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Review Article

The Validity of Vital Signs for Pain Assessment in critically Ill Adults: A Narrative Review

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ABSTRACT

Objectives: Pain assessment in the intensive care unit (ICU) is challenging because many patients are unable to self-report or exhibit pain-related behaviors. In such situations, vital signs (VS) through continuous monitoring are alternative cues for pain assessment. This review aimed to describe the reliability and validity of VS for ICU pain assessment.
Design: Narrative review of the literature.
Data sources: Medline, Embase, CINAHL, Cochrane.
Review/Analysis methods: A narrative review was conducted with a comprehensive search in four databases. Search terms included VS, pain assessment, and ICU.
Results: Out of 1,359 results, 30 studies from 17 countries were included. Heart rate, blood pressure, and respiratory rate were most used for ICU pain assessment. Assessments were performed at rest before procedures, during nociceptive and non-nociceptive procedures, and after procedures. Increases in respiratory rate were clinically significant by more than 25% during nociceptive procedures (e.g., endotracheal suctioning, turning) compared with rest/pre-procedures in five studies. Correlations of VS with self-reported pain (reference standard measure) and behavioral pain scores (alternative measure) were absent or weak.
Conclusions: VS are not valid indicators for ICU pain assessment. Increases of respiratory rate may be a cue for the detection of pain. However, fluctuations in respiratory rate can be influenced by opioids or controlled ventilation mode. Our results dissuade the use of VS for pain assessment because of the lack of association with ICU pain reference standards. Other physiologic measures of pain in critically ill adults should be explored.

Most, if not all, critically ill adults experience pain during their stay in the intensive care unit (ICU) due to their reasons for admission and standard care procedures (i.e., endotracheal suctioning, catheter insertion/removal, turning/repositioning, etc.) (Puntillo et al., 2014). Many of these standard care procedures can be described as noxious stimuli which are "damaging or threatens damage to normal tissues" (Raja et al., 2020, p. 1977) and may cause pain (Puntillo et al., 2014). Suboptimal management of pain is associated with negative consequences such as prolonged duration of mechanical ventilation and ICU stay, higher mortality rate, and chronic pain development (Georgiou et al., 2015; Kemp et al., 2019).

Pain and nociception are distinct, but interrelated concepts (Melzack, 1999). Pain is described as an unpleasant sensory and emotional personal experience associated with, or resembling that associated with, actual or potential tissue damage (Raja et al., 2020). Nociception is the neural physiologic process of encoding noxious stimuli (International Association for the Study of Pain IASP, 2020) which may lead to pain. The consequences of encoding noxious stimuli may be manifested through autonomic (e.g., fluctuations in vital signs) and behavioral responses (e.g., facial expressions) (International Association for the Study of Pain IASP, 2020). Thus, they may provide cues for pain assessment when communication ability is impaired.

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Patient self-reporting is the reference standard measure of pain. However, many patients in the ICU are unable to self-report because of their critical condition, which may alter their level of consciousness (LOC) or require mechanical ventilation and sedation (Devlin et al., 2018). In such situations, the "Pain, Agitation, Delirium, Immobility and Sleep disruption (PADIS)" practice guidelines recommend using behavioral scales as alternative pain measures (Devlin et al., 2018)— e.g., the Critical-Care Pain Observational Tool [CPOT] (Gélinas et al., 2006), or the Behavioral Pain Scale [BPS] (Payen et al., 2001). However, behaviors can be masked in heavily sedated patients, those receiving neuromuscular blocking agents, or those suffering from neurologic damages severely affecting their motor system. Therefore, other parameters must be explored for pain assessment. Although vital signs (VS) through continuous ICU monitoring are commonly used by nurses for pain assessment (Damico et al., 2016; Gnass, 2015; Rose et al., 2012), they are not recommended for this purpose (Devlin et al., 2018; Herr et al., 2019). However, no comprehensive review on the psychometric performance of VS for ICU pain assessment is available.

Aim and the Research Question

In this narrative review, we summarized and critically analyzed the literature on the psychometric performance of VS for pain assessment in critically ill adults able or not to self-report in the ICU. The research question was: "What are the reliability and validity of VS for ICU pain assessment in critically ill adults?"

Concept of Validity Testing

We focused on the reliability and validity of VS for the purpose of pain assessment. Reliability is a necessary condition of validity and refers to the consistency of VS values when the pain condition has not changed. Test-retest reliability is a strategy to evaluate whether VS parameters yield the same values over time in similar conditions (Streiner et al., 2015). For example, pre- and post- procedure assessments may lead to similar values in patients with stable conditions. Validity refers to the ability of VS to measure pain (Streiner et al., 2015). Relevant validation strategies of VS for ICU pain assessment include: (1) the ability of VS to discriminate between different conditions, e.g., nociceptive versus non-nociceptive procedures or rest conditions (i.e., discriminative validation); and (2) the association between VS and either patient self-reporting as the reference standard measure of pain, or an alternative behavioral measure of pain in the target population such as CPOT or BPS (i.e., criterion validation) (Streiner et al., 2015). Thus, we examined the test-retest reliability, discriminative, and criterion validation of VS for pain assessment in critically ill adults.

Methods

A narrative review was the best approach as it is designed for answering research questions, which are relevant to clinical practice and are specific but in a broader sense than questions requiring systematic reviews (Baethge et al., 2019; Gregory & Denniss, 2018). Our research question aimed for a comprehensive understanding of the current knowledge on the topic, contrasting opposite findings, and identifying gaps for future research (Gasparyan et al., 2011; Gregory & Denniss, 2018). This narrative review was guided by the Scale for the Assessment of Narrative Review Articles (SANRA) to support quality content (Baethge et al., 2019). More specifically and in accordance with SANRA's recommendations for a high-quality narrative review, we specified our research question, included a comprehensive literature search, and provided evidence tables of relevant findings (Baethge et al., 2019).

Eligibility Criteria

Studies were selected if they: (1) were conducted in adult ICU settings; (2) included participants aged 18 years or older; (3) reported VS as an indicator for pain assessment; and (4) used reliability or validation strategies. Studies were excluded if they were: (1) conference abstracts; (2) editorials; (3) case studies; (4) studies conducted in post-operative units; and (5) studies that reported VS for reasons other than pain assessment (e.g., hemodynamic stability). The studies from the previous PADIS practice guidelines were also included in this updated review. We excluded one study of PADIS (Young et al., 2006) because the values of VS were reported only as percentage; thus, we were unable to include it in our analysis.

Search Strategy

The search strategy was developed by the authors and an experienced health research librarian. We initially searched Medline, Embase, CINAHL, and Cochrane health-related databases from their date of inception to April 6, 2022. We grouped the keywords under three concepts: (1) vital signs; (2) pain assessment; and (3) intensive care unit. Keywords were grouped as follows: (1) concept one: autonomic response, vital signs fluctuations, and each VS alone (i.e., heart rate, respiratory rate, blood pressure, SpO2[oxygen saturation]); (2) concept two: pain measurement/assessment, pain management, pain detection; and (3) concept three: intensive care unit, critical care, intensive care. Boolean operators "AND" and "OR" were used to combine the search terms. Additionally, the reference lists of the included studies were also searched for any further eligible studies. Results of the database searches were downloaded into Endnote X9. The search resulted in 1,359 citations. Duplicates were removed and the remaining (n = 976) citations were exported to the Rayyan software (Ouzzani et al., 2016) for title and abstract screening against the eligibility criteria. The search process narrowed the results to a total of 30 articles, mostly in English but two were in Turkish (Bayrak-kahraman & Özdemir, 2016) and Persian (Nazari et al., 2019). For languages not understood by the authors, Google translator was used, and multilingual colleagues were consulted to help with the translation when necessary.

Summary of Extracted Data

Data on sample characteristics, types of nociceptive and non-nociceptive procedures, reliability and validation strategies, and reference standards were collected from citations and described. The results of VS fluctuations during a nociceptive procedure compared with rest/pre-procedures were reported via calculation of mean change percentage (difference in VS value during nociceptive procedures and rest/pre-procedure X 100). The range of means was reported for each VS separately. The range of Pearson and Spearman's rho correlation coefficients of VS with reference standards (i.e., self-report, behavioral pain scores) were reported and identified as weak (≤.30), moderate (.40-.60), and strong (≥.70) (Akoglu, 2018).

Results

The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram is illustrated in Figure 1 (Moher et al., 2010). A total of 3,469 patients in the ICU were included in 30 studies. Table 1 summarizes characteristics of the study samples, VS that were examined, and types of procedures. Patients were admitted to the ICU with various diagnoses

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Table 1
Characteristics of the Study Samples, VS, and Procedures (n = 30 Studies).

First Author	Year	Country	Sample of ICU patients	LOC	VS	Procedures	
						NOC	N-NOC
Abdelhakeem	2021	Egypt	35 surgical MV Patients	Altered	HR SBP DBP	Repositioning	Rest
Aïssaoui	2005	Morocco	30 medical MV Patients	Altered	HR MBP	Suctioning Peripheral Venous Puncture	Rest
Arbour	2010	Canada	105 cardiac surgery MV patients	Unconscious = 105 Became conscious = 99	HR MBP RR SpO2	Turning +/- other care	Rest & post-procedures
Arbour	2014	Canada	45 TBI MV patients	Unconscious = 8 Altered = 21 Conscious = 16	HR SBP DBP MBP RR SpO2	Turning	NIBP Pre- & post-procedures
Arroyo-Novoa	2008	USA	695 mixed ICU patients (medical-surgical, trauma/burn) (n = 643 MV)	No assessment documented	HR SBP DBP	Suctioning	Rest
Aslanidis	2017	Greece	24 medical - surgical MV Patients	Altered = 7 Unconscious = 17	HR SBP MBP DBP RR	Suctioning	Rest
Ayasrah	2016	Jordan	247 medical - surgical MV Patients	Altered = 214 Unconscious = 33	HR SBP DBP	Repositioning Suctioning Vascular puncture	Pre-procedure Eyecare Mouthcare Central venous Catheter dressing change
Azevedo-Santos	2016	Brazil	15 Neurological (Mainly TBI) MV patients	Unconscious	HR SBP DBP MBP	Suctioning	Rest Eye cleaning
Bayrak-Kahraman[a]	2016	Turkey	40 medical MV patients	Unconscious	HR MBP RR SpO2	NGT insertion Suctioning Arterial catheterization	Rest
Boitor	2016	Canada	125 cardiac surgery patients	Conscious	HR MBP RR SpO2	Mediastinal Tube removal	NIBP Pre- & post-procedures
Boitor	2019	Canada	101 brain-injured patients (n = 54 MV)	Unconscious = 19 Altered = 34 Conscious = 48	HR SBP DBP RR SpO2	Turning	Soft touch Pre- & post-procedures
Chanques	2009	France	30 medical-surgical ICU patients (n = 23 MV)	Conscious	HR MBP RR SpO2	Turning	Rest
Chen	2015	Taiwan	120 medical ICU patients	Conscious = 76 Altered = 44	HR MBP	Suctioning	NIBP Pre- & post-procedures
Cheng	2018	Taiwan	316 medical - surgical MV patients	Conscious = 203 Unconscious = 113	HR MBP RR SpO2	Suctioning	NIBP Pre- & post-procedures
Cho	2021	South Korea	12 brain-injured MV patients	Unconscious = 3 Altered = 6 Conscious = 3	HR MBP SBP DBP RR SpO2	Suctioning Turning Trapezius pinch	NIBP Pre- & post-procedures
Erden	2018	Turkey	120 neurosurgical patients	Conscious = 84 Unconscious = 36	HR MBP RR SpO2	Suctioning Mobilization Turning Wound care	Pre- & post-procedures
Faritous	2016	Iran	70 cardiac MV surgery patients	No assessment documented	HR MBP	Suctioning or Turning	Pre- & post-procedures

(*continued on next page*)

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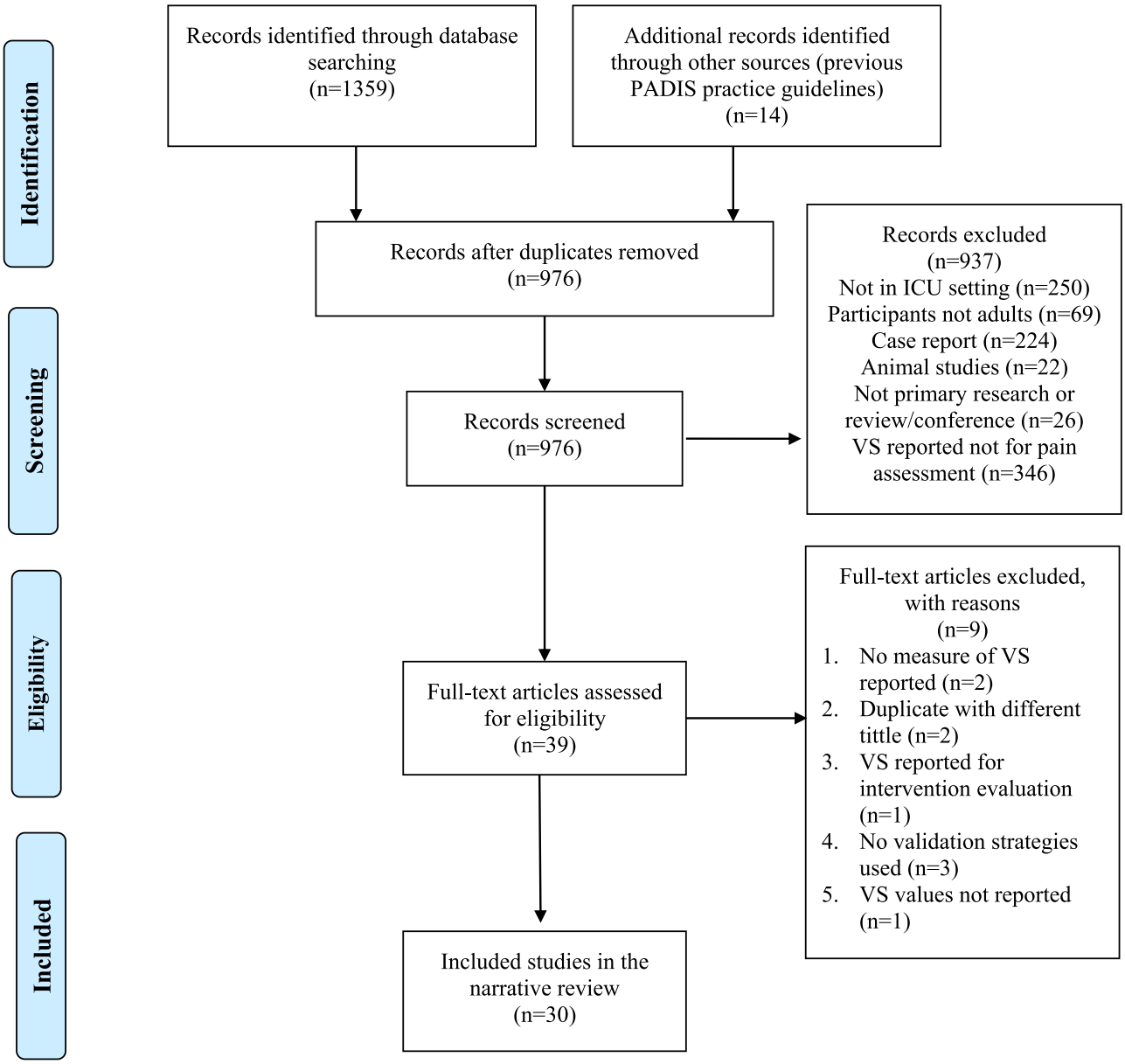

Figure 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses flow diagram.

(75% medical-surgical, 12% cardiac, and 13% brain-injury), and had different LOC (34% conscious, 24% altered LOC, and 42% unconscious).

Pain assessments were performed at rest, pre-procedure, and during procedures in all studies, and 10 to 20 minutes post-procedure in 16 studies. The most common nociceptive procedures were endotracheal/tracheal suctioning (n = 17 studies) and turning/repositioning (n = 18 studies). Non-nociceptive procedures included non-invasive blood pressure using cuff inflation (NIBP) (n = 7 studies), eye care (n = 3 studies), and soft touch (n = 2 studies).

Vital Signs Used for Pain Assessment

Hemodynamic parameters such as heart rate [HR] (n = 30 studies) and blood pressure [BP] (i.e., systolic [SBP], diastolic [DBP], and mean [MBP]) (n = 29 studies) were the most frequent VS used for pain assessment in critically ill adults. Respiratory parameters including respiratory rate [RR] (n = 16 studies) and SpO2 (n = 13 studies) were also assessed in some studies for this purpose (Table 1). All VS were available via ICU monitoring devices.

Reliability and Validity of Vital Signs for ICU Pain Assessment

Reliability and validation strategies used for the evaluation of VS in each study and relevant findings are described in Table 2, 3, and 4. In the following sections, we synthesized the data from included studies to describe test-retest reliability, discriminative validation, and criterion validation results for each VS separately.

Heart rate

Test-retest reliability of HR pre-/post- nociceptive procedures was reported in 16 studies (Table 2). After nociceptive procedures, HR decreased to reach similar values found at pre-procedures;

Table 1 (*continued*)

First Author	Year	Country	Sample of ICU patients	LOC	VS	Procedures	
						NOC	N-NOC
Gélinas	2007	Canada	55 medical-surgical/trauma MV ICU patients	Conscious = 30 Unconscious = 25	HR MBP RR SpO2	Turning	NIBP Pre- & post-procedures
Gélinas	2009	Canada	257 medical-surgical/trauma MV ICU patients	Conscious = 144 Unconscious = 113	HR MBP RR SpO2	Turning combined or not with other care	Pre- & post-procedures
Hasanin	2016	Egypt	87 surgical patients	Altered	HR SBP DBP	Turning	Rest
Ito	2021	Japan	34 cardiac surgery MV patients	Altered	HR SBP RR	Turning	Rest
Kapoustina	2014	Canada	43 brain-injured patients	Conscious	HR SBP DBP MBP RR SpO2	Turning	NIBP Pre- & post-procedures
Khanna	2018	India	60 medical - surgical MV patients	Altered	HR SBP DBP	Suctioning Positioning	Pre- & post-procedures
Latorre Marco	2016	Spain	190 medical - surgical & neurosurgical MV patients	Unconscious	HR SBP DBP RR	Suctioning Turning	Soft touch Pre- & post-procedures
Li	2009	USA	48 cardiac surgery MV patients	Unconscious	HR	Suctioning Turning	Soft touch Pre- procedures
Nazari[b]	2019	Iran	35 TBI MV patients	Unconscious	HR RR SpO2	Nail bed pressure	NIBP Pre- & post-procedures
Payen	2021	France	30 surgical/trauma MV ICU patients	Unconscious	HR MBP	Suctioning Mobilization	Rest Compression stocking applications Central venous catheter dressing changes
Ribeiro	2018	Brazil	27 TBI MV patients	Unconscious	HR SBP DBP	Suctioning	Eye cleaning Rest post-procedure
Siffleet	2007	Australia	61 medical-surgical ICU patients	Conscious	HR SBP DBP	Suctioning Turning Dressing change Drain removal Cough exercise Line removal	Rest
Stotts	2004	USA	412 medical-surgical ICU, cardiac surgery, other units' patients	Conscious	HR SBP DBP	Wound care	Rest

VS = vital signs; ICU = intensive care unit; LOC = level of consciousness; NOC = nociceptive; N-NOC = non-nociceptive; MV = mechanically ventilated; HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; MBP = mean blood pressure; RR = respiratory rate; SpO2 = oxygen saturation; TBI = traumatic brain injury; NIBP = non-invasive blood pressure using cuff inflation; NGT = nasogastric tube.

[a] Published in Turkish.

[b] Published in Persian.

thus, supporting stable values pre- and post-procedures in most studies. However, HR values remained slightly higher (3-4 bpm) or lower (2 bpm) post-procedures in five studies.

Discriminative validation of HR was examined in 30 studies (Table 3). Statistically significant increases from 2% to 26% (range: 2-19 bpm) during nociceptive procedures compared with rest and/or pre-procedures were found in 23 studies. From these, only three studies reported significant increases of greater than 20% (range: 18-22 bpm) during endotracheal suctioning (Azevedo-Santos et al., 2016; Cho & Hong, 2021; Ribeiro et al., 2018). In another study, HR decreased significantly (15% reduction) during nociceptive procedures (e.g., venous puncture) (Ayasrah, 2016). Similar values of HR during nociceptive and non-nociceptive procedures were reported in four studies.

Criterion validation of HR was evaluated using patient self-reporting in nine studies and with the CPOT or BPS in eight studies (Table 4). Eight studies reported absence of or nonsignificant positive weak correlations ($\leq$.30) between HR and self-reported pain intensity during nociceptive procedures. Erden et al. (2018) found a significant positive weak correlation (Spearman's rho = .32) during wound care procedure in 62 neurosurgery ICU patients. Only one study reported a significant positive moderate correlation (Spearman's rho = .69) during turning in 99 cardiac surgery ICU patients (Arbour & Gélinas, 2010). Eight studies reported absence of

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Table 2
Test-Retest Reliability Pre- and Postnociceptive Procedures (n = 16 Studies).

First Author	Year	Nociceptive procedure	HR	SBP	DBP	MBP	RR	SpO2
Arbour	2010	Turning +/- other care	↓[a]			↔	↔	↔
Arbour	2014	Turning	↔			↔	↔	↔
Arroyo-Novoa	2008	Suctioning	↔	↔	↔			
Boitor	2016	Mediastinal Tube Removal	↓[a]			↓[a]	↑[a]	↔
Boitor	2019	Turning	↑[c]	↑[b]	↑[c]		↑[b]	↔
Chen	2015	Suctioning	↔			↔		
Cheng	2018	Suctioning in conscious group	↔			↔	↔	↔
		Suctioning in unconscious group	↔			↔	↔	↔
Cho	2021	Suctioning	↔	↔	↔	↔	↔	↔
		Turning						
		Trapezius pinch						
Erden	2018	Suctioning	↔			↔	↔	↔
		Mobilization	↔			↔	↓[d]	↔
		Turning	↔			↔	↔	↔
		Wound care	↔			↔	↔	↔
Faritous	2016	Suctioning or Turning	↔			↑[a]		
Gélinas	2007	Turning	↑[c]			↔	↔	↔
Gélinas	2009	Turning +/- other care	↔			↔	↔	↔
Kapoustina	2014	Turning	↑[c]	↑[c]	↔	↑[c]	↔	↔
Latorre Marco	2016	Suctioning	↔	↔	↔		↔	
		Turning						
Nazari	2019	Nail bed pressure	↔				↑[a]	↔
Stotts	2004	Wound care	↔	↔	↔			

HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; MBP = mean blood pressure; RR = respiratory rate; SpO2 = oxygen saturation; ↑ = increased; ↓ = decreased; ↔ = no change.
[a] $p \leq .01$.
[b] $p \leq .05$.
[c] Not significant.
[d] $p \leq .001$.

or nonsignificant weak correlations (≤.30) between HR and behavioral pain scores.

Blood pressure

BP consisted of three parameters: SBP (16 studies), DBP (15 studies), and MBP (17 studies). Test-retest reliability of SBP, DBP, and MBP at pre-/post- nociceptive procedures was examined in 15 studies (Table 2). These parameters remained stable at pre-/post-procedures only in 11 studies. Slight increases of up to 5% and decreases of 4% were also reported in BP values post-procedure compared with pre-procedure in four studies.

Discriminative validation of BP parameters was examined in 28 studies (Tables 3). Statistically significant slight increases up to 11% in SBP (range: 3-14 mm Hg), 12% in DBP (range: 5-10 mm Hg), and 13% in MBP (range: 2-10 mm Hg) during nociceptive procedures compared with rest and/or pre-procedures were reported in 18 studies. Significant increases in SBP by 19% and 17%, DBP by 27% and 15%, and MBP by 12% and 17% during nociceptive procedures were found in only two studies with samples of 24 and 12 ICU patients, respectively (Aslanidis et al., 2018; Cho & Hong, 2021). Other studies reported either nonsignificant slight increases (<20%) or no changes in BP parameters during nociceptive procedures.

Criterion validation was evaluated using patient self-reporting of pain in nine studies and the CPOT or BPS in a total of eight studies (Table 4). Eight studies reported absence of or nonsignificant positive weak correlations (≤.30) between BP parameters and self-reported pain intensity during different nociceptive procedures. Only Boitor et al. (2019) reported a moderate positive correlation between SBP (Spearman's rho=.62) and self-reported pain intensity during turning in 24 brain-injured ICU patients. Eight studies reported absence of or nonsignificant positive weak correlations (≤.30) between BP parameters and behavioral pain scores. Only Khanna et al. (2018) reported a significant weak correlation (r = .15) between DBP and the CPOT scores during positioning in 60 sedated medical-surgical ICU patients.

Respiratory rate

Test-retest reliability of RR at pre-/post- nociceptive procedures was examined in 12 studies (Table 2). RR remained stable at pre-/post- nociceptive procedures in most studies. RR was higher (8% increase) or lower (9% decrease) at post-procedures compared with pre-procedures values in four studies (Boitor et al., 2016; Boitor et al., 2019; Erden et al., 2018; Nazari et al., 2019).

Discriminative validation of RR was examined in 16 studies (Table 3). Statistically significant increases from 6% to 30% (range: 1-5 brpm) during nociceptive procedures compared with rest and/or pre-procedures were found in 14 studies. Kapoustina et al. (2014) reported significant RR increases of 75% during turning in 43 brain-injured ICU patients. Only one study reported no changes in RR during suctioning in 36 neurosurgery ICU patients (Erden et al., 2018). In two studies where statistically nonsignificant findings were found, RR increased by 25% (range: 2-4) during suctioning and turning in 34 and 190 mechanically ventilated ICU patients unable to self-report, respectively (Ito et al., 2022; Latorre-Marco et al., 2016).

Criterion validation of RR was evaluated using patient self-reporting of pain in eight studies and the CPOT in one study (Table 4). Absence of or nonsignificant positive weak correlations (≤.30) were found between RR and self-reported pain intensity during nociceptive procedures in eight studies. Spearman's rho correlations of .32 (turning), .36 (wound care), and .53 (mobilization) were found between RR and self-reported pain intensity scores in 84 neurosurgical ICU patients (Erden et al., 2018). No significant correlation was found between RR and CPOT scores in 125 cardiac surgery ICU patients during chest tube removal (Boitor et al., 2016).

Oxygen saturation

Test-retest reliability of SpO2 at pre-/post- nociceptive procedures was examined in 11 studies and showed stable values (Table 2).

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Table 3
Discriminative Validity at Rest/Pre- and During Nociceptive Procedures (n = 30)

First Author	Year	Nociceptive procedure	HR	SBP	DBP	MBP	RR	SpO2
Abdelhakeem	2021	Repositioning	↔	↔	↔			
Aïssaoui	2005	Suctioning	↑[a]			↑[a]		
		Venous puncture						
Arbour	2010	Turning +/- other care	↑[b]			↑[b]	↑[c]	↔
Arbour	2014	Turning	↔	↔	↑[d]	↑[d]	↑[a]	↔
Arroyo-Novoa	2008	Suctioning	↑[b]	↑[b]	↑[b]			
Aslanidis	2017	Suctioning in RSS = 2-4 group	↑[d]	↑[c]	↑[c]	↑[d]	↑[d]	
		Suctioning in RSS = 5-6 group	↑[c]	↑[a]	↑[b]	↑[c]	↑[c]	
Ayasrah	2016	Repositioning	↑[a]	↑[a]	↑[b]			
		Suctioning	↑[a]	↑[a]	↑[a]			
		Vascular puncture	↓[a]	↓[a]	↔			
Azevedo-Santos	2016	Suctioning	↑[a]	↑[d]	↑[d]	↑[d]		
Bayrak-Kahraman	2016	NGT	↑[a]			↑[b]	↑[a]	↓[d]
		Suctioning	↑[a]			↑[a]	↑[a]	↔
		Arterial catheterization	↑[a]			↑[a]	↑[a]	↔
Boitor	2016	Mediastinal Tube Removal	↑[b]			↔	↑[b]	↔
Boitor	2019	Turning	↑[c]	↑[c]	↔		↑[c]	↔
Chanques	2009	Turning	↑[c]			↑[d]	↑[c]	↔
Chen	2015	Suctioning	↑[a]			↑[a]		
Cheng	2018	Suctioning in conscious group	↑[b]			↑[b]	↑[b]	↓[b]
		Suctioning in unconscious group	↑[b]			↑[b]	↑[b]	↓[b]
Cho	2021	Suctioning	↑[a]	↑[a]	↑[a]	↑[a]	↑[a]	↔
		Turning						
		Trapezius pinch						
Erden	2018	Suctioning	↑[b]			↑[d]	↔	↓[c]
		Mobilization	↑[a]			↑[d]	↑[a]	↓[d]
		Turning	↑[a]			↑[d]	↑[a]	↔
		Wound care	↑[a]			↑[d]	↑[a]	↓[d]
Faritous	2016	Suctioning or Turning	↔			↑[b]		
Gélinas	2007	Turning	↑[a]			↑[a]	↑[a]	↓[a]
Gélinas	2009	Turning +/- other care	↑[d]			↑[c]	↑[a]	↔
Ito	2021	Turning	↑[e]	↑[e]			↑[e]	
Kapoustina	2014	Turning	↑[a]	↔	↔	↑[d]	↑[a]	↔
Hasanin	2016	Suctioning	↑[c]	↑[c]	↑[d]			
		Positioning						
Khanna	2018	Suctioning	↑[a]	↑[a]	↑[a]			
		Positioning	↑[d]	↑[a]	↑[a]			
Latorre Marco	2016	Suctioning and turning	↑[e]	↑[e]	↑[e]		↑[e]	
Li	2009	Suctioning	↑[c]					
		Turning						
Nazari	2019	Nail bed pressure	↑[a]				↑[b]	↔
Payen	2001	Suctioning	↑[c]			↑[c]		
		Mobilization						
Ribeiro	2018	Suctioning	↑[b]	↑[d]	↑[d]			
Siffleet	2007	Suctioning	↑[d]	↑[d]	↑[d]			
		Turning	↑[d]	↑[d]	↑[d]			
		Dressing change	↑[d]	↔	↔			
		Drain removal	↑[d]	↑[d]	↔			
		Cough exercise	↑[d]	↑[d]	↔			
		Line removal	↔	↔	↔			
Stott	2004	Wound care	↑[b]	↑[b]	↔			

HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; MBP = mean blood pressure; RR = respiratory rate; SpO2 = oxygen saturation; RSS = Ramsay Sedation Scale; NGT = nasogastric tube; ↑ = increased; ↓ = decreased; ↔ = no change.
[a] $p \leq .001$.
[b] $p \leq .01$.
[c] $p \leq .05$.
[d] Not significant.
[e] p value not reported.

Discriminative validation of SpO2 was examined in 13 studies (Table 3). Statistically significant decreases of 2% (range: 1-2% in oxygen saturation value) during nociceptive procedures compared with rest and/or pre-procedures were reported in only three studies (Cheng et al., 2018; Erden et al., 2018; Gélinas & Johnston, 2007). No changes or statistically nonsignificant findings were found in 12 studies. Contrarily, one study found that SpO2 decreased more than 2% during NIBP procedure, but it did not change during turning procedure in 43 brain-injured patients (Kapoustina et al., 2014).

Criterion validation of SPO2 was evaluated using patient self-reporting of pain in eight studies and the CPOT in one study (Table 4). Seven studies reported absence of or nonsignificant positive weak correlations (≤.30) between RR and self-reported pain intensity during nociceptive procedures. A negative weak correlation of RR with self-reported pain intensity (r = -.20) during turning in 43 brain-injured ICU patients was found in one study (Arbour & Gélinas, 2010). No significant correlation was found between SpO2 and CPOT scores in 125 cardiac surgery ICU patients during chest tube removal (Boitor et al., 2016).

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Table 4
Criterion Validity During Nociceptive Procedures (n = 16).

First Author	Year	Reference Standard	Nociceptive procedures	HR	SBP	DBP	MBP	RR	SpO2
Abdelhakeem	2021	BPS	Repositioning	r = ∅	r = ∅	r = ∅			
Aïssaoui	2005	BPS	Suctioning Peripheral Venous Puncture	ρ = 0.16[a]			ρ = - 0.02[a]		
Arbour	2010	0-10 FPT	Turning +/- other care	r = 0.69[b]			r = - 0.09[NS]	r = 0.03[NS]	r = - 0.2[c]
Arbour	2014	0-10 FTP Presence of pain (Yes/No)	Turning	r = ∅ r_{pb} = 0.679[c]	r = ∅	r = ∅	r = ∅	r = ∅ r_{pb} = 0.736[c]	r = ∅
Azevedo-Santos	2016	BPS	Suctioning	r = NS	r = NS	r = NS	r = NS		
Boitor	2016	0-10 NRS	Mediastinal Tube	r = NS			r = NS	r = NS	r = NS
		CPOT	Removal	r = NS			r = NS	r = NS	r = NS
Boitor	2019	0-10 NRS	Turning	r = 0.255[a]	r = 0.617[d]	r = 0.316[a]		r = 0.281[a]	r = 0.262[a]
Chen	2015	0-10 NRS	Suctioning	ρ = 0.12[a]			ρ = 0.01[a]		
Cheng	2018	Presence of pain (Yes/No)	Suctioning	β = ∅			β = ∅	β = ∅	β = ∅
Erden	2018	0-10 NRS	Suctioning	r = 0.274[a]			r = 0.305[a]	r = 0.106[a]	r = 0.216[a]
			Mobilization	r = 0.218[a]			r = 0.056[a]	r = 0.532[d]	r = 0.102[a]
			Turning	r = 0.184[a]			r = - 0.119[a]	r = 0.316[d]	r = 0.204[a]
			Wound care	r = 0.317[c]			r = - 0.061[a]	r = 0.358[c]	r = 0.102[a]
Faritous	2016	CPOT	Suctioning or Turning	r = - 0.190[a]			r = 0.211[a]		
Gélinas	2007	0-10 FPT	Turning	r = NS			r = NS	r = NS	r = NS
Kapoustina	2014	0-10 FPT	Turning	r = ∅	r = ∅	r = ∅	r = ∅	r = ∅	r = ∅
Khanna	2018	CPOT	Suctioning	r = 0.058[a]	r = 0.014[a]	r = 0.124[a]			
			Positioning	r = 0.014[a]	r = 0.068[a]	r = 0.154[c]			
Payen	2001	BPS	Suctioning Mobilization	r = ∅			r = ∅		
Ribeiro	2018	BPS	Suctioning	r = - 0.16[a]	r = 0.14[a]	r = 0.26[a]			

HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; MBP = mean blood pressure; RR = respiratory rate; SpO2 = oxygen saturation; BPS = Behavioral Pain Scale; FPT = Faces Pain Thermometer; NS = not significant; NRS = Numeric Rating Scale; CPOT = Critical-Care Pain Observational Tool; ∅ = no correlation.
[a] Not significant.
[b] $p \leq 0.001$.
[c] $p \leq .05$.
[d] $p \leq .01$.

Discussion

This is the first narrative review to comprehensively report the validity of VS for pain assessment in adult ICU patients during 20 years of research. Overall, 30 studies from 17 countries across six continents were included. The most common VS used for ICU pain assessment were HR and BP. Most VS showed stable values at pre- and post- procedures, demonstrating test-retest reliability. Discriminative validation of all VS was supported in most studies but did not reach clinical significance for most. Moreover, criterion validation of VS using reference standards was not supported for ICU pain assessment.

Discriminative changes of VS in response to nociceptive procedures may be triggered by different mechanisms. Many ICU standard care procedures are noxious stimuli and may trigger not only the nociception process but also the biologic stress response. This leads to the release of catecholamines including norepinephrine from the terminals of sympathetic nerves and epinephrine from the adrenal cortex (McCance & Huether, 2018). The immediate effects of catecholamines are manifested through increases in VS including HR (chronotropic effect of epinephrine on cardiac activation), BP (peripheral vasoconstriction caused by norepinephrine), and RR (caused by binding of epinephrine to beta receptors) (McCance & Huether, 2018). The synapses of nociceptors with muscle fibers throughout the spinal cord may result in muscle rigidity and decreased diaphragmic excursion (Carr & Goudas, 1999); therefore, hypoxemia (i.e., decrease in blood oxygen saturation) may be detected by decreases in SpO2. Therefore, VS values may change in response to nociceptive procedures as was demonstrated in many included studies of this review. If enough time post-procedure (15-20 minutes) is given to allow elimination of catecholamines (i.e., epinephrine and norepinephrine) (Widmaier et al., 2016), then the VS values should be similar to their pre-procedure values, which was demonstrated as test-retest reliability in some studies.

Despite statistically significant changes of VS during some nociceptive ICU procedures, their clinical significance is negligible. Clinically significant changes are of paramount importance to guide clinical practice (Polit, 2017). One approach for establishing clinical significance refers to the interpretation of change scores into meaningful clinical data perceived as effective and beneficial (Polit, 2017). ICU experts deem a change in VS values by more than 20% as clinically significant for pain assessment (Devlin et al., 2018; Gélinas, 2016). Only a small number of studies have shown clinically significant changes in some VS values during nociceptive procedures. For example, HR increased more than 25% only in three of 23 studies, but it also remained unchanged in seven studies. No clinically significant changes were reported for BP parameter in 28 studies. RR has shown clinically significant increases of more than 25% during nociceptive procedures in five of 14 studies. Yet, attention should be given to conditions that hinder respiratory function (i.e., opioid-induced respiratory depression or controlled ventilation assistance alter the RR). A systematic review highlighted that pain may influence respiration by increasing RR

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and volume; nonetheless, hyperventilation may also reflect the aversive feelings related to pain and fear (Jafari et al., 2017). Similar to other VS, increases in RR are not specific to pain. Indeed, pain, fear, and anxiety may coexist, which emphasizes the importance of using assessment tools that are more sensitive and specific to pain (Gélinas et al., 2014). Although the clinical significance for SpO2 has not been specified, it was the weakest parameter in responding to nociceptive procedures as its changes were negligible or absent. In summary, our results did not support discriminative validation of VS for ICU pain assessment due to inconsistency in clinically significant changes and frangibility of these parameters to other clinical conditions (e.g., shock, hypovolemia, arrythmias), treatments, and medications (e.g., beta-blockers, vasopressors) (Herr et al., 2019). Moreover, VS changes may be inaccurate pain indicators in critically ill adults suffering from chronic pain conditions (Herr et al., 2019; Sacco et al., 2013).

Lack of correlation between VS and pain reference standards hinders criterion validation of their use for ICU pain assessment. Similar findings were demonstrated in other contexts of care such as emergency and pre-hospital care, where weak correlations between VS and self-reported pain were not considered to be clinically significant for pain assessment (Block et al., 2017; Lord & Woollard, 2011). The lack of correlation of VS with the reference standard measures of pain (i.e., self-reporting, behavioral scales) represents a major limitation. Therefore, absence of criterion validation of VS to pain compromises their use for ICU pain assessment.

Pain assessment remains challenging in patients in the ICU unable to self-report. To date, no reliable and valid physiologic parameters have been identified for ICU pain assessment. Future studies are required to explore new technologies that are developed for the purpose of nociception and pain monitoring. Some studies have shown that the simultaneous combination of multiple physiologic parameters through AI algorithms may be superior to individual parameters (e.g., HR and BP) for the monitoring of nociception and related pain in anesthetized adults (Ben-Israel et al., 2013; Edry et al., 2016; Martini et al., 2015; Renaud-Roy et al., 2019; Stockle et al., 2018). The Nociception Level Index (NOL^{TM}) is the only multi-parameter physiological technology that incorporates several VS in its algorithm to estimate the level of nociception and related pain (Ben-Israel et al., 2013). The NOL has been pilot tested for ICU pain assessment (Gélinas et al., 2021; Shahiri et al., 2020) but future studies are required to further validate its use in the ICU context.

Limitations

Narrative reviews are often subjected to selection bias. To mitigate this issue, we uniformly applied our eligibility criteria. Although we used a comprehensive list of keywords and a systematic search strategy in four databases, it is likely that some relevant studies might have been missed. Nevertheless, we illustrated our search strategy, structured, and analyzed studies with similar findings (Gasparyan et al., 2011). Also, we used the SANRA as a guiding framework in this narrative review.

Some limitations must be highlighted. First, the non-invasive blood pressure cuff inflation has been considered as a non-nociceptive procedure in primary studies included in this review. However, attention should be paid to chronic pain etiologies such as allodynia and fibromyalgia. With the presence of these conditions, the cuff inflation could have caused significant pain. Yet, this information was not available in included studies. Pain resulting from chronic pain conditions should be explored in future research. A second limitation relates to the heterogeneity of samples across studies e.g., different LOC and diagnostic categories. Nonetheless, our analysis of reliability and validity findings were consistent across studies. A third and last limitation, we did not extract data on the administration of analgesics before procedures which could have influenced VS. It is worth mentioning that this information was reported in only a few studies included in this review. Moreover, an optimal strategy to examine the influence of analgesia on VS would be to compare their fluctuations pre- and post-analgesic administration. However, such a strategy was not commonly examined in included studies. This objective could be explored in future research.

Conclusion

Consistent with clinical recommendations and practice guidelines (Devlin et al., 2018; Herr et al., 2019), findings of our narrative review suggest that VS available through continuous ICU monitoring devices lack reliability and validity for ICU pain assessment. Even though VS values fluctuate during nociceptive ICU procedures, their changes are often not clinically significant. Moreover, criterion validation of individual VS was not supported for ICU pain assessment due to lack of correlations with reference standards (i.e., the patient's self-report of pain intensity, behavioral pain measures: CPOT or BPS). To conclude, ICU nurses should only use VS as cues to begin further pain assessment using valid methods such as the patient's self-report of pain whenever possible, or behavioral pain measures. For a comprehensive list of valid pain assessment tools, readers can refer to Devlin et al. (2018) and Herr et al. (2019). Alternative physiologic measures are urgently needed to guide pain detection in critically ill adults in whom none of the reference standard pain methods can be used.

References

Abdelhakeem, A. K., Amin, A., Hasanin, A., Mukhtar, A., Eladawy, A., & Kassem, S. (2021). Validity of pulse oximetry-derived peripheral perfusion index in pain assessment in critically ill intubated patients. *Clinical Journal of Pain, 37*(12), 904–907.

Aïssaoui, Y. s., Zeggwagh, A. A., Zekraoui, A. c., Abidi, K., & Abouqal, R. (2005). Validation of a behavioral pain scale in critically ill, sedated, and mechanically ventilated patients. *Anesthesia and Analgesia, 101*(5), 1470–1476.

Akoglu, H. (2018). User's guide to correlation coefficients. *Turkish Journal of Emergency Medicine, 18*(3), 91–93.

Arbour, C., & Gélinas, C. (2010). Are vital signs valid indicators for the assessment of pain in postoperative cardiac surgery ICU adults? *Intensive & Critical Care Nursing, 26*(2), 83–90.

Arbour, C., Choinière, M., Topolovec-Vranic, J., Loiselle, C. G., & Gélinas, C. l. (2014). Can fluctuations in vital signs be used for pain sssessment in critically ill patients with a traumatic brain injury? *Pain Research and Treatment*. Advance online publication https://www.hindawi.com/journals/prt/2014/175794/ .

Aslanidis, T., Grosomanidis, V., Karakoulas, K., & Chatzisotiriou, A. (2018). Electrodermal activity monitoring during endotracheal suction in sedated adult intensive care unit patients. *Folia Medica (Plovdiv), 60*(1), 92–101.

Ayasrah, S. (2016). Care-related pain in critically ill mechanically ventilated patients. *Anaesthesia and Intensive Care, 44*(4), 458–465.

Azevedo-Santos, I. F., Alves, I. G. N., Badauê-Passos, D., Santana-Filho, V. J., & De-Santana, J. M. (2016). Psychometric analysis of behavioral pain scale brazilian version in sedated and mechanically ventilated adult patients: A preliminary study. *Pain Practice, 16*(4), 451–458.

Baethge, C., Goldbeck-Wood, S., & Mertens, S. (2019). Sarna-a scale for the quality assessment of narrative review articles. *Research Integrity and Peer Review, 4*, 5.

Bayrak-kahraman, B., & Özdemir, L. (2016). Yoğun bakım hastalarının invaziv girişimler sırasındaki davranışsal ve fizyolojik ağrı göstergelerinin değerlendirilmesi. *Turkish Journal of Research & Development in Nursing, 18*(2/3), 13–21.

Ben-Israel, N., Kliger, M., Zuckerman, G., Katz, Y., & Edry, R. (2013). Monitoring the nociception level: A multi-parameter approach. *Journal of Clinical Monitoring & Computing, 27*(6), 659–668.

Block, P. R., Thorn, B. E., Kapoor, S., & White, J. (2017). Pain catastrophizing, rather than vital signs, associated with pain intensity in patients presenting to the emergency department for pain. *Pain Management Nursing, 18*(2), 102–109.

Boitor, M., Fiola, J. L., & Gélinas, C. (2016). Validation of the critical-care pain observation tool and vital signs in relation to the sensory and affective components of pain during mediastinal tube removal in postoperative cardiac surgery intensive care unit adults. *Journal of Cardiovascular Nursing, 31*(5), 425–432.

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Boitor, M., Richard-Lalonde, M., Bérubé, M., Émilie, G., & Gélinas, C. (2019). Vital signs fluctuations and their relationship with pain in the brain-injured adult critically ill - a repeated-measures descriptive-correlational study. *Intensive & Critical Care Nursing, 55*, Article 102743.

Carr, D. B., & Goudas, L. C. (1999). Acute pain. *Lancet, 353*(9169), 2051–2058.

Chen, H. J., & Chen, Y. M. (2015). Pain assessment: Validation of the physiologic indicators in the ventilated adult patient. *Pain Management, 16*(2), 105–111.

Cheng, L.-H., Tsai, Y.-F., Wang, C.-H., & Tsay, P.-K. (2018). Validation of two Chinese-version pain observation tools in conscious and unconscious critically ill patients. *Intensive & Critical Care Nursing, 44*, 115–122.

Cho, Y., & Hong, G. R. S. (2021). Behavioral and physiological pain responses in brain-injured patients who are unable to communicate in the intensive care unit. *Pain Management Nursing, 22*(1), 80–85.

Damico, V., Tonella, S., Murano, L., & Coppadoro, A. (2016). Strumenti e metodi di accertamento del dolore in terapia intensiva: Indagine in 173 unità italiane. *Pain Nursing Magazine -Italian Online Journal, 5*, 29–34. https://doi.org/10.19190/PNM2016.1ao29.

Devlin, J. W., Skrobik, Y., Gélinas, C. I., Needham, D. M., Slooter, A. J. C., Pandharipande, P. P., Watson, P. L., Weinhouse, G. L., Nunnally, M. E., Rochwerg, B., Balas, M. C., van den Boogaard, M., Bosma, K. J., Brummel, N. E., Chanques, G., Denehy, L., Drouot, X., Fraser, G. L., Harris, J. E., Joffe, A. M., Kho, M. E., Kress, J. P., Lanphere, J. A., McKinley, S., Neufeld, K. J., Pisani, M. A., Payen, J.-F., Pun, B. T., Puntillo, K. A., Riker, R. R., Robinson, B. R. H., Shehabi, Y., Szumita, P. M., Winkelman, C., Centofanti, J. E., Price, C., Nikayin, S., Misak, C. J., Flood, P. D., Kiedrowski, K., & Alhazzani, W. (2018). Clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. *Critical Care Medicine, 46*(9), e825–e873.

Edry, R., Recea, V., Dikust, Y., & Sessler, D. I. (2016). Preliminary intraoperative validation of the nociception level index: A noninvasive nociception monitor. *Anesthesiology, 125*(1), 193–203.

Erden, S., Demir, N., Ugras, G. A., Arslan, U., & Arslan, S. (2018). Vital signs: Valid indicators to assess pain in intensive care unit patients? An observational, descriptive study. *Nursing & Health Sciences, 20*(4), 502–508.

Gasparyan, A. Y., Ayvazyan, L., Blackmore, H., & Kitas, G. D. (2011). Writing a narrative biomedical review: Considerations for authors, peer reviewers. *Rheumatology International, 31*(11), 1409–1417.

Gélinas, C. (2016). Pain assessment in the critically ill adult: Recent evidence and new trends. *Intensive & Critical Care Nursing, 34*, 1–11.

Gélinas, C., Chanques, G., & Puntillo, K. (2014). In pursuit of pain: Recent advances and future directions in pain assessment in the ICU. *Intensive Care Med, 40*(7), 1009–1014.

Gélinas, C., Fillion, L., Puntillo, K. A., Viens, C., & Fortier, M. (2006). Validation of the critical-care pain observation tool in adult patients. *American Journal of Critical Care, 15*(4), 420–427.

Gélinas, C., & Johnston, C. (2007). Pain assessment in the critically ill ventilated adult: Validation of the critical-care pain observation tool and physiologic indicators. *Clinical Journal of Pain, 23*(6), 497–505.

Gélinas, C., & Arbour, C. (2009). Behavioral and physiologic indicators during a nociceptive procedure in conscious and unconscious mechanically ventilated adults: Similar or different? *Journal of Critical Care, 24*(4), 628 e627-617.

Gélinas, C., Shahiri, T. S., Richard-Lalonde, M., Laporta, D., Morin, J. F., Boitor, M., Ferland, C. E., Bourgault, P., & Richebé, P. (2021). Exploration of a multi-parameter technology for pain assessment in postoperative patients after cardiac surgery in the intensive care unit: The nociception level index (NOL)™. *Journal of Pain Research, 14*, 3723–3731.

Georgiou, E., Hadjibalassi, M., Lambrinou, E., Andreou, P., & Papathanassoglou, E. D. (2015). The impact of pain assessment on critically ill patients' outcomes: a systematic review. *BioMed Research International, 2015*, Article 503830 (2015).

Gnass, I. (2015). Die Schmerzeinschätzung - beobachtet im Intensivbereich. *Pflege & Gesellschaft, 04*, 348–361.

Gregory, A. T., & Denniss, A. R. (2018). An introduction to writing aarrative and systematic reviews - Tasks, tips and traps for aspiring authors. Heart, Lung & Circulation, *27*(7), 893–898.

Hasanin, A., Mohamed, S. A. R., & El-Adawy, A. (2017). Evaluation of perfusion index as a tool for pain assessment in critically ill patients. *Journal of Clinical Monitoring & Computing, 31*(5), 961–965.

Herr, K., Coyne, P. J., Ely, E., Gélinas, C., & Manworren, R. C. B. (2019). Pain assessment in the patient unable to self-report: Clinical practice recommendations in support of the ASPMN 2019 position statement. *Pain Management Nursing, 20*(5), 404–417.

Ito, Y., Teruya, K., & Nakajima, E. (2022). Evaluation of pain severity in critically ill patients on mechanical ventilation. *Intensive & Critical Care Nursing, 68*, Article 103118.

Jafari, H., Courtois, I., Van den Bergh, O., Vlaeyen, J. W. S., & Van Diest, I. (2017). Pain and respiration: A systematic review. *Pain, 158*(6), 995–1006.

Kapoustina, O., Echegaray-Benites, C., & Gelinas, C. (2014). Fluctuations in vital signs and behavioural responses of brain surgery patients in the intensive care unit: Are they valid indicators of pain? *Journal of Advanced Nursing, 70*(11), 2562–2576.

Kemp, H. I., Laycock, H., Costello, A., & Brett, S. J. (2019). Chronic pain in critical care survivors: A narrative review. *British Journal of Anaesthesia, 123*(2), e372–e384.

Khanna, P., Pandey, R. K., Chandralekha, C., Sharma, A., & Pangasa, N. (2018). Comparison between critical-care pain observation tool and physiologic indicators for pain assessment in the critically ill, mechanically ventilated adult patients. *Saudi Journal of Anaesthesia, 12*(3), 384–388.

Latorre-Marco, I., Acevedo-Nuevo, M., Solis-Munoz, M., Hernandez-Sanchez, L., Lopez-Lopez, C., Sanchez-Sanchez, M. M., Wojtysiak-Wojcicka, M., de Las Pozas-Abril, J., Robleda-Font, G., Frade-Mera, M. J., De Blas-Garcia, R., Gorgolas-Ortiz, C., De la Figuera-Bayon, J., & Cavia-Garcia, C. (2016). Psychometric validation of the behavioral indicators of pain scale for the assessment of pain in mechanically ventilated and unable to self-report critical care patients. *Medicina Intensiva, 40*(8), 463–473.

Li, D., Miaskowski, C., Burkhardt, D., & Puntillo, K. (2009). Evaluations of physiologic reactivity and reflexive behaviors during noxious procedures in sedated critically ill patients. *Journal of Critical Care, 24*(3), 472 e479-e413.

Lord, B., & Woollard, M. (2011). The reliability of vital signs in estimating pain severity among adult patients treated by paramedics. *Emergency Medicine Journal, 28*(2), 147–150.

Martini, C. H., Boon, M., Broens, S. J., Hekkelman, E. F., Oudhoff, L. A., Buddeke, A. W., & Dahan, A. (2015). Ability of the nociception level, a multiparameter composite of autonomic signals, to detect noxious stimuli during propofol-remifentanil anesthesia. *Anesthesiology, 123*(3), 524–534.

McCance, K. L., & Huether, S. E. (2018). *Pathophysiology-E-book: The biologic basis for disease in adults and children* (8th ed.). New York: Elsevier Health Sciences.

Melzack, R (1999). Pain and stress: A new perspective. In R. J. Gatchel, & D. C. Turk (Eds.), *Psychosocial factors in pain: Critical perspectives* (pp. 89–106). New York: Guilford Press.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Group, P. (2010). Preferred reporting items for systematic reviews and meta-analyses: The prisma statement. *International Journal of Surgery (London, England), 8*(5), 336–341.

Nazari, R., Nia, H. S., Sharif, S. P., Rahimi, A., Jamali, S., & Vahedparast, H. (2019). Effect of nociceptive stimulation on heart rate, respiratory rate and spo2 in patients with traumatic brain injury. *Journal of Mazandaran University of Medical Sciences, 28*(169), 75–82.

Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan—a web and mobile app for systematic reviews. *Systematic Reviews, 5*(1), 1–10.

Payen, J. F., Bru, O., Bosson, J. L., Lagrasta, A., Novel, E., Deschaux, I., Lavagne, P., & Jacquot, C. (2001). Assessing pain in critically ill sedated patients by using a behavioral pain scale. *Critical Care Medicine, 29*(12), 2258–2263.

Polit, D. F. (2017). Clinical significance in nursing research: A discussion and descriptive analysis. *International Journal of Nursing Studies, 73*, 17–23.

Puntillo, K. A., Max, A., Timsit, J. F., Vignoud, L., Chanques, G., Robleda, G., Roche-Campo, F., Mancebo, J., Divatia, J. V., Soares, M., Ionescu, D. C., Grintescu, I. M., Vasiliu, I. L., Maggiore, S. M., Rusinova, K., Owczuk, R., Egerod, I., Papathanassoglou, E. D., Kyranou, M., Joynt, G. M., Burghi, G., Freebairn, R. C., Ho, K. M., Kaarlola, A., Gerritsen, R. T., Kesecioglu, J., Sulaj, M. M., Norrenberg, M., Benoit, D. D., Seha, M. S., Hennein, A., Periera, F. J., Benbenishty, J. S., Abroug, F., Aquilina, A., Monte, J. R., An, Y., & Azoulay, E. (2014). Determinants of procedural pain intensity in the intensive care unit. the europain(r) study. *American Journal of Respiratory and Critical Care Medicine, 189*(1), 39–47.

Raja, S. N., Carr, D. B., Cohen, M., Finnerup, N. B., Flor, H., Gibson, S., Keefe, F. J., Mogil, J. S., Ringkamp, M., Sluka, K. A., Song, X. J., Stevens, B., Sullivan, M. D., Tutelman, P. R., Ushida, T., & Vader, K. (2020). The revised international association for the study of pain definition of pain: concepts, challenges, and compromises. *Pain, 161*(9), 1976–1982.

Renaud-Roy, E., Stockle, P. A., Maximos, S., Brulotte, V., Sideris, L., Dube, P., Drolet, P., Tanoubi, I., Issa, R., Verdonck, O., Fortier, L. P., & Richebe, P. (2019). Correlation between incremental remifentanil doses and the Nociception Level (NOL) index response after intraoperative noxious stimuli. *Canadian Journal of Anaesthesia, 66*(9), 1049–1061.

Ribeiro, C. J. N., Araujo, A. C. S., Brito, S. B., Dantas, D. V., Nunes, M. D. S., Alves, J. A. B., & Ribeiro, M. (2018). Pain assessment of traumatic brain injury victims using the brazilian version of the behavioral pain scale. *Revista Brasileira de Terapia Intensiva, 30*(1), 42–49.

Rose, L., Smith, O., Gelinas, C., Haslam, L., Dale, C., Luk, E., Burry, L., McGillion, M., Mehta, S., & Watt-Watson, J. (2012). Critical care nurses' pain assessment and management practices: A survey in canada. *American Journal of Critical Care, 21*(4), 251–259.

Sacco, M., Meschi, M., Regolisti, G., Detrenis, S., Bianchi, L., Bertorelli, M., Pioli, S., Magnano, A., Spagnoli, F., Giuri, P. G., Fiaccadori, E., & Caiazza, A. (2013). The relationship between blood pressure and pain. *Journal of Clinical Hypertension, 15*(8), 600–605.

Shahiri, T. S., Richard-Lalonde, M., Richebe, P., & Gelinas, C. (2020). Exploration of the nociception Level (NOL) index for pain assessment during endotracheal suctioning in mechanically ventilated patients in the intensive care unit: An observational and feasibility study. *Pain Management Nursing, 21*(5), 428–434.

Siffleet, J., Young, J., Nikoletti, S., & Shaw, T. (2007). Patients' self-report of procedural pain in the intensive care unit. *Journal of Clinical Nursing, 16*(11), 2142–2148.

Stockle, P. A., Julien, M., Issa, R., Decary, E., Brulotte, V., Drolet, P., Henri, M., Poirier, M., Latulippe, J. F., Dorais, M., Verdonck, O., Fortier, L. P., & Richebe, P. (2018). Validation of the PMD100 and its NOL index to detect nociception at different infusion regimen of remifentanil in patients under general anesthesia. *Minerva Anestesiologica, 84*(10), 1160–1168.

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Stotts, N. A., Puntillo, K., Bonham Morris, A., Stanik-Hutt, J., Thompson, C. L., White, C., & Reitman Wild, L. (2004). Wound care pain in hospitalized adult patients. *Heart and Lung, 33*(5), 321–332.

Streiner, D. L., Norman, G. R., & Cairney, J. (2015). *Health measurement scales : a practical guide to their development and use (Fifth)*. Oxford University Press.

Widmaier, E. P., Raff, H., Strang, K. T., & Vander, A. J. (2016). *Vander's human physiology : the mechanisms of body function (Fourteenth)*. McGraw-Hill.

Young, J., Siffleet, J., Nikoletti, S., & Shaw, T. (2006). Use of a behavioural pain scale to assess pain in ventilated, unconscious and/or sedated patients. *Intensive & Critical Care Nursing, 22*(1), 32–39.

International Association for the Study of Pain (IASP). (2020). Pain terms: A list with definitions and notes on usage. Retrieved April 16, 2022, from https://www.iasp-pain.org/resources/terminology/.

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