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Implementation of a pain management algorithm in intensive care units and evaluation of nurses' level of adherence with the algorithm

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Introduction

Despite extensive research about pain and pain management, many patients in intensive care units (ICU) report a significant amount of pain.[1, 2] Pain should be assessed routinely and repetitively,[3] but this assessment is not always done.[4] Valid pain assessment tools are available and recommended,[3] but a substantial proportion of ICU nurses do not use them in their clinical practice.[5] Reasons for not using these valid pain assessment tools include nurses' knowledge deficits, misconceptions about pain assessment, and resistance to use valid tools.[6-8] In addition, in a survey of critical care nurses, increased workload hemodynamic instability, and patients' inability to communicate were the barriers considered to interfere with pain assessment and management most frequently.[9] In addition, system factors like the learning culture of an ICU[10] may pose additional barriers.

Evidence-based algorithms can be used to improve pain management in clinical practice.[11] However, only one pain management algorithm for ICU patients, that included both pain assessment and management, was found (i.e., Pain Assessment and Intervention Notation (PAIN) algorithm[12]). While this algorithm was developed in the 1990's using the best available evidence, it was tested only in patients who could self-report pain. In addition, only 31 patients were included in their study and the nurses who used the algorithm reported that it was too long and too complex.

Therefore, for the purposes of the current study,[13] a shorter, evidence-based pain management algorithm was developed. In brief, the algorithm guided ICU nurses to assess patients' pain during their ICU stay, at least once a shift and both at rest and during turning[14] using valid pain assessment tools. A numeric rating scale (NRS) was used when patients could self-report pain.[15] The Behavioral Pain Scale (BPS) was used when patients received mechanical ventilation and were unable to self-report pain.[16] The Behavioral Pain Scale-Non Intubated (BPS-NI) was used in non-intubated patients who were unable to self-report pain.[17] Pain treatment actions were chosen based on cut-points that defined a pain event. A NRS score of >3,[3, 18, 19] a BPS-score of >5,[3, 16, 19] or a BPS-NI score of >5[17] were defined as a pain event. If the pain intensity score was higher than the pre-specified cut-point (i.e., a pain event), the nurses were guided to consider increasing pain treatment. If the pain intensity score was less than the cut-point (i.e., not a pain event), the nurses were guided to consider either decreasing or continuing pain treatment. Pain treatments included analgesics within each patient's prescription or non-pharmacologic interventions such as changing the patient's position.

A wide range of factors (e.g., nurses' level of knowledge, misconceptions about pain assessment and resistance to use valid tools, increased nursing workload, hemodynamically unstable patients, patients who are unable to communicate, learning culture of an ICU) may influence nurses' use of pain management tools.[6-10] Therefore, an evaluation of nurses' level of adherence with the pain management algorithm following its implementation was warranted. In addition, the identification of patient and unit characteristics that could influence adherence warranted evaluation. Of note, in a study where ICU nurses' level of adherence with a sedative, analgesic, and neuromuscular blocking agent guideline in mechanically ventilated ICU patients was evaluated, the adherence rate were only 58%.[20] Therefore, the purposes of this study were to: describe the implementation of the pain management algorithm in three ICU's; evaluate ICU nurses' levels of adherence with the algorithm; and identify patient and unit characteristics that were associated with nurses' level of adherence.

Methods

Ethical approval

The Regional Ethics Committee (2011/2582 D) and the leadership at the hospitals that participated in the study approved this study. The study was registered in ClinicalTrials.gov (NCT01599663).

Implementation of the pain assessment algorithm

The algorithm was implemented in three units (i.e., one medical/surgical ICU, one surgical ICU, one post anaesthesia care unit) at two hospitals. Prior to this study, these units had no protocols or guidelines for pain assessment or management. However, nurses were able to titrate doses of prescribed analgesics. The implementation process consisted of the provision of education in pain assessment and management as well as in the use of the pain management algorithm by all nurses employed in the three units.

Education

All of the nurses received 1.5 hours of education in pain management by the principal investigator (BFO). One of the benefits of this educational session was that it provided nurses with the opportunity to ask questions and to discuss relevant topics. The lecture focused on the occurrence of pain in ICU patients and how to assess their pain. Information was provided on the validity and reliability as well as on the use of the three pain assessment tools. The nurses were educated about clinically meaningful cut-points and how to make decisions about changing the patients' pain treatment. Finally, the entire algorithm and a description of the entire project were presented. All temporary staff were given a summary of this education. The physicians were informed about the algorithm in a meeting prior to its implementation and they received an email about the project.

Practice period

After the educational program, nurses practiced using the algorithm over a three week period.[19] The principal investigator and a resource person were available on the units to answer questions and provide support. During this three weeks period, the principal investigator and a resource person verified that the nurses did the pain assessments and used the algorithm correctly. The resource person was an ICU nurse who was educated by the principal investigator. At the end of this practice period, initial levels of adherence with the algorithm were evaluated on a single day. Twenty ICU patients who were enrolled on this day were included in the pilot study of adherence. These patients had an ICU stay that ranged from one to 11 days, for a total of 360 shifts. Pain was assessed during 281 of these shifts (i.e., adherence rate of 78%).

Implementation period

Following the practice period, the algorithm was implemented on the three units. All ICU patients >18 years of age admitted to the three units were assessed and managed using the pain management algorithm. Patients were included if they were able to self-report pain or express pain behaviors. They were excluded if they could not self-report pain or express pain behaviors (e.g., quadriplegic, receiving neuromuscular blockade or paralyzing drugs, being investigated for brain death). The principal investigator and the resource person reminded the nurses to use the algorithm. They were available to answer questions and provide support every day and had telephone, email, and/or in person contact during the whole implementation period. Written information (i.e., emails, the unit's website) was provided to the nurses about the progress of the study. Written reminders on how to use the algorithm were placed in a number of sites on the three units. The pain management algorithm was placed at the bedside of every ICU patient. All these strategies were used to reinforce the use of the algorithm.

Data collection

Patient data

All patients who met the study's inclusion criteria and were hospitalized in one of the study units were included in the study. Data about patients' gender, age, status of mechanical ventilation during ICU stay, and diagnosis measured using the International Classification of Diseases (ICD-10 codes) were collected from their medical records. The Simplified Acute Physiology Score (SAPS II)[21] was used as the measure of disease severity. The SAPS is a widely used severity score and mortality estimation tool that is calculated during the first 24 hours of each patient's ICU stay. The SAPS includes 17 variables: 12 physiologic variables (e.g., vital signs, oxygenation status), age, type of admission, and three underlying disease variables (metastatic cancer, acquired immune deficiency syndrome (AIDS), hematologic malignancy). The score can range from 0 to 163, with higher scores indicating higher disease severity and higher probability of hospital mortality. Goodness-of-fit tests indicate that SAPS II provides an accurate estimate of the risk of death without having to specify a primary diagnosis.[21]

Unit data

Nurses' workload was measured using the Nine Equivalents of Nursing Manpower Score (NEMS).[22] The NEMS includes 9 variables (i.e., basic monitoring, intravenous medication, mechanical ventilator support, supplementary ventilator care, single vasoactive medication, multiple vasoactive medications, dialysis techniques, specific interventions in the ICU, specific interventions outside the ICU). Scores can range from 0 (low workload) to 66 (high workload). The intraclass correlation coefficient for the NEMS is reported at .92.[22] A daily NEMS was calculated for each ICU patient. In addition, the number of shifts each patient was in the ICU was recorded.

Nurses' level of adherence with the algorithm

Nurses' level of adherence with the algorithm was evaluated using pain scores from the first six days of each patient's ICU stay. The first shift (maximum of first eight hours) was excluded from the adherence analysis because the number of hours the patients were enrolled varied based on the time they were admitted to the ICU.

The nurses documented the patients' pain score (i.e., using the NRS, the BPS, or the BPS-NI) on all three shifts, both at rest and during turning (i.e., six pain scores per patient per day). If additional pain assessments were needed, the nurses documented all of the pain assessments performed. However, a maximum of one score at rest and one score during turning were included in the adherence analysis by shift (i.e., between 8 AM and 10 AM, between 3 PM and 5 PM, between 10 PM and 12 AM). If more than one pain score was documented during a shift, only the first score was recorded. If no pain scores were documented, a zero was entered into the database (i.e., enrolled in the study, but pain was not assessed).

Statistical analysis

Descriptive statistics were used to describe patient characteristics. The diagnostic groups that had <5% of the patients, were merged into the category "other diagnoses". Age was divided into 20 year increments and SAPS and NEMS were categorized into quartiles. The quartile approach was taken to examine differences among risk groups and to be able to compare findings from a similar study.[19]

Adherence was defined as the total number of pain scores that was recorded during the first six days of the patients' ICU stay, divided by the total number of pain scores that should have been recorded based on the number of shifts they were cared for in the ICU, multiplied by 100. An adherence rate was calculated for each patient that could range from 0% to 100%. In addition, to determine whether nurses' level of adherence was associated with patient and unit characteristics, adherence rates were correlated with patients' age, gender, diagnosis (ICD 10 codes), use of mechanical ventilation (yes or no), severity of disease (SAPS), nursing workload (NEMS per day), and shift (day, evening, night). Paired sample t-tests, independent sample t-tests, and analyses of variance with Bonferroni correction were used to evaluate associations between adherence rates and demographic and clinical characteristics of the patients, as well as unit characteristics.

Variables with p-values of <.05 in the bivariate analyses were included simultaneously as independent variables in a multivariate regression model to predict adherence. Shift was not included in the multivariate analysis because the same patients were assessed every shift. A p-value of <.05 was considered statistically significant. Categorical pairwise contrasts were evaluated using Bonferroni correction. Therefore, a p-value of <.017 for characteristics with three dummy coded variables and a p-value of <.01 for characteristics with five dummy coded variables were considered statistically significant. Statistical analyses were performed using the Statistical Package for the Social Science (SPSS) version 21.0 (SPSS Inc., Chicago,IL).

Results

Nurses' participation

Overall, 217 nurses (94%) participated in the educational program prior to the implementation of the pain management algorithm. Nurses who did not participate in the educational program (n=15) were given a written summary of the lecture.

Reasons for patient exclusion

A total of 461 patients were hospitalized during the 22 weeks of this study. Of these 463 eligible patients, 63 were excluded for the following reasons: ICU stay was <24 hours (n=56); not able to express pain (n=4); or age <18 years (n=3). Of the remaining patients, 113 did not have an algorithm initiated during the ICU stay (documentation of pain assessments was not available). Compared with the 285 patients who had an algorithm initiated, these patients had a significantly shorter length of stay (mean 2.4 vs. 6.1 days, $p<.001$); a higher percentage had spontaneous ventilation (80.0% vs. 48.1%, $p<.001$); and a lower NEMS per day (27.8 vs. 32.0, $p=.001$). Based on these exclusions, adherence with the algorithm was evaluated in 285 patients.

Patient and unit characteristics

The mean age of the patients who had a pain algorithm was 58.9 years (standard deviation (SD) =18.5; range 18-91), mean SAPS was 36.9 (SD=19.0; range 2-103), and mean NEMS per day was 32.0 (SD=10.3; range 8-82). In total, 67.0% of the patients were male. The most common diagnosis was "injury, poisoning, or certain other consequences of external causes" (33.0%) (ICD SS00-T98). More than half of the patients (51.9%) required mechanical ventilation during the ICU stay (Table 1).

Adherence with the algorithm related to unit characteristics

The 285 patients were in the ICU for a total of 2832 shifts that equated with 5664 pain assessments (i.e., each patient had pain assessed every shift at rest and during turning). A total of 4223 pain assessments were recorded which equates with an overall mean adherence rate of 73.5%. Adherence rates were significantly lower on evening (71.2%, $t=3.44$, $p=.001$) and night (71.4%, $t=3.21$, $p=.002$) shifts compared to the morning shift (77.7%). Patients in the 1st and 4th quartile NEMS were assessed significantly less frequently than patients in the 3rd quartile NEMS ($p=.003$, Table 2).

Adherence with the algorithm related to patient characteristics

As shown in Table 2, male patients were assessed significantly less frequently than females. Patients with "injury, poisoning, or certain other consequences of external causes", "other diagnosis", and "diseases of the digestive system" were assessed significantly less frequently than patients with "diseases of the respiratory system". Patients with a lower severity of disease (i.e., lower SAPS) were assessed significantly less frequently than patients with a higher severity of disease. No significant differences in adherence rates were found between ventilated and non-ventilated patients or among different age groups.

Associations between nurses' adherence rates and selected characteristics of the patients

In the multivariate regression analysis, only gender and diagnosis were significantly associated with level of adherence (Table 3). Adherence rates were lower for male patients compared to female patients. In addition, compared to patients with diseases of the respiratory system, patients with "injury, poisoning, certain other consequences of external causes" had significantly lower adherence rates. The overall model explained 16.2% of the variance in adherence and diagnosis made the largest unique contribution to the explained variance (4.4%).

Discussion

Nurses' adherence with the algorithm

This study is the first to evaluate for differences in nurses' level of adherence with a pain management algorithm across ICU shifts in adults patients, as well as to identify potential predictors of nurses' adherence. Across 5644 pain assessments, the average adherence rate was 73.5%. This adherence rate is higher than the 58% associated with the use of a sedative, analgesic, and neuromuscular blocking agent guideline in mechanically ventilated ICU patients[20] and the 66% found in a study of patients on general medical wards.[23] Of note, in a systematic review of 23 studies,[24] overall adherence rates with pain assessment protocols in hospitals ranged from 24% to 100%.

However, a direct comparison of adherence rates across studies is difficult because of the way that these rates were calculated. For example, Kerner and colleagues[23] calculated their adherence rate based on an admission assessment and a single pain assessment for each ICU day. In contrast, in the present study, the adherence rate was calculated based on a prespecified number of pain assessments per shift. In addition, the length of the assessment period could affect adherence rates, if the effect of an intervention diminishes over time. While Bair and colleagues[20] evaluated adherence rates for only fourteen weeks, in the present study the evaluation was done over 22 weeks. Third, differences in patient characteristics (e.g., ICU[20] versus medical wards[23]) could influence adherence rates.

Finally, the choice of implementation strategies could affect adherence rates. In prior research,[25] pain management education enhanced nurses' knowledge. Therefore, education was an integral component in our implementation plan. In addition, as part of the implementation of the algorithm, the principal investigator and the resource person reminded the nurses to use the algorithm, because feedback strategies were shown to improve adherence in other studies.[24,20,23]

Radtke and colleagues[26] found that sustained documentation rates for sedation, pain, and delirium scores increased significantly when they used an expanded training program (i.e., resource group, lectures, movie, handouts, one to one instructions over three cycles) compared to a traditional training program (i.e., over one cycle). In the current study, a traditional training approach was used. Our adherence rates may have been higher if we had used an expanded training program. However, the costs would have increased substantially.

Nurses' adherence with the algorithm related to patient and unit characteristics

In the multiple regression analysis, nurses' adherence rates were lower for male compared to female patients. To our knowledge, other studies have not examined the association between adherence with pain assessments and gender. However, females report higher pain intensity scores for experimental[27] and clinical[28] pain and more fear of pain than men.[27] If females express pain and fear of pain more readily than males, it may lead nurses to assess their pain more frequently.

Patients with "injury, poisoning, certain other consequences of external causes" were assessed less often than patients with "diseases of the respiratory system". This finding is a bit surprising because one would expect that patients with an injury would experience more pain. On the other hand, the prevalence and intensity of pain in ICU medical patients are not lower than in surgical-trauma patients.[29] It should be noted that patients with an injury had a lower mean SAPS (mean score 29.6 (SD=16.5)) than patients with respiratory diseases (mean score 41.6 (SD=14.5), p=.001) which suggests that other factors influenced nurses' ability to perform pain assessments in these patients. Additional research is warranted to determine which specific patient characteristics influence nurses' adherence with pain assessment.

In terms of unit characteristics, pain assessments were documented significantly less often on evening and night shifts compared to day shift. One potential explanation is that the resource persons were available primarily during the day. One of their main tasks was to remind and support the nurses to use the algorithm. Feedback strategies are known to be effective when implementing assessment tools in hospitals.[24] Because the same patients were assessed every shift, shift was not included in the multivariate analysis.

Our sample has similar[19] or lower[30] mean SAPS than previous studies. In the bivariate analysis, nurses' adherence rates were lower for patients who were categorized with lower SAPS and this characteristic approached significance in the multivariate analysis (p=.062). One possible explanation could be that nurses had more time to assess pain in patients with higher disease severity because of a higher nurse to patient ratio. On the other hand, hemodynamic instability was found to be a barrier to pain assessment and management.[9] Additional research is warranted to determine which specific SAPS characteristics influence nurses' adherence with a pain management algorithm.

In the multivariate regression analysis, nursing workload, measured as NEMS quartiles, was not associated with nurses' adherence rates. This finding contrasts with survey results that found that nursing workload was one of the barriers that most frequently interfered with pain assessments and management.[9] This finding suggests that what nurses' self-report of nursing workload, is not always the same as what is objectively measured using a tool like NEMS.

In the current study, patient and unit characteristics were chosen because associations between these characteristics and adherence with a pain management algorithm were not evaluated in previous studies. While individual patient[27,28] or unit[9] characteristics were evaluated individually in previous studies, no studies were identified that evaluated the influence of both patient and unit characteristics on nurses' level of adherence.

In the multivariate regression analysis, only 16.2% of the variance in adherence was explained by gender, SAPS, diagnosis, and NEMS. Since the explained variance was relatively small, other factors that were not measured in this study warrant consideration. Prior research found that nurse characteristics (e.g., knowledge deficits or misconceptions about pain assessment, resistance to use valid tools[6-8]); as well as patient characteristics (e.g., hemodynamic instability in critically ill patients[9]); and system factors (e.g., learning culture on the units[10]) could be barriers to effective pain management. Unfortunately, these variables were not evaluated in the current study. Additional research is needed to determine which of these characteristics would explain additional variance in adherence rates.

Limitations and strengths

The analysis of adherence was based on data from 285 ICU patients. However, for 113 patients admitted to the ICU the algorithm form was not initiated. These 113 patients' lengths of stay were significantly shorter, a higher percentage had spontaneous ventilation, and their NEMS scores were lower. These differences may have affected adherence rates. Another limitation is that adherence rates were evaluated only during the first six days of the ICU stay and not for the entire ICU stay. However, the median length of stay was 3.2 days. Additional research is needed to determine which of these characteristics would explain additional variance in adherence rates.

Implications for practice and research

Despite these limitations, findings from this study suggest that a pain management algorithm is a useful tool to increase ICU nurses' adherence with pain assessment. Additional research is needed to evaluate additional patient, unit, and nurse characteristics that may influence nurses' adherence rates. Finally, the effectiveness of the pain algorithm to improve pain management in ICU patients needs to be investigated.

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Table 1 – Patient (N=285) and unit characteristics

Characteristic	Mean ± SD	
Age (years)	58.9 ± 18.5	
Severity of disease (Simplified Acute Physiology Score)	36.9 ± 19.0	
Nursing workload (Nine Equivalents of Nursing Manpower Score) per day	32.0.± 10.3	
	n	(%)
Male gender	191	(67.0)
Diagnoses (International Classification of Diseases, ICD-10 codes)		
Diseases of the respiratory system	29	(10.2)
Neoplasms	34	(11.9)
Diseases of the circulatory system	38	(13.3)
Diseases of the digestive system	42	(14.7)
Other diagnoses	48	(16.8)
Injury, poisoning, certain other consequences of external causes	94	(33.0)
Mechanical ventilation (% yes)	148	(51.9)

Abbreviations: SD=standard deviation

Table 2 – Associations between a number of patient and unit characteristics and adherence with the pain management algorithm

Characteristic		n	% adherence * Mean ± SD	Statistics
Gender				
Male		191	71.0 ± 21.0	t=3.03
Female		94	78.6 ± 17.2	p=.003
Mechanical ventilation				
Yes		148	74.1 ± 19.2	t=-.52
No		137	72.9 ± 21.1	p=.600
Age (years)				
18-39		58	69.0 ± 20.6	F(3,281)=1.68 p=.171
40-59		65	73.6 ± 20.0	
60-79		125	74.2 ± 19.5	
80-99		37	78.1 ± 21.2	
Diagnosis (International Classification of Diseases, ICD-10 codes)				
1 Diseases of the respiratory system		29	87.3 ± 14.9	F(5,279)=4.72
2 Neoplasms		34	74.1 ± 17.9	p<.001
3 Diseases of the circulatory system		38	77.8 ± 19.9	1>4, 5, and 6
4 Diseases of the digestive system		42	72.8 ± 19.5	
5 Other diagnoses		48	72.4 ± 20.5	
6 Injury, poisoning, certain other consequences of external causes		94	68.2 ± 20.5	
Severity of disease (Simplified Acute Physiology Score, SAPS)				
1^{st} quartile	(≤22.9)	61	69.2 ± 19.5	F(3,262)=3.02
2^{nd} quartile	(23.0- 33.4)	72	72.9 ± 19.7	p=.030
3^{rd} quartile	(33.5- 48.9)	65	73.4 ± 20.0	4^{th} >1^{st}
4^{th} quartile	(≥49.0)	68		

Nursing workload			79.4 ± 19.5	
(Nine Equivalents of Nursing Manpower Score, NEMS)				
1st quartile	(≤ 24.4)	70		F(3,277)=4.83
2nd quartile	(24.5-31.7)	71	69.3 ± 21.5	p=.003
3rd quartile	(31.8-38.1)	71	76.4 ± 19.4	3rd>1st and 4th
4th quartile	(≥38.2)	69	79.4 ± 18.1	
			69.3 ± 19.3	

Abbreviations: SD=standard deviation

*% adherence Is calculated for each patients

Table 3 – Results of the final multivariate regression analysis for predictors of adherence with the pain management algorithm

Predictors	Final multivariate regression			
	B	95% CI	p-value	R^2 change
Gender			.002	3.2%
Males versus females	-7.8	-12.8, -2.8		
Severity of disease (Simplified Acute Physiology Score, SAPS)			.062	2.5%
1st quartile (reference group)				
2nd quartile versus 1st quartile	1.2	-5.5, 7.9	.720	
3rd quartile versus 1st quartile	1.6	-5.7, 9.0	.666	
4th quartile versus 1st quartile	9.0	1.3, 16.6	.021	
Diagnosis (International Classification of Diseases, ICD-10 code)			.026	4.4%
Diseases of the respiratory system (reference group)				
Neoplasms	-5.5	-15.8, 4.8	.293	
Diseases of the circulatory system	-7.6	17.0, 1.8	.111	
Diseases of the digestive system	-11.2	-20.5, -2.0	.018	
Other diagnoses	-11.5	-20.5, 2.5	.013	
Injury, poisoning, certain other consequences of external causes	-13.6	-22.2, -5.0	.002	
Nursing workload (Nine Equivalents of Nursing Manpower Score, NEMS)			.137	1.9%
1st quartile (reference group)				
2nd quartile versus 1st quartile	4.8	-1.8, 11.4	.156	
3rd quartile versus 1st quartile	4.9	-2.0, 11.8	.164	
4th quartile versus 1st quartile	-1.2	-8.1, 5.7	.723	
Explained variance (R^2)			.001	16.2%

Abbreviations: B=Unstandardized regression weights; CI=Confidence Interval