The Efficacy of the COMFORT Scale in Assessing Optimal Sedation in Critically Ill Children Requiring Mechanical Ventilation

Sedation is often necessary to optimize care for critically ill children requiring mechanical ventilation. If too light or too deep, however, sedation can cause significant adverse reactions, making it important to assess the degree of sedation and maintain its optimal level. We evaluated the efficacy of the COMFORT scale in assessing optimal sedation in critically ill children requiring mechanical ventilation. We compared 12 month data in 21 patients (intervention group), for whom we used the pediatric intensive care unit (PICU) sedation protocol of Asan Medical Center (Seoul, Korea) and the COMFORT scale to maintain optimal sedation, with the data in 20 patients (control group) assessed before using the sedation protocol and the COMPORT scale. Compared with the control group, the intervention group showed significant decreases in the total usage of sedatives and analgesics, the duration of mechanical ventilation (11.0 days vs. 12.5 days) and PICU stay (15.0 days vs. 19.5 days), and the development of withdrawal symptoms (1 case vs. 7 cases). The total duration of sedation (8.0 days vs. 11.5 days) also tended to decrease. These findings suggest that application of protocol-based sedation with the COMPORT scale may benefit children requiring mechanical ventilation.

Key Words : *Sedation; Children; Mechanical Ventilation; Withdrawal; Critical Care*

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INTRODUCTION

Managing the comfort of children in the pediatric intensive care unit (PICU) is one of the most difficult challenges facing pediatric staff. These critically ill children are placed in an unfamiliar and unpredictable environment, where visual and auditory stimuli are excessive, painful stimuli are frequent, and sleep disturbances are common (1, 2). Sedation is an essential tool in maintaining an optimal level of comfort and safety for critically ill patients (3). Excessive sedation, however, can lead to prolonged mechanical ventilation, ventilator-associated pneumonia or lung injury, or neuromuscular disorders. By contrast, too little sedation can lead to interference with effective mechanical ventilation, myocardial and cerebral ischemia, and potentially dangerous outcomes such as self-extubation or removal of other mechanical devices (4). Although clinical tools are available to assess and monitor the degree of sedation in individual patients (5), most of them have limitations in children. However, the COMFORT scale has been validated in critically ill children (6).

In adults, there is increasing evidence that protocol-directed sedation of intubated patients can reduce the duration of mechanical ventilation, the length of stay in the intensive care unit (ICU) and hospital, and tracheostomy rates, and

can enhance the quality of sedation with reduced drug costs (7-9). However, few studies have evaluated the effects of sedation practices on clinical outcomes in children. We therefore sought to identify whether protocol-directed sedation with the COMFORT scale in critically ill children could affect clinical outcomes, including duration of mechanical ventilation, length of stay in the ICU, total amount and duration of sedatives, and withdrawal symptoms.

MATERIALS AND METHODS

The study was conducted at the PICU (22 beds) of Asan Medical Center (AMC), Seoul, Korea. Patients were eligible if they were intubated, received mechanical ventilation, and required sedation through continuous intravenous infusion for longer than 48 hr. Patients who were admitted to the PICU after surgery, resuscitated from cardiac arrest, transferred from an outside institution where sedatives had already been administrated, or had abnormal neurological deficits were excluded. The PICU sedation protocol of AMC (Fig. 1) was developed prior to this study, and PICU physicians were encouraged to adhere to this protocol during the study period. During the 12-month period (July 2003-June 2004),

one clinical pharmacist evaluated the level of sedation twice daily in each patient using the COMFORT scale. The pharmacist then discussed these results with an attending physician, who adjusted the infusion rates of sedatives to attain an optimal COMFORT score, between 17 and 26 points. Data were collected prospectively for the study period (intervention group) and were compared with retrospective empiric therapy results during a 12-month period (July 2002-June 2003) prior to the study (control group). The control group consisted of patients admitted to the PICU who satisfied the study inclusion criteria. Baseline demographic data, PRISM III score, and reason for admission were recorded for all patients. Clinical outcome variables, including duration of mechanical ventilation, length of stay in the PICU, total dose of sedatives, and occurrence of withdrawal symptoms were compared between the two groups. Data were analyzed on an intention-to-treat basis. Continuous variables were analyzed using the Mann-Whitney rank sum test and presented as median values (with 25th and 75th percentiles). Discrete variables were analyzed using chi-square analysis with Fisher's exact test or Pearson's chi-square test, as appropriate. A p value le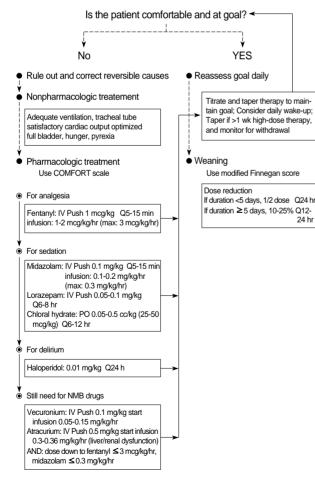ss than <0.05 was considered statistically significant, and all tests were based on two-sided hypothesis testing. SPSS 12.0 K for Windows was used for all statistical analyses.

RESULTS

Demographic variables

A total of 53 patients were included in the study, 26 in the intervention group and 27 in the control group. Five patients in the intervention group and seven in the control group were later excluded because their endotracheal tubes had been removed or they died within the first 48 hr. Thus, 21 patients in the intervention group and 20 patients in the control group were included in the analysis.

Demographic characteristics, PRISM III scores and diagnosis on ICU admission were similar in the two groups. The type of continuously used sedatives did not differ significantly between the two groups (Table 1). Neuromuscular blocking agents were infused continuously into nine patients in the intervention group and eight in the control group (p=0.85).

Outcomes

The use of protocol-directed sedation with the COMFORT scale in the intervention group was associated with significant decreases, compared with the control group, in the mean duration of mechanical ventilation (12.5 vs. 11.0 days, p=0.04) and in the median length of stay in the PICU (15.0 vs. 19.5 days, p=0.04) (Table 2). The duration of sedation also tended to be lower in the intervention group than in the control group (8.0 days vs. 11.5 days, p=0.053) (Table 2).

The overall development of withdrawal symptoms was sig-

Fig. 1. Protocol of pediatric intensive care unit sedation at Asan Medical Center.

Table 1. Demographic characteristics of study patients

Clinical phenotypes	Intervention group (N=21)	Control group (N=20)	p value
Age (months)	20.1±30.7	21.7±25.2	0.437
Sex (male/female)	8/13	9/11	0.282
Weight (kg)	8.1±4.9	10.1±5.6	0.071
PRISM III score	8.0±5.4	8.3±5.3	0.572
Diagnosis (n)			
ARDS	7	8	
Pneumonia	8	7	
Bronchiolitis	5	4	
Others	1	1	
Sedatives*			
Fentanyl	7	2	
Midazolam	3	2	
Fentanyl and midazolam	11	15	
Ketamine	0	1	

*Continuously infused sedatives.
ARDS, acute respiratory distress syndrome.

Table 2. Comparison of outcomes and withdrawal between study groups

Outcomes and withdrawal	Intervention group (N=21)	Control group (N=20)	p value
	Median (interquartile range)		
Duration of mechanical ventilation (days)	11.0 (5.0-13.5)	12.5 (8.3-49.5)	0.04
Length of PICU stay (days)	15.0 (9.0-19.5)	19.5 (12.5-60.3)	0.04
Duration of sedation (days)	8.0 (3.5-13.0)	11.5 (8.0-33.3)	0.05
Withdrawal (n)	1	7	0.02
Mild*	1	5	
Moderate*	0	2	

*Modified Finnegan score (26); mild 0-7, moderate 8-11.
PICU, pediatric intensive care unit.

Table 3. Comparison of sedatives used in the two study groups

Sedatives	Intervention group (N=21)	Control group (N=20)	p value
	Median (interquartile range)		
Continuously used			
Fentanyl			
Total dose (mcg/kg)	204.0 (94.8-433.2)	495.5 (280.3-835.1)	0.02
Maximum rate (mcg/kg/hr)	2.0 (1.4-2.5)	3.0 (2.5-3.0)	<0.01
Midazolam			
Total dose (mcg/kg)	37.5 (5.9-53.4)	55.0 (23.3-77.1)	0.08
Maximum rate (mcg/kg/hr)	0.2 (0.2-0.3)	0.3 (0.3-0.4)	0.01
PRN or intermittently			
Used (n*)			
Fentanyl	1.0 (1.0-2.0)	6.0 (1.5-14.5)	0.03
Midazolam	3.0 (2.0-5.0)	8.5 (5.0-8.5)	<0.01
Lorazepam	4.0 (2.0-6.3)	13.0 (7.3-30.5)	<0.01
Chloral hydrate	3.0 (1.0-6.3)	17.0 (5.5-25.0)	<0.01
Ketamine	2.0 (1.5-4.0)	3.0 (2.0-11.0)	0.26
NMB drugs	2.0 (1.0-3.8)	9.0 (5.5-27.0)	<0.01

*Frequency of use. NMB, neuromuscular blocking.

nificantly lower in the intervention than in the control group (1 vs. 7 patients, p=0.02). Mild withdrawal symptoms, mainly presenting as loose stools and vomiting, was seen in one patient in the intervention group and five in the control group; whereas moderate withdrawal symptoms, presenting as tremors and abnormal sleep patterns, were observed only in two control group patients (Table 2).

The total dose and maximum rate of continuous fentanyl infusion and the maximum rate of continuous midazolam infusion were significantly lower in the intervention group than in the control group (Table 3). Except for ketamine, the frequencies of intermittent doses of sedatives and neuromuscular blocking drugs were also significantly lower in the intervention group than in the control group (Table 3).

DISCUSSION

Using a sedation protocol has been shown to be effective in adjusting sedation at the 'agitated' end of the range, whereas sedation scoring systems have been found effective in adjusting sedation regimens at the opposite, or 'over-sedated', end of the range (10). To navigate between agitation and over-sedation, we integrated the COMFORT scale with the PICU sedation protocol at AMC.

In this study, we investigated and documented the effect of the systematic use of a sedation protocol together with the COMFORT scale in critically ill children requiring mechanical ventilation. We found that this combination produced better outcomes than the subjective judgment of a physician alone. The duration of mechanical ventilation and the length of stay in the ICU were significantly reduced in the intervention group compared with the control group. These findings are consistent with the results of previous studies in adults, which demonstrated relationships between sedation practices and the duration of mechanical ventilation (11-16). Our sedation protocol was developed for patients requiring mechanical ventilation. To determine optimal sedation level goals,

physicians were required to evaluate each patient's causes of restlessness and whether analgesics, sedatives or both were required. In addition, a pharmacist and a nursing team were employed to support these judgments. Our protocol provided guidelines for choices of analgesics and/or sedatives, daily reassessment, and dose adjustments. To our knowledge, no previous studies have addressed the clinical effects of a sedation protocol plus a sedation scoring system in children. Our study results suggest that sedation protocols together with the COMFORT scale can be safely implemented to improve outcomes in critically ill children.

We chose to use the COMFORT scale as a sedation scoring system, because it has been demonstrated to be reliable and has been validated as a descriptor of behavioral and physiologic distress in critically ill children (17-20). In addition, the COMFORT scale can measure not only the level of consciousness but other parameters, including face grimacing, muscle tone, physiological values and the level of agitation, all of which are considered possible reflectors of tolerability to the PICU environment. Furthermore, the COMFORT scale was designed to be age-independent.

The target range of the COMFORT score corresponding to optimal sedation has been found to be between 17 and 26 points (21). We therefore used this range as our target goal, and we regulated the infusion rate of sedatives for each patient using the COMFORT score and the sedation protocol. Maintenance of the optimal level of sedation would therefore reduce the amount of times patients were over-sedated or agitated, thus reducing the amount and frequency of sedatives used. We found that the doses of continuously infused sedatives and their maximal infusion rates were lower in the intervention group, as was the frequency of PRN or intermittently

used sedatives.

Critically ill children who have required long-term sedation for mechanical ventilation often experience withdrawal syndromes after the termination of sedation, characterized by agitation, anxiety, muscle twitching, sweating, and tremors (22). Previous studies of protocol-based sedation, however, have not evaluated withdrawal symptoms in these children (3, 11, 12, 23, 24). Abstinence syndrome is commonly associated with opiates and benzodiazepines, usually occurring between 5 and 10 days after drug commencement (22). We thus classified patients receiving more than 5 days of sedative treatment into a risk group for withdrawal symptoms. Patients in the risk group who required reduced doses of sedatives had their infusion rates reduced by 10-25% of the original dose at an interval of 12-24 hr, with withdrawal symptoms monitored using a modified Finnegan score (25). We found that both the incidence and severity of withdrawal symptoms were reduced in our intervention group.

This study had several limitations. Since it was not a randomized, controlled trial, and it used a historical control group, methodologic weaknesses were present, and it was difficult to quantify the effects of bias, including those associated with improved general care between the sampling periods of the two groups. However, there were no differences in main strategies on ventilator care and attending staff, and we believe the quality of general care was also similar. In addition, our study evaluated small numbers of patients in each group. Inclusion of larger numbers of patients would require a longer study period, but that may have led to more errors inherent in using historical controls. We therefore limited the study period to 12 months. Furthermore, we did not evaluate the impact of sedation protocol on other outcomes, such as the occurrence of unplanned extubation and ventilator-associated pneumonia, and on treatment costs.

In conclusion, we found that the PICU sedation protocol of Asan Medical Center, together with the COMFORT scale, may be a safe and practical approach to treating pediatric patients receiving mechanical ventilation. This protocol decreased the duration of mechanical ventilation, the length of stay in the PICU, total dose of sedatives, and the incidence of withdrawal symptoms.

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