACHE II score (mean, SD)	14.28 (6.18)	16.60 (5.49)
Glasgow Coma Scale (median, interquartile range)	10.00 (6.00)	10.00 (4.00)
Glasgow Coma Scale adapted (median, interquartile range)	9.00 (5.00), $n = 85$	13.00 (4.50), $n = 25$
Richmond Agitation Sedation Scale score (median, interquartile range)	−2.00 (4.00)	−1.00 (2.00)
Confusion Assessment Method-Intensive Care Unit (n, %)		
Positive	8 (5.4)	4 (9.3)
Negative	25 (17.0)	5 (11.6)
Not evaluable	50 (34.0)	14 (32.6)
Missing	64 (43.5)	20 (46.5)
Mechanically ventilated (n, %)		
Yes	85 (57.8)	25 (58.1)
No	62 (42.2)	18 (41.9)

[a]MVA, motor vehicle accident—the parentheses indicate the position of the patient during the accident.

ventilated (32%/28%) (Table 4). During turning, grimace was observed in only 12% and 14% of participants in the first and the second data collection sets, respectively. Resistance was found in 25% of participants in the first data collection set, but the percentage increased to 40% in the second data collection set. During soft touch of both data collection sets, most patients had no facial tension (82%/88%), did not move (65%/56%), exhibited no resistance (81%/72%) or vocalization (63%/78%), and had an easy ventilation (99%/92%).

During turning of the first data collection set, all active face items were observed more frequently than during soft touch (McNemar chi-square, $P < 0.05$), but not muscle rigidity. Neutral behaviors such as no facial tension, no movement, easy ventilation, and

no vocalization were significantly more frequent during soft touch than turning. Specific to unconscious patients, only brow lowering, face flushing, and coughing were statistically more frequent during turning compared to soft touch. Conversely, the absence of facial tension and easy ventilation were statistically more frequent during soft touch than turning.

Significant differences were observed between patient groups (unconscious, altered, conscious) during turning for brow lowering, eyebrow elevation, eye opening, eye closing, levator contraction, mouth opening, grimace, cautious movements, lower limb flexion, guarding, and normal speaking (chi-square (2), $P < 0.05$). These behaviors were expressed more frequently by conscious patients.

Like turning, active face items (e.g., brow lowering, eye opening, eyes tightly closed, eye weeping, mouth opening, face flushing) (McNemar chi-square, $P < 0.032$) and body items (e.g., trying to reach the pain site, flexion of the upper and the lower limbs, and cautious movements) (McNemar chi-square, $P < 0.004$) were more frequent during the other nociceptive procedures than at rest (Table 5). Many mechanically ventilated patients ($n = 15$, 62.5%) experienced coughing during other nociceptive procedures, whereas almost all of them ($n = 21$, 95.5%) had easy ventilation at rest.

Comparison of Active Behaviors by ICU Diagnosis and Brain Injury Localization

During turning, some behaviors (i.e., eye closing, opened eyes, cautious movements, lower limb flexion, trying to reach pain site, rubbing pain site, guarding, pulling tubes, muscle rigidity) were observed in higher proportions (differences in proportions from 9% to 30%) in non-TBI compared to TBI patients (chi-square tests (1) = 3.99−12.52, $P < 0.05$). Eye weeping was the only item more frequent in TBI (21%) than in non-TBI patients (2%) (chi-square test (1) = 10.41, $P = 0.001$).

Patients with localized injuries in cerebral hemispheres ($n = 112$) were categorized based on the area of their cerebral injury: frontal only ($n = 26$), frontal and other area ($n = 48$), and other area without frontal ($n = 38$). Frequencies of individual behaviors did not differ between the three groups during turning (chi-square test (2), $P > 0.05$). The median total scores during turning for patients with frontal-only brain injury were 4.00 (IQR = 4.25), for those with frontal and other area 3.00 (IQR = 4.00), and for those with other area without frontal 4.00 (IQR = 4.25). The total number of active behaviors was not significantly different between these three groups for any procedure (i.e., pre-turning, turning, pre-soft touch, soft touch) (Kruskal Wallis Test (2), $P > 0.389$).

Discriminative Validation of Active Behaviors

For both data collection sets, the total score of active behaviors was significantly higher during turning compared to pre-turning (Wilcoxon = 9.873 and 5.072, $P < 0.001$) and soft touch (Wilcoxon = 9.486 and 4.937, $P < 0.001$) regardless of LOC but was similar between pre-soft touch and soft touch ($P > 0.773$) (Table 6). The total score was significantly higher during the other nociceptive procedures compared to prior (Wilcoxon = 4.632, $P < 0.001$). The total score was also significantly higher for the conscious compared to the unconscious and altered patient groups regardless of procedure (pre-soft touch, soft touch, pre-turning, turning) (Mann-Whitney *U*, $P < 0.017$) for the first data collection set only.

For the first data collection set, subscores for the facial and body dimension were significantly higher during turning compared to pre-turning ($P < 0.001$) and soft touch ($P < 0.001$), but not between pre- and during soft touch ($P > 0.701$). Subscores for the muscle rigidity dimension were not significantly different across procedures ($P > 0.05$). Subscores for vocalization/compliance with the ventilator were

Table 3
Percentages of Interrater Agreement During Turning of the First Data Collection Set

Behavior	Percentage Agreement >90%	Behavior	Percentage Agreement 80%−90%	Behavior	Percentage Agreement <80%
Attempting to sit up	97.9	Eyebrow elevation	88.8	Levator contraction	78.3
Clenching fists	97.9	Eye weeping	86.7	No resistance	77.9
Limb extension (upper)	96.6	Orbit tightening	86.7	Brow lowering	75.5
Pulling tubes	96.6	Moaning	85.5	Limb flexion (upper)	72.4
Defensive grabbing	96.6	Alarms activated but stop	85.5	Eye opening	71.3
Rubbing pain site	96.6	Eye closing	85.3	Cautious movements	68.3
Biting tube	95.8	Face flushing	83.2		
Try to reach pain site	95.2	Eyes tightly closed	82.5		
Limb extension (lower)	95.1	Coughing	81.9		
Restlessness	93.8	Mouth opening	81.8		
Grimace	93.7	Verbal complaints of pain	80.6		
Guarding pain site	92.4	Limb flexion (lower)	80.0		
		Resistance	80.0		

Table 4

Frequencies of Behaviors Expressed by Brain-Injured ICU Patients at Different Levels of Consciousness During Turning and Soft Touch for the First ($n = 147$)/Second ($n = 43$) Data Collections

	Level of Consciousness									All		
	Unconscious ($n = 26/4$)			Altered ($n = 56/11$)			Conscious ($n = 65/28$)					
Behaviors	Turning	Soft Touch	McNemar Test (P)	Turning	Soft Touch	McNemar Test (P)	Turning	Soft Touch	McNemar Test (P)	Turning	Soft Touch	McNemar Test (P)
Face—active behaviors												
Brow lowering	6/2	0/0	0.031/0.500	22/4	2/1	<0.001/0.250	40/15	14/0	<0.001/<0.001	68/21[a]	16/1[a]	<0.001/<0.001
Eyebrow elevation	0/1	1/0	1.00/1.00	5/2	1/0	0.219/0.500	16/3	7/1	0.049/0.500	21/6[a]	9/1	0.023/0.063
Orbit tightening	1/0	0/0	1.00/-	7/2	1/0	0.031/0.500	8/7	0/0	0.008/0.016	16/9	1/0	<0.001/0.004
Eye opening	5/0	1/1	0.219/1.00	29/3	4/0	<0.001/0.250	28/12	12/9	0.005/0.607	62/15[a]	17/10	<0.001/0.359
Eye closing	1/0	0/0	1.00/-	5/1	0/0	0.063/1.00	16/4	5/3	0.019/1.00	22/5[a]	5/3[a]	0.001/0.727
Eyes tightly closed	2/2	0/0	0.500/0.500	11/1	0/0	0.001/1.00	9/5	1/1	0.008/0.219	22/8	1/1	<0.001/0.039
Eye weeping	4/1	0/0	0.125/1.00	12/6	3/0	0.022/0.031	5/2	0/1	0.063/0.500	21/9	3/1	<0.001/0.008
Levator contraction	4/1	0/0	0.125/1.00	8/4	0/0	0.008/0.125	21/11	1/1	<0.001/0.006	33/16[a]	1/1	<0.001/<0.001
Mouth opening	1/1	0/1	1.00/1.00	11/1	1/0	0.006/1.00	20/7	3/1	<0.001/0.031	32/9[a]	4/2	<0.001/0.039
Biting tube	1/0	0/0	1.00	3/1	0/0	0.25/1.00	3/0	0/0	0.25/-	7/1	0/0	0.016/1.00
Face flushing	7/1	0/0	0.016/1.00	11/4	0/0	0.001/0.125	14/7	1/0	<0.001/0.016	32/12	1/0	<0.001/<0.001
Grimace	0/0	0/0	—	4/1	0/0	0.125/1.00	14/5	2/2	<0.001/0.375	18/6[a]	2/2	<0.001/0.219
Face—neutral behaviors												
No tension	16/1	25/4	0.012/0.250	22/3	53/10	<0.001/0.016	12/9	43/24	<0.001/<0.001	50/13	121/38[a]	<0.001/<0.001
Closed eyes	25/3	25/4	1.00/1.00	49/8	46/9	0.549/1.00	20/14	30/16	0.041/0.774	94/25[a]	101/29[a]	0.296/0.424
Opened eyes	1/1	0/0	1.00/1.00	7/3	3/2	0.219/1.00	45/14	20/8	<0.001/0.146	53/18[a]	23/10[a]	<0.001/0.057
Open mouth	1/0	0/0	1.00/-	8/3	8/4	1.00/1.00	15/8	9/7	0.109/1.00	24/11	17/11	0.118/1.00
Smile	0/0	0/0	—	0/0	0/0	—	5/1	0/0	0.063/1/00	5/1[a]	0/0	0.063/1.00
Body—active behaviors												
Cautious movements	4/0	2/0	0.50/-	12/4	2/1	0.006/0.375	42/14	9/5	<0.001/0.004	58/18[a]	13/6	<0.001/0.002
Try to reach pain site	1/1	0/0	1.00/1.00	8/0	0/0	0.008/-	6/5	1/0	0.125/0.063	15/6	1/0	0.001/0.031
Guarding pain site	0/0	0/0	—	0/0	0/0	—	8/1	1/0	0.016/1.00	8/1[a]	1/0	0.016/1.00
Rubbing pain site	0/1	0/0	-/1.00	3/0	0/0	0.25/-	2/0	0/0	0.50	5/1	0/0	0.063/1.00
Upper limb flexion	3/1	1/0	0.625/1.00	14/2	3/0	0.013/0.500	22/4	5/3	<0.001/1.00	39/7	9/3	<0.001/0.344
Lower limb flexion	2/1	1/0	1.00/1.00	12/2	11/0	1.00/0.500	21/5	4/1	<0.001/0.219	35/8[a]	16/1[a]	0.002/0.039
Upper limb extension	1/0	0/0	1.00/-	2/2	1/0	1.00/0.500	2/0	2/0	1.00/-	5/2	3/0	0.625/0.500
Lower limb extension	0/0	0/0	—	3/1	2/0	1.00/1.00	4/0	3/3	1.00/0.250	7/1	5/3	0.727/0.625
Restlessness	0/0	0/0	—	2/1	3/0	1.00/1.00	4/3	7/5	0.549/0.625	6/4	10/5	0.454/1.00
Defensive grabbing	0/0	0/0	—	2/1	0/1	0.50/1.00	3/2	0/0	0.25/0.500	5/3	0/1	0.063/0.625
Attempting to sit up	0/0	0/0	—	2/0	0/0	0.50	2/1	3/2	1.00/1.00	4/1	3/2	1.00/1.00
Pulling tubes	0/0	0/0	—	3/1	1/0	0.625/1.00	4/2	0/0	0.125/0.500	7/3	1/0	0.070/0.250
Body—neutral behaviors												
Doesn't move	14/3	20/4	0.18/1.00	27/5	41/9	0.007/0.219	9/6	35/11	<0.001/0.227	51/14	96/24[a]	<0.001/0.031
Muscle rigidity—active behaviors												
Resistance	5/1	0/2	0.063/1.00	16/4	8/2	0.039/0.500	16/12	18/7	0.815/0.227	37/17	26/11[a]	0.091/0.210
Clenching fists	1/0	1/0	1.00/-	2/1	1/0	1.00/1.00	0/0	0/1	-/1.00	3/1	2/1	1.00/1.00
Muscle rigidity—neutral behaviors												
No resistance	20/3	24/2	0.289/1.00	39/6	48/9	0.022/0.250	49/16	47/20	0.804/0.344	108/25	119/31[a]	0.10/0.210

(*Continued*)

Table 4
Continued

Behaviors	Level of Consciousness									All		
	Unconscious ($n = 26/4$)			Altered ($n = 56/11$)			Conscious ($n = 65/28$)					
	Turning	Soft Touch	McNemar Test (P)	Turning	Soft Touch	McNemar Test (P)	Turning	Soft Touch	McNemar Test (P)	Turning	Soft Touch	McNemar Test (P)
Ventilator compliance—active behaviors												
Mechanically ventilated	$n = 25/2$			$n = 45/8$			$n = 15/15$			$n = 85/25$		
Alarms activated but stop	5/0	0/0	0.063/-	10/2	0/0	0.002/0.500	3/3	0/1	0.25/0.500	18/5	0/1	<0.001/0.125
Coughing	7/0	0/0	0.016/-	13/3	0/1	<0.001/0.625	7/4	1/1	0.016/0.625	27/7	1/2	<0.001/0.289
Ventilator compliance—neutral behaviors												
Easy ventilation	16/2	25/2	0.004/-	26/3	44/8	<0.001/0.063	7/9	15/13	0.008/0.125	49/14	84/23	<0.001/0.004
Vocalization—active behaviors												
Not mechanically ventilated	$n = 1/2$			$n = 11/3$			$n = 50/13$			$n = 62/18$		
Moaning	0/0	0/0	—	4/1	1/1	0.25/1.00	15/5	8/0	0.118/0.063	19/6	9/1	0.031/0.063
Verbal complaints of pain	0/0	0/0	—	0/1	0/0	-/1.00	8/2	3/0	0.180/0.500	8/3	3/0	0.180/0.250
Vocalization—neutral behaviors												
No vocalization	1/2	1/2	—	7/2	10/2	0.25/1.00	18/6	28/10	0.078/0.063	26/10	39/14	0.026/0.219
Normal speaking	0/0	0/0	—	0/0	0/0	—	21/3	13/3	0.096/1.00	21/3[a]	13/3	0.096/1.00

Frequencies for the second data collection ($n = 43$) appear after the slash.
[a]$P < 0.05$ (behaviors are significantly different across levels of consciousness for the first data collection).

significantly different not only between turning and the nonnociceptive procedures (pre-turning [Wilcoxon = 6.661, $P < 0.001$] and soft touch [Wilcoxon = 5.693, $P < 0.001$]), but also between pre- and during soft touch (Wilcoxon = 2.271, $P = 0.023$). During turning, subscores were significantly higher for the conscious patients compared to the unconscious and altered patient groups for the facial (Kruskal Wallis (2) = 16.416, $P < 0.001$) and body movement (Kruskal Wallis (2) = 25.313, $P < 0.001$) dimensions, but not for muscle rigidity (Kruskal Wallis (2) = 0.793, $P = 0.673$) and vocalization/compliance with a ventilator (Kruskal Wallis (2) = 0.214, $P = 0.899$).

For the second data collection set, all subscores, except muscle rigidity, were significantly higher during turning compared to pre-turning and soft touch ($P < 0.05$), but similar between pre- and during soft touch ($P > 0.124$).

Criterion Validation of Active Behaviors

Of the 147 patients of the first data collection set, only 35 of those conscious ($n = 65$) could self-report pain during turning. Seventeen reported having pain while 18 denied pain during turning. Of these, 33 could use the 0–10 FPT. Overall, median pain intensity during turning was 1 (range: 0–8), and TBI patients reported higher pain intensity (median = 3, range 0–8, $n = 16$) compared to non-TBI patients (median = 0, range 0–6, $n = 17$) (Mann-Whitney $U = 84.50$, $P = 0.048$) possibly due to the multiple body traumas experienced in addition to the TBI. The total score of active behaviors was not significantly different between those reporting and those denying pain (Mann-Whitney $U = 133.00$, $P = 0.505$) and was poorly correlated with patients' self-reported pain intensity (Spearman rho = 0.17, $P = 0.339$). Only six patients could self-report their pain during turning of the second data collection set and four during the other procedures, and statistical analyses could not be performed.

Behaviors Predictive of Pain Intensity

The most significant and potentially significant predictors ($P < 0.09$) of pain intensity during turning were grimace (beta = 0.47, $P = 0.006$), mouth opening (beta = 0.36, $P = 0.039$), orbit tightening (beta = 0.34, $P = 0.053$), eye weeping (beta = 0.33, $P = 0.062$), and eyes tightly closed (beta = 0.30, $P = 0.086$), and the regression model (F (5, 27) = 2.64, $P = 0.05$) including these five predictors explained 33% of variance. These five behaviors were significantly different between those reporting the presence of pain and those negating pain during turning (Mann-Whitney $U = 101.00$, $P = 0.05$) and

Table 5

Frequencies and Percentages of Behaviors Expressed by Brain-Injured ICU Patients at Different Levels of Consciousness During Other Painful Procedures and at Rest ($n = 29$)

	Level of Consciousness									All		
	Unconscious ($n = 4$)			Altered ($n = 16$)			Conscious ($n = 9$)					
Behaviors	Other Proc	At Rest	McNemar Test (P)	Other Proc	At Rest	McNemar Test (P)	Other Proc	At Rest	McNemar Test (P)	Other Procedures	At Rest	McNemar Test (P)
Face—active behaviors												
Brow lowering	2 (50.0)	1 (25.0)	1.00	8 (50.0)	1 (6.3)	0.016	5 (55.6)	0 (0.0)	0.063	15 (51.7)	2 (6.9)	<0.001
Eyebrow elevation	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—
Orbit tightening	0 (0.0)	0 (0.0)	—	2 (12.5)	0 (0.0)	0.500	3 (33.3)	0 (0.0)	0.250	5 (17.2)	0 (0.0)	0.063
Eye opening	0 (0.0)	0 (0.0)	—	5 (31.3)	1 (6.3)	0.125	6 (66.7)	4 (44.4)	0.500	11 (37.9)[a]	5 (17.2)[a]	0.031
Eye closing	0 (0.0)	0 (0.0)	—	2 (12.5)	0 (0.0)	0.500	2 (22.2)	0 (0.0)	0.500	4 (13.8)	0 (0.0)	0.125
Eyes tightly closed	1 (25.0)	0 (0.0)	1.00	3 (18.8)	0 (0.0)		2 (22.2)	0 (0.0)	0.500	6 (20.7)	0 (0.0)	0.031
Eye weeping	1 (25.0)	0 (0.0)	1.00	4 (25.0)	0 (0.0)	0.125	2 (22.2)	0 (0.0)	0.500	7 (24.1)	0 (0.0)	0.016
Levator contraction	0 (0.0)	0 (0.0)	—	2 (12.5)	0 (0.0)	0.500	3 (33.3)	0 (0.0)	0.250	5 (17.2)	0 (0.0)	0.063
Mouth opening	0 (0.0)	0 (0.0)	—	4 (25.0)	0 (0.0)	0.125	4 (44.4)	1 (11.1)	0.250	8 (27.6)	1 (3.4)	0.016
Biting tube	0 (0.0)	0 (0.0)	—	1 (6.3)	0 (0.0)	1.00	1 (11.1)	0 (0.0)	1.00	2 (6.9)	0 (0.0)	0.500
Face flushing	0 (0.0)	0 (0.0)	—	7 (43.8)	1 (6.3)	0.031	2 (22.2)	0 (0.0)	0.500	9 (31.0)	1 (3.4)	0.008
Grimace	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	2 (22.2)	0 (0.0)	0.500	2 (6.9)	0 (0.0)	0.500
Face—neutral behaviors												
No tension	1 (25.0)	3 (75.0)	0.500	5 (31.3)	15 (93.8)	0.002	2 (22.2)	8 (88.9)	0.031	8 (27.6)	26 (89.7)	<0.001
Closed eyes	3 (75.0)	4 (100.0)	1.00	15 (93.7)	15 (93.8)	1.00	7 (77.8)	8 (88.9)	1.00	25 (86.2)	27 (93.1)	0.500
Opened eyes	1 (25.0)	0 (0.0)	1.00	1 (6.3)	1 (6.2)	1.00	2 (22.2)	1 (11.1)	1.00	4 (13.8)	2 (6.9)	0.500
Open mouth	0 (0.0)	0 (0.0)	—	1 (6.3)	3 (18.8)	0.500	2 (22.2)	1 (11.1)	1.00	3 (10.3)	4 (13.8)	1.00
Smile	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	1 (11.1)	0 (0.0)	1.00	1 (3.4)	0 (0.0)	1.00
Body—active behaviors												
Cautious movements	0 (0.0)	0 (0.0)	—	9 (56.3)	1 (6.3)	0.008	5 (55.6)	2 (22.2)	0.375	14 (48.3)	3 (10.3)	0.003
Try to reach pain site	0 (0.0)	0 (0.0)	—	4 (25.0)	0 (0.0)	0.125	3 (33.3)	0 (0.0)	0.250	7 (24.1)	0 (0.0)	0.016
Guarding pain site	1 (25.0)	0 (0.0)	1.00	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	1 (3.4)[a]	0 (0.0)	1.00
Rubbing pain site	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—
Upper limb flexion	1 (25.0)	0 (0.0)	1.00	4 (25.0)	0 (0.0)	0.125	4 (44.4)	2 (22.2)	0.625	9 (31.0)	2 (6.9)	0.039
Lower limb flexion	1 (25.0)	0 (0.0)	1.00	6 (37.5)	0 (0.0)	0.031	3 (33.3)	0 (0.0)	0.250	10 (34.5)	0 (0.0)	0.002
Upper limb extension	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—
Lower limb extension	0 (0.0)	0 (0.0)	—	2 (12.5)	1 (6.3)	1.00	0 (0.0)	0 (0.0)	—	2 (6.9)	1 (3.4)	1.00
Restlessness	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	1 (11.1)	1 (11.1)	1.00	1 (3.4)	1 (3.4)	1.00
Defensive grabbing	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	1 (11.1)	0 (0.0)	1.00	1 (3.4)	0 (0.0)	1.00
Attempting to sit up	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—
Pulling tubes	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—	0 (0.0)	0 (0.0)	—
Body—neutral behaviors												
Doesn't move	2 (50.0)	4 (100.0)	0.500	2 (12.5)	12 (75.0)	0.002	1 (11.1)	6 (66.7)	0.063	5 (17.2)	22 (75.9)	<0.001
Muscle rigidity—active behaviors												
Resistance	1 (25.0)	1 (25.0)	1.00	8 (50.0)	3 (18.7)	0.063	5 (55.6)	6 (66.7)	1.00	14 (48.3)	10 (34.5)	0.125
Clenching fists	0 (0.0)	0 (0.0)	—	2 (12.5)	0 (0.0)	0.500	2 (22.2)	0 (0.0)	0.500	4 (13.8)	0 (0.0)	0.125
Muscle rigidity—neutral behaviors												
No resistance	3 (75.0)	3 (75.0)	1.00	7 (43.8)	13 (81.3)	0.031	4 (44.4)	3 (33.3)	1.00	14 (48.3)	19 (65.5)	0.063
Ventilator compliance—active behaviors												
Mechanically ventilated	$n = 4$			$n = 14$			$n = 4$			$n = 22$		
Alarms activated but stop	0 (0.0)	0 (0.0)	—	6 (42.9)	1 (7.1)	0.063	0 (0.0)	0 (0.0)	—	6 (27.3)	1 (4.5)	0.063
Coughing	2 (50.0)	0 (0.0)	0.500	10 (62.4)	0 (0.0)	0.008	3 (75.0)	0 (0.0)	0.250	15 (62.5)	0 (0.0)	<0.001

(*Continued*)

Table 5
Continued

Behaviors	Level of Consciousness									All		
	Unconscious ($n = 4$)			Altered ($n = 16$)			Conscious ($n = 9$)					
	Other Proc	At Rest	McNemar Test (P)	Other Proc	At Rest	McNemar Test (P)	Other Proc	At Rest	McNemar Test (P)	Other Procedures	At Rest	McNemar Test (P)
Ventilator compliance—neutral behaviors												
Easy ventilation	2 (50.0)	4 (100.0)	0.500	4 (28.6)	13 (92.9)	0.012	1 (25.0)	4 (100.0)	0.250	7 (31.8)	21 (95.5)	<0.001
Vocalization—active behaviors												
Not mechanically ventilated	$n = 0$			$n = 2$			$n = 5$			$n = 7$		
Moaning	—	—	—	0 (0.0)	0 (0.0)	—	2 (40.0)	0 (0.0)	0.500	2 (28.6)	0 (0.0)	0.50
Verbal complaints of pain	—	—	—	0 (0.0)	0 (0.0)	—	1 (20.0)	0 (0.0)	1.00	1 (14.3)	0 (0.0)	1.00
Vocalization—neutral behaviors												
No vocalization	—	—	—	2 (100.0)	2 (100.0)	—	3 (60.0)	5 (100.0)	0.500	5 (71.4)	7 (100.0)	0.500
Normal speaking	—	—	—	—	—	—	—	—	—	—	—	—

[a]$P < 0.05$, chi-square test (behaviors are significantly different across levels of consciousness).

were moderately correlated with self-reported pain intensity (Spearman rho = 0.47, $P = 0.006$).

Discussion

This study described the behaviors expressed by brain-injured ICU patients during nociceptive and nonnociceptive procedures. Active behaviors were more frequent during turning and other nociceptive procedures, and neutral behaviors were more frequent at rest and during soft touch. Only specific active behaviors related to facial expression were predictors of self-reported pain intensity during turning. Some behaviors were more frequently observed according to the ICU diagnosis (TBI vs. non-TBI), but not brain injury localization.

In this study, self-reported pain intensity during turning was mild and similar to pain intensity as reported by elective brain surgery patients.[12] Unfortunately, only a few patients could self-report during the other nociceptive procedures (i.e., endotracheal suctioning and drain removal), which are known to be more painful than turning.[15] Similarly to previous studies,[2,3] very few participants (35/147; 24% of total sample) could self-report their pain, although 65 of them (44%) were conscious. These data show the challenges in assessing pain in this population and highlight the need to rely on alternative measures for pain assessment in patients unable to self-report their pain.

Percentages of interrater agreement were high (>80%) for most behaviors, and some were in the 70% range. These percentages are acceptable considering the high number of raters ($n = 10$) involved compared to only two as used in previous studies.[2,4,19] Only "cautious movements" obtained a value < 70%, but its description was vague, thereby allowing room for interpretation. Furthermore, raters observed 40 behaviors simultaneously, some of which were subtle (e.g., orbit tightening, cautious movements) and more difficult to detect. Differences in observations might also stem from the fact that one rater completed the behavioral checklist at the bedside and one using videos. The bedside rater may have captured a behavior not recorded on the video and vice versa. The dressing on the patient's head or fixation of the endotracheal tube around the mouth may have interfered with the raters' observations of the upper face (e.g., brow lowering) and around the mouth (e.g., levator contraction).

A higher number of active behaviors were observed during turning and other nociceptive procedures compared to rest and soft touch, and this number was even higher in conscious patients. Consistent with previous studies,[2,4,19] neutral behaviors were more frequently observed at rest and during soft

Table 6
Medians and Ranges for Total Number of Active Behaviors and Subscores for Each Procedure

	Before Turning		Turning		Before Soft Touch		Soft Touch			
Other Procedure	First Data Collection	Second Data Collection	First Data Collection	Second Data Collection	First Data Collection	Second Data Collection	First Data Collection	Second Data Collection	At Rest Before Other Procedure	During Other Procedure
Total score	0 (0–7)	1 (0–5)	4 (0–17)	5 (0–13)	1 (0–7)	1 (0–4)	0 (0–11)	1 (0–5)	1 (0–5)	4 (0–14)
Unconscious	0 (0–3)	0 (0–1)	2 (0–7)	2 (0–10)	0 (0–2)	0.5 (0–1)	0 (0–1)	1 (0–2)	0.5 (0–1)	2.5 (1–4)
Altered	0 (0–4)	1 (0–2)	3 (0–17)	6 (0–11)	0 (0–5)	1 (0–4)	0 (0–4)	0 (0–3)	0 (0–3)	6 (0–11)
Conscious	1 (0–7)	1 (0–5)	5 (1–14)	5 (0–13)	1 (0–7)	1 (0–4)	1 (0–7)	2 (0–5)	1 (0–5)	4 (2–14)
Face subscore	0 (0–5)	0 (0–3)	2 (0–10)	2 (0–9)	0 (0–4)	0 (0–2)	0 (0–5)	0 (0–3)	0 (0–2)	2 (0–7)
Unconscious	0 (0–2)	—	1 (0–4)	2 (0–5)	0 (0–1)	—	0 (0–1)	0 (0–2)	0 (0–1)	1 (0–2)
Altered	0 (0–2)	0 (0–2)	1.5 (0–10)	2 (0–9)	0 (0–3)	0 (0–1)	0 (0–3)	0 (0–1)	0 (0–2)	2.5 (0–5)
Conscious	0 (0–5)	0 (0–3)	3 (0–8)	2 (0–7)	0 (0–4)	0 (0–2)	0 (0–5)	1 (0–3)	0 (0–2)	2 (1–7)
Body subscore	0 (0–4)	0 (0–2)	1 (0–7)	1 (0–5)	0 (0–3)	0 (0–3)	0 (0–6)	0 (0–2)	0 (0–2)	1 (0–5)
Unconscious	0 (0–0)	—	0 (0–2)	0 (0–4)	0 (0–1)	—	0 (0–1)	—	—	0.5 (0–2)
Altered	0 (0–2)	0 (0–1)	0 (0–5)	1 (0–5)	0 (0–3)	0 (0–3)	0 (0–3)	0 (0–2)	0 (0–1)	1 (0–4)
Conscious	0 (0–4)	0 (0–2)	1 (0–7)	1 (0–5)	0 (0–3)	1 (0–3)	0 (0–6)	0.5 (0–2)	0 (0–2)	2 (0–5)
Muscle rigidity subscore	0 (0–2)	0 (0–1)	0 (0–2)	0 (0–1)	0 (0–2)	0 (0–1)	0 (0–2)	0 (0–1)	0 (0–1)	1 (0–2)
Unconscious	0 (0–1)	0 (0–1)	0 (0–1)	0 (0–1)	0 (0–1)	0.5 (0–1)	0 (0–1)	0.5 (0–1)	0 (0–1)	0 (0–1)
Altered	0 (0–2)	0 (0–1)	0 (0–2)	0 (0–1)	0 (0–1)	0 (0–1)	0 (0–2)	0 (0–1)	0 (0–1)	1 (0–2)
Conscious	0 (0–2)	0 (0–1)	0 (0–1)	0 (0–1)	0 (0–2)	0 (0–1)	0 (0–1)	0 (0–1)	0 (0–1)	1 (0–2)
Ventilation/vocalization subscore	0 (0–2)	0 (0–1)	0 (0–2)	0 (0–2)	0 (0–1)	0 (0–1)	0 (0–2)	0 (0–2)	0 (0–1)	1 (0–2)
Unconscious	0 (0–1)	—	0 (0–2)	—	0 (0–0)	—	0 (0–0)	—	—	0.5 (0–1)
Altered	0 (0–2)	0 (0–1)	0 (0–2)	0 (0–2)	0 (0–1)	0 (0–1)	0 (0–1)	0 (0–1)	0 (0–1)	1 (0–2)
Conscious	0 (0–1)	0 (0–1)	0 (0–2)	0 (0–2)	0 (0–1)	0 (0–1)	0 (0–2)	0 (0–2)	—	1 (0–2)

touch. The number of face and body items was more likely to increase during nociceptive procedures compared to muscle rigidity, ventilator compliance, and vocalization items. In previous studies, muscle rigidity was found to be mainly absent in most TBI patients[2] but present in 32%–48% of non-TBI patients during turning.[4] Muscle rigidity was also observed in similar proportions of 28% and 35% of ICU patients with various diagnoses in a large international study ($n = 3851$).[27] Ventilator compliance items may not be specific to pain as they can be triggered by secretions, ventilator mode/setting, and endotracheal tube position.[28] In addition, coughing may have been triggered by endotracheal suctioning in mechanically ventilated patients, a nociceptive procedure included in this study. It is worth to mention that ventilation compliance and vocalization items differed before and during soft touch, which may indicate the possibility of allodynia for some patients.

Although observed in a small proportion of participants (12% during turning, and 7% during other nociceptive procedures), grimace was a strong predictor of pain intensity in conscious patients. ICU clinicians concur on the high relevance of grimace for pain assessment in this population[28] and are frequently observed during nociceptive procedures in ICU patients.[27] Many face items were observed during turning and other nociceptive procedures; however, eyebrow elevation can be indicative of anxiety or fear[29] and eye opening of awakening secondary to stimulation and should not be used as indicators of pain. Some body items such as trying to reach, rubbing, and guarding were more clearly related to pain as they were targeted toward the pain site, but cautious movements, limb flexion, restlessness, defensive grabbing, attempting to sit up, and pulling tubes did not appear to be pain specific and could have been a response to stimulation or agitation.[28]

Some behaviors were more frequent in non-TBI patients, but eye weeping was the sole item mainly observed in TBI patients, which may be related to their underlying injury mechanism. Eye weeping was only described in two previous studies[2,19] and deemed relevant to use for pain assessment in conscious brain-injured ICU patients by clinicians.[28] Face flushing was not described in other ICU patients but appeared to be associated with nociceptive procedures. Unconscious patients were more sedated, expressed more subtle behaviors (e.g., brow lowering, face flushing), and exhibited almost no body movements, thereby making pain assessment in this subgroup more challenging compared to patients with higher LOC who expressed not only a higher number but also more specific behaviors (e.g., grimace, verbal complaints of pain).

Limitations

The raters were not blinded to procedures and may have observed more behaviors during procedures known to be painful. The combination of bedside observation and the use of videos may have led to differences in checklist ratings. Only 35 patients could self-report their pain, which limited the power of the analyses to detect all potentially predictive behaviors

of self-reported pain intensity. Nevertheless, this is the first study to include a heterogeneous group of brain-injured ICU patients and other nociceptive procedures in addition to turning.

Conclusion

Brain-injured ICU patients expressed a variety of behaviors during nociceptive procedures, with conscious patients showing the highest number of behaviors and unconscious patients expressing only a few. The former group expressed more intense behaviors such as grimace, whereas the latter expressed subtle behaviors such as brow lowering. Only some behaviors were predictive of self-reported pain intensity and others may indicate other symptoms (e.g., anxiety, fear) or conditions (e.g., awakening, agitation). Some behaviors were more frequently observed in non-TBI than TBI patients, whereas eye weeping was mainly present in TBI patients. These results will be useful in the revision of existing pain assessment tools such as the CPOT and BPS/BPS-NI to make their content more suited to this vulnerable population. Other objective or multiparametric nociception monitoring devices (e.g., Analgesia Nociception Index or Nociception Level Index)[30,31] could also be considered in the validation process of behavioral pain scales.

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