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Correlation between the actual sleep time 24 hours prior to an examination and the time to achieve chloral hydrate sedation in pediatric patients in South Korea: a prospective cohort study

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Purpose: This study investigated correlations between the actual sleep time 24 hours prior to an examination and the time to achieve chloral hydrate sedation in pediatric patients. **Methods:** With parental consent, 84 children who were placed under moderate or deep sedation with chloral hydrate for examinations from November 19, 2020 to July 9, 2022 were recruited. **Results:** Patients' average age was 19.9 months. Pediatric neurology patients and those who underwent electroencephalography took significantly longer to achieve sedation with chloral hydrate. There was a negative correlation between the time to achieve sedation and actual sleep time within 24 hours prior to the examination. Positive correlations were found between the actual sleep time 24 hours prior to the examination and the second dose per weight, as well as between the sedation recovery time and awake hours before the examination. **Conclusion:** Sleep restriction is not an effective adjuvant therapy for chloral hydrate sedation in children, and sedation effects vary according to pediatric patients' characteristics. Therefore, it would be possible to reduce the unnecessary efforts of caregivers who restrict children's sleep for examinations. It is more important to educate parents about safe sedation than about sleep restriction.

Key words: Chloral hydrate; Deep sedation; Pediatric nursing; Sleep; Time

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INTRODUCTION

Sedation involves using drugs to depress consciousness while maintaining cardiopulmonary function in certain situations to minimize patients' anxiety and pain so that they can withstand examinations or procedures [1,2]. Sedation for diagnostic tests is essential in pediatric patients who have difficulty cooperating [3-5]. Magnetic resonance imaging (MRI) and electroencephalography (EEG), in particular, require more prolonged and deeper sleep than computed tomography (CT) [5-8]. Some pediatric patients cannot cooperate with procedures such as MRI, EEG, CT, and cardiography. If sedation fails due to a prolonged time to reach sedation or side effects, the hospitalization of pediatric patients may be extended, causing significant setbacks to the diagnosis and treatment plans [9].

Chloral hydrate is the most commonly used drug for pediatric sedation, with a rapid onset of action and recovery [3,9]. In clinical practice, chloral hydrate at a dose of 50 to 75 mg/kg is administered orally to infants and can be administered once again at a dose less than the initial maximum dose after 20 to 30 minutes according to the criteria recommended in the guidelines for pediatric sedation compiled by the Korean Society of Pediatric Anesthesiologists [9,10].

Previous studies have shown that sedation using chloral hydrate is affected by several variables, including dosage, the administration method, weight, sex, compliance, the duration and nature of treatment, and the patient's health status [11,12]. In particular, sedation failure is frequent in clinical practice when chloral hydrate is administered at the manufacturer's

recommended first dose of 50 mg/kg, resulting in failure to test due to re-dosing at a dose less than the initial maximum dose or prolonged time to achieve sedation. Accordingly, clinical wards conduct education on limiting sleep time along with pre-examination fasting as an additional measure to increase the success of sedation, but there is insufficient evidence for this. Furthermore, excessively limiting sleep time places unnecessary stress on patients and their caregivers and causes hyperactivity in patients during the sedation process.

Sleep restriction is a therapy introduced by Spielman et al. [13] in 1987 that reduces sleep opportunities by limiting sleep time, resulting in a high motivation for sleep that leads to deep sleep and increases sleep efficiency [14]. According to research by Maeng and Oh [11], a shorter sleep time the day before dental treatment was associated with a greater sedation effect. Kimiya et al. [15] reported that a sleep reduction intervention where children aged 3 or younger were put to sleep an hour later and awoken an hour early increased the sedation effect. The authors therefore suggested a 2-hour sleep restriction that is achieved by adjusting the time of falling asleep or waking up until the sleep efficiency reaches between 80% and 85%. It was suggested that this sleep restriction intervention improves sleep persistence through a complementary mechanism of causing mild sleep deprivation and reinforcing homeostatic sleep desire [16].

Pediatric sedation guidelines [17] do not provide instructions on pre-sedation sleep restriction education for pediatric patients. However, several studies have reported that sleep restriction before sedation reduced the test failure rates and impacted the sedation effect [11,15,18-20]. According to Maeng and Oh [11], a shorter sleep time the day before dental treatment was associated with a greater sedation effect. The study of Ong et al. [18] showed that 55% of children could undergo examinations with natural sleep alone (i.e., without sedation) when partial sleep deprivation was recommended prior to EEG examinations, and Alix et al. [19] reported that an intervention using sleep reduction and melatonin increased the sedation effect during EEG. In contrast, Cui et al. [21] stated that sleep deprivation did not enhance the success rate of chloral hydrate sedation in pediatric patients, and Sury et al. [22] pointed out limitations in the evidence supporting the efficacy of sleep deprivation in aiding sedation and acknowledged the practical difficulties of this approach [23].

Most of the intervention methods used in many studies involved performing examinations at a specific time and limiting the amount of sleep the day prior, but these methods have limited applicability to clinical practice where examinations are conducted at varying times. Therefore, research on pre-sedation sleep reduction on the examination day was deemed necessary for tests that are frequently performed in the pediatric ward, such as MRI, EEG, CT, echocardiography, and dimercaptosuccinic acid (DMSA) renal scans.

To this end, the present study aimed to evaluate correlations between the actual sleep time 24 hours prior to an examination and the time to achieve chloral hydrate sedation in pediatric patients. This study will contribute to confirming whether reducing sleep time before sedation is an evidence-based nursing practice.

The objective of the current study was to investigate the correlation between the sedation effect and actual sleep time 24 hours prior to an examination in pediatric patients receiving choral hydrate sedation. The specific objectives were as follows: 1) to identify the general characteristics of patients undergoing sedation, 2) to identify the sleep-related and sedation-related characteristics of patients undergoing sedation, 3) to compare the differences between the length of time required to achieve sedation and recovery time according to patients' general characteristics, 4) to identify the correlation between the actual sleep time 24 hours prior to an examination and the time to achieve chloral hydrate sedation in pediatric patients.

METHODS

Ethics statement: This study was approved by the Institutional Review Board (IRB) of the Catholic University Medical Center (CMC) (KC20OASI0673). Informed consent was obtained from all participants.

1. Study Design

A prospective cohort study was performed to identify the correlation between actual sleep time and the time to achieve chloral hydrate sedation 24 hours prior to an examination in pediatric patients. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines [24].

2. Subjects

The participants were patients aged 4 to 60 months (5-year-old) who were admitted to the pediatric ward at C University Hospital located in Seoul, South Korea. The enrolled pediatric patients were placed under moderate or deep sedation with chloral hydrate for examinations from November 19, 2020 to July 9, 2022. Patients classified as American Society of Anesthesiologists (ASA) level III or higher on the Physical Status Classification System of the ASA [16] and patients who had experienced symptoms of elevated intracranial pressure, such as headache, lethargy, nausea, and decreased consciousness were excluded from this study. Other exclusion criteria were

two or more of the following conditions: cardiac diseases, abnormal heart or lung sounds, respiratory distress, and craniocervical junction disorders. Patients with those conditions were excluded due to their increased risk of respiratory complications during providing moderate or deep sedation. Infants under 4 months of age were also excluded from the study because they have not yet formed a sleep cycle and their sleep patterns fluctuate widely [7]. G*Power version 3.1.9.2 was used to calculate the number of subjects required for Pearson correlation analysis [25], with the effect size set as .3, a significance level of .05, and power set as .80. The resulting number of subjects was 84, and considering a 10% dropout rate, we recruited 95 parents who agreed to participate. Data from 84 participants were used after excluding 11 patients who had errors in the consent form or received additional intravenous sedatives.

3. Study Tool

1) General characteristics

The primary caregivers of the participants were surveyed on the patients' general characteristics, including sex, age, weight, the primary caregiver, the clinical department, the purpose of hospitalization, and medical history using questionnaires. Data on sedation time were collected from electronic medical records, including the following: the patient's past sedation experience, the name of the examination, the examination duration, and the pre-examination fasting time.

2) Sleep characteristics

Sleep-related data were collected from parents, which included the following; average nap time, frequency of naps, average sleep time, actual sleep time within 24 hours of the examination, awakening time (immediately prior to the examination), and the presence or absence of sleep restriction of 2 hours or more.

3) Time to achieve sedation and success of sedation state

To suit the current institution's circumstances, the Catholic Medical Center Modified Observer's Assessment of Alertness/Sedation (CMOAA/S) scale was used as a sedation evaluation scale, which was modified from the Observer's Assessment of Alertness/Sedation (OAA/S) scale developed by Chernik et al. [26]. The time to achieve sedation was defined as the time it takes from immediately after the nurse's administration of chloral hydrate on the patient to when the patient reaches 2 points on the CMOAA/S scale (deep sedation), and this time was identified by measuring the heart rate, oxygen saturation, and the CMOAA/S scale every 5 minutes using a pulse oximeter. The scoring of the CMOAA/S scale ranges from 1 to 5, with lower scores meaning deeper sedation. A score of 1 signifies a state of deep sedation where the patient only responds to strong stimuli (e.g., pinching or strong shaking of the body) and does not open their eyes to stimuli. A score of 2 is a state of moderate sedation, where the patient responds to actions (e.g., light shaking of the body or weak stimulation), and a score of 3 indicates mild sedation, where the patient responds to sounds (e.g., responds only to loud noise or repeated calling of their name). A score of 4 is a state of wakefulness where patients react slowly when their name is called in a normal tone, and a score of 5 is a state of immediate response, cooperation, calmness, and orientation. In the present study, a score of 2 on the CMOAA/S scale was considered to indicate successful sedation, corresponding to a state in which the patient's eyes open, but do not make eye contact, when the patient is lightly rocked back and forth while holding their shoulders.

4) Number of oral administrations of chloral hydrate

If a patient was not sedated within 20 to 30 minutes of observation after the administration of chloral hydrate, an additional dose was administered according to the prescription of the pediatrician up to a maximum dose of 10 mL (4 to 24 months old) and 20 mL (25 months to 6 years old).

5) Post-sedation recovery time

The Post Anesthesia Recovery (PAR) score developed by Aldrete [27] was used to measure post-sedation recovery time. Items regarding reflexive abilities, respiration, circulation, consciousness, and oxygen saturation are scored from 0 to 2. A higher composite score corresponds to a higher degree of recovery. The time point at which the total PAR score becomes 9 or higher was regarded as the time of complete sedation recovery and was recorded as the time spent for sedation recovery.

4. Data Collection

A participant recruitment notice for the present study was posted on a bulletin board at the pediatric ward of C University Hospital in Seoul from November 20, 2020 to July 9, 2022. The co-authors provided a description of the study to the primary caregivers (the participants in data collection) regarding the purpose and methods of the study, stating that the results would not be used for any other purpose than research and that participation could be withdrawn at any time. The study was conducted only with those who consented to participate in the study in writing. Regarding sedation, the primary caregivers received an explanation about reducing sleep time in the same way as before this study. The primary caregivers then reported the degree of sleep restriction within 24 hours

before the examination.

A range that did not deviate from the age-specific sleep deprivation guideline [28] was explained, and the actual sleep restriction time that occurred during the primary caregiver's care for the child was investigated through a questionnaire. The time to achieve sedation, number of oral administrations of chloral hydrate, and post-sedation recovery time were collected from medical records. In order to verify reliability between observers, two nurses were required to evaluate one patient at the same time.

Measures were taken so the case report forms could not be easily replicated or distributed, and the responsible researcher stored them to prevent information leakage. Personal information (e.g., name and hospital registration number) that could identify the research subjects was coded at the time of the medical record review. The researcher's records only included the coded study numbers, and identifiable personal information was not exposed to protect the subjects' information. The records related to the study will be stored for 3 years from the end of the study and will be destroyed after the retention period expires. Participants received a small gift.

5. Data Analysis

The collected data were analyzed using SPSS 24.0 (IBM Corp., Armonk, NY, USA), and the specific statistical methods were as follows.

The general characteristics of the subjects and their sedation- and sleep-related characteristics were analyzed using descriptive statistics (frequency, percentage, mean, and standard deviation). The relationships of sedative dosing and sedation-related characteristics with sleep restriction were analyzed using the x^2 test after checking the respective normality distribution by performing the Shapiro-Wilk test. The relationships between the time to achieve sedation, the number of sedative doses, sedation recovery time, and sleep time restriction were analyzed with Pearson correlation coefficients.

RESULTS

1. General Characteristics of the Pediatric Patients

The 84 children included in this study comprised more boys (n=49, 58.3%) than girls (n=35, 41.7%). The sample's age ranged from 4 to 60 months, with a mean of 19.9 months, and the mean weight was 11.6 kg. The primary caregivers of all 84 patients were parents. Half of the patients were treated in the Department of Pediatric Infection (n=42, 50.0%), followed by those admitted to the Department of Pediatric Neurology (n=20, 23.8%). Infection was the most common diagnosis, with 35 patients (41.7%), followed by seizure (n=20, 23.8%). The purpose of hospitalization was examinations for 64 patients (76.2%) and treatment for 20 (23.8%). Seventy-nine patients (94.0%) had no relevant past medical history, while five (6.0%) did (Table 1).

2. Characteristics Related to Sleep Induction in the Pediatric Patients

There were 30 pediatric patients (35.7%) with past sedation experience and two (2.4%) taking phenobarbital or sodium valproate, which affects sedation. Thus, most pediatric patients were not taking sedation-related medications. Among the examinations performed under sedation, 26 (31.0%) underwent CT and MRI, and 26 (31.0%) underwent echocardiography. The average examination duration was 34 minutes, and 51 patients (60.7%) had examinations in the afternoon (i.e., 12:00 to 17:59). The average nap time was 2.32 hours, the frequency of naps was 1.55, and the average sleep time was 11.92 hours. The actual sleep time within 24 hours prior to the

Table 1. General Characteristics of the Pediatric Patients (*N*=84)

Variables	Categories	n (%) or M±SD	Range
Sex	Male	49 (58.3)	
	Female	35 (41.7)	
Age (month)	≤12	33 (39.3)	4-60
	13-24	24 (28.6)	
	25-36	22 (26.2)	
	>37	5 (5.9)	
		19.9±14.7	
Body weight (kg)	<10	32 (38.1)	6-25
	10-14.9	36 (42.9)	
	15-19.9	13 (15.5)	
	≥20	3 (3.5)	
		11.6±3.7	
Caregiver	Parents	84 (100.0)	
Clinical department	Pediatric infection	42 (50.0)	
	Pediatric cardiology	12 (14.3)	
	Pediatric neurology	20 (23.8)	
	Pediatric nephrology	4 (4.8)	
	Pediatric pulmonology	6 (7.1)	
Diagnosis	Acute pyelonephritis	8 (9.5)	
	Seizure	20 (23.8)	
	Infection	35 (41.7)	
	Heart disease	9 (10.7)	
	Cancer or other	12 (14.3)	
Purpose of hospitalization	Treatment	20 (23.8)	
	Examination	64 (76.2)	
Past medical history	Yes	5 (6.0)	
	No	79 (94.0)	

M, mean; SD, standard deviation.

examination was 10.23 hours, and the mean waking hours within 24 hours of the examination was 5.54 hours. Forty-four pediatric patients (52.4%) had less than a 2-hour sleep restriction before the examination, and 40 (47.6%) had over a 2-hour sleep restriction. The mean number of chloral hydrate doses required for sedation was 1.19, the mean total chloral hydrate dose was 6.53 mL, and the mean dose per kilogram of body weight was 0.56 mL. Thirteen patients (15.5%) were administered the second chloral hydrate. The average time to achieve sedation after chloral hydrate administration was 19.51 minutes, and the mean sedation recovery time was 56.37 minutes (Table 2).

3. Difference between Achieve Sedation and Sedation Recovery Time according to General Characteristics

The longest time to achieve sedation was observed for pediatric neurology patients (24.85 minutes), while the shortest was in pediatric nephrology patients (11.25 minutes); a statistically significant difference was found in the time to achieve sedation depending on the clinical department ($z=9.66$, $p=.047$). There was also a significant difference in the time to achieve sedation according to the type of examination, with 24.17 minutes for EEG, 22.54 minutes for MRI and CT, and 15.10 minutes for DMSA scans ($z=9.56$, $p=.023$; Table 3).

There was no statistically significant difference in the time to achieve sedation according to sex, diagnosis, and past sedation experience. Likewise, no statistically significant difference was found in the sedation recovery time according to the patients' sleep-related characteristics.

4. Correlation between Sleep-related Factors and Sedation-related Factors in the Pediatric Patients

The average nap time and the frequency of naps were positively correlated ($r=.65$, $p<.001$), and the average nap time

Table 2. Characteristics Related to Sleep Induction in the Pediatric Patients ($N=84$)

Variables	Categories	n (%)	M±SD	Range
Sedation experience	Yes	30 (35.7)		
	No	54 (64.3)		
Sedation-related medication (anticonvulsant drug)	Yes	2 (2.4)		
	No	82 (97.6)		
Examination	EEG	12 (14.3)		
	MRI or CT	26 (31.0)		
	Echocardiography	26 (31.0)		
	Nuclear medical examination	20 (23.8)		
Time of examination	Morning (6:00 am to 11:59 am)	23 (27.4)		
	Afternoon (12:00 pm to 5:59 pm)	51 (60.7)		
	Night (6:00 pm to 05:59 am)	10 (11.9)		
Naps	Average nap time (h)		2.32±1.40	0–10
	Frequency of naps		1.55±1.02	0–6
Sleeping	Average sleep time (h)		11.92±1.58	8–17
	Actual sleep time (24 hours prior to an examination)		10.23±1.86	7–14
Fasting time (h)			5.44±1.81	3–12
Sleep restriction	No (<2 h)	44 (52.4)		
	Yes (≥2 h)	40 (47.6)		
Chloral hydrate syrup (mL)	Frequency		1.19±0.55	1–5
	1st CHS actual dosage		5.85±1.80	3–10
	1st CHS dosage/kg		0.51±0.08	0.25–1.01
	2nd CHS actual dosage	13 (15.5)	4.78±2.82	2.00–10.00
	2nd CHS dosage/kg	13 (15.5)	0.33±0.11	0.24–0.49
	Total dosage		6.53±3.02	3.00–20.00
	Total CHS dosage/kg		0.56±0.14	0.41–1.01
Sedation	Time to sedation (min)		19.51±12.39	5.00–100.00
	Awakening time (immediately prior to an examination) (h)		5.54±2.42	0.50–12.00
	Examination progress time (min)		34.00±20.52	1.00–120.00
	Sedation recovery time (min)		56.37±109.90	0.00–720.00

CHS, chloral hydrate syrup; CT, computed tomography; EEG, electroencephalography; M, mean; MRI, magnetic resonance imaging; SD, standard deviation.

Table 3. Difference between Achieve Sedation Time and Sedation Recovery Time according to General Characteristics of the Pediatric Patients (*N*=84)

Variables	Categories	n (%)	Sedation time (min)			Sedation recovery time (min)		
			M±SD	Z*	*p*	M±SD	Z*	*p*
Sex	Male	49 (58.3)	18.78±9.98	-0.41	.680	57.08±101.85	-0.08	.935
	Female	35 (41.7)	20.54±15.24			55.37±121.81		
Clinical department	Pediatric infection	42 (50.0)	19.38±9.83	9.66	.047	42.95±51.33	6.54	.162
	Pediatric cardiology	12 (14.3)	15.58±5.00			44.67±48.85		
	Pediatric neurology	20 (23.8)	24.85±19.32			56.25±158.03		
	Pediatric nephrology	4 (4.8)	11.25±4.79			90.00±48.99		
	Pediatric pulmonology	6 (7.1)	16.00±7.13			151.67±252.28		
Diagnosis	Acute pyelonephritis	8 (9.5)	14.75±4.30	4.39	.356	81.88±61.23	4.19	.381
	Seizure	20 (23.8)	18.00±10.01			70.00±159.98		
	Infection	35 (41.7)	14.75±4.37			38.91±43.59		
	Heart disease	9 (10.7)	23.85±19.42			32.89±37.60		
	Cancer or other	12 (14.3)	19.60±9.72			85.17±185.74		
Sedation experience	Yes	30 (35.7)	19.33±7.32	-0.83	.410	35.63±42.57	-1.13	.258
	No	54 (64.3)	19.61±14.53			67.89±132.45		
Examination	EEG	12 (14.3)	24.17±6.69	9.56	.023	20.83±17.94	2.18	.535
	MRI, CT	26 (31.0)	22.54±19.61			85.58±183.82		
	Echocardiogram	26 (31.0)	17.73±6.67			50.19±51.62		
	Nuclear medical examination	20 (23.8)	15.10±5.43			47.75±50.12		
Time of examination	Morning (6:00 am to 11:59 am)	23 (27.4)	19.61±8.37	2.01	.366	36.70±42.14	0.74	.692
	Afternoon (12:00 pm to 5:59 pm)	51 (60.7)	20.22±14.62			43.51±49.29		
	Night (6:00 pm to 05:59 am)	10 (11.9)	15.70±6.27			167.20±279.22		
Sleep restriction	No (< 2 h)	44 (52.4)	17.27±7.53	-1.77	.077	50.16±101.60	-0.51	.607
	Yes (≥ 2 h)	40 (47.6)	21.98±15.89			63.20±119.29		

*Mann-Whitney U test; CT, computed tomography; EEG, electroencephalography; M, mean; MRI, magnetic resonance imaging; SD, standard deviation.

and average sleep time were also positively correlated (r=.70, p <.001). The average sleep time and the frequency of naps were positively correlated (r=.52, p <.001). The actual sleep time within 24 hours prior to the examination was negatively correlated with both the first chloral hydrate syrup dose per kilogram of body weight (r=-.23, p =.035) and the second chloral hydrate syrup dose (r=-.28, p =.011). The total chloral hydrate dose also showed a negative correlation with the actual sleep time within 24 hours prior to the examination (r=-.39, p <.001). The total chloral hydrate syrup dose per weight was positively correlated with both the first chloral hydrate syrup dose (r=.43, p <.001) and the second chloral hydrate syrup dose (r=.81, p <.001). A negative correlation was found between the time to achieve sedation and the actual sleep time within 24 hours prior to the examination (r=-.22, p =.048). The time to achieve sedation was positively correlated with both the second chloral hydrate syrup dose (r=.40, p <.001) and the total chloral hydrate syrup dose (r=.27, p =.014). Positive correlations were observed between the sedation recovery time and awake hours before the examination (r=.27, p =.014; Table 4).

DISCUSSION

The present study was conducted to determine whether the actual sleep time was correlated with the time to achieve chloral hydrate sedation 24 hours prior to an examination in pediatric patients. Song [9] stated that chloral hydrate is the most commonly used drug in sedation for diagnostic tests without inducing pain in children and that it is most effective at about 30 minutes after oral administration and requires 1-2 hours to recover.

In the current study, sedation took an average of 19 minutes and recovery took 56 minutes, with a maximum of 100 minutes for sedation and 720 minutes for recovery, indicating substantial variation among patients. In contrast, the study of Seo et al. [29], which used chloral hydrate in pediatric patients requiring sutures for lacerations, reported that the average time to achieve sedation was 31 minutes and 96 minutes for patients who required an additional dose.

Although Kim et al. [1] studied the degree of nurses' knowledge of pediatric sedation and Seo and Park [30] investigated awareness, nursing needs, and nursing satisfaction of guard-

Table 4. Correlations between Sleep-related Factors and Sedation-related Factors in the Pediatric Patients (*N*=84)

Variables	1	2	3	4	5	6	7	8	9	10
	r (*p*)	r (*p*)	r (*p*)	r (*p*)	r (*p*)	r (*p*)	r (*p*)	r (*p*)	r (*p*)	r (*p*)
1. Average nap time (h)	1.00									
2. Frequency of naps	.65 (<.001)	1.00								
3. Average sleep time (h)	.70 (<.001)	.52 (<.001)	1.00							
4. Actual sleep time (24 hours prior to an examination) (h)	-.08 (.489)	.04 (.705)	.02 (.869)	1.00						
5. 1st CHS dosage/kg (mL)	14 (.191)	.12 (.270)	.14 (.207)	-.23 (.035)	1.00					
6. 2nd CHS dosage/kg (mL)	-.04 (.725)	.03 (.756)	-.12 (.262)	-.28 (.011)	-.19 (.086)	1.00				
7. Total CHS dosage/kg (mL)	.05 (.650)	.11 (.344)	-.03 (.781)	-.39 (<.001)	.43 (<.001)	.81 (<.001)	1.00			
8. Time to sedation (min)	.09 (.407)	.01 (.976)	.01 (.919)	-.22 (.048)	-.17 (.121)	.40 (<.001)	.27 (.014)	1.00		
9. Awakening time before examination (h)	-.12 (.272)	-.16 (.152)	-.17 (.130)	-.15 (.161)	-.09 (.416)	-.04 (.699)	-.09 (.398)	.03 (.807)	1.00	
10. Sedation recovery time (min)	-.12 (.286)	-.07 (.561)	-.13 (.244)	-.12 (.298)	-.12 (.259)	.18 (.100)	.09 (.406)	-.03 (.768)	.27 (.014)	1.00

CHS, chloral hydrate syrup.

ians regarding conscious sedation as a pre-examination procedure, it was difficult to compare the results of this study with prior research, no study has yet identified the correlation between sleep time and sedation in pediatric patients.

Among the sedation-related characteristics of the patients in the current study, the time to achieve sedation was significantly different according to the clinical department. This finding is similar to the results reported by Choi et al. [31], who found that sedation using chloral hydrate failed in 77 out of 161 (47.8%) pediatric patients with neurological disorders. Although no direct comparison can be made due to a lack of studies measuring the time to achieve sedation according to the pediatric clinical department, it would be reasonable to interpret this finding as suggesting that pediatric neurology patients have underlying diseases or are taking medications that can affect sedation, which may affect the time to achieve sedation.

The time to achieve sedation according to the type of examination was the longest for EEG at 24.17 minutes, similar to the findings of Choi et al. [31]. In pediatric patients with neurological disorders, such as delayed development or convulsive seizures, sedation using chloral hydrate is challenging, and side effects due to excessive doses may occur more easily. An explanation for this may be the fact that many of the children who underwent EEG examinations had neurological diseases such as convulsions or seizures.

A study reported that partial sleep restriction reduced the need for sedatives in conducting pediatric EEG [18] and another study reported an increased sedative effect of chloral hydrate for pediatric patients with shorter sleep times [11]. However, contrary to the prediction that the chloral hydrate syrup dose would be lower and that the time to achieve sedation would be shorter if the actual sleep time within 24 hours prior to the examination were shorter, the first and second chloral hydrate syrup doses per weight and the time to achieve sedation were negatively correlated with sleep time before the examination. In other words, children with less sleep time were less sedated and required more chloral hydrate. An explanation for this result may be that sedation was reached according to the disease characteristics of individual pediatric patients rather than sleep restriction.

In addition, there was a significant positive correlation between the sedative recovery time and the alert time before the examination, which also deviated from the expectation that a shorter sedation recovery time would be associated with a longer pre-examination alert time. This result was different from the study by Kimiya et al. [15], which reported that a sleep restriction intervention (putting patients to bed an hour late and waking them up an hour early) increased the sedation effect and another study [32], where sleep deprivation by put-

ting patients to bed 2 hours late and waking them up and hour early was reported to be an essential factor in sedation.

In the current study, the participants were educated on sleep restriction, but the actual sleep restriction time was at the caregiver's discretion, so sleep restriction was not randomly controlled. This study is meaningful since it laid a foundation for recognizing that there may be no significant correlation between the actual sleep time 24 hours prior to an examination and the time to achieve chloral hydrate sedation in pediatric patients. However, only the pediatric ward of one university hospital was investigated, and data collection bias may have occurred. Therefore, it is necessary to reconfirm the results of this study by conducting further studies.

CONCLUSION

The present study examined the actual sleep time and the time to achieve chloral hydrate sedation 24 hours prior to an examination and sedation-related factors, including all examinations performed from day to night in pediatric wards, to determine whether the traditional practice of sleep restriction before examinations using sedation influenced sedation. The results of this study contribute to establishing evidence for effectiveness by showing that sleep restriction is not an effective adjuvant therapy for chloral hydrate sedation in children and that sedation effects vary according to pediatric patients' individual characteristics. These findings suggest that it would be possible to reduce the unnecessary effort of caregivers who restrain sleep for examinations. This will ultimately contribute to reducing the duration of hospitalization by implementing effective sedation and efficient diagnosis and treatment processes for pediatric patients in clinical wards. It is more important to educate parents about safe sedation than about sleep restriction.

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Conceptualization: all authors; Data collection, Formal analysis: all authors; Writing-original draft: all authors; Writing-review and editing: all authors; Final approval of published version: all authors.

Conflict of interest

No existing or potential conflict of interest relevant to this article was reported.

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Data availability

Please contact the corresponding author for data availability.

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REFERENCES

1. Kim NY, Ju HO, Park SY. Performance and knowledge of nurses on the practice of pediatric sedation. Journal of the Korean Society of Maternal and Child Health. 2021;25(4):260-268. https://doi.org/10.21896/jksmch.2021.25.4.260
2. Yoo YC. Issues in procedural sedation outside the operating theater: characteristics and safety of commonly used sedatives and analgesics. Journal of the Korean Medical Association. 2013;56(4): 285-291. https://doi.org/10.5124/jkma.2013.56.4.285
3. Kim DK. Procedural sedation and analgesia in pediatric emergency department. Pediatric Emergency Medicine Journal. 2018;5(2):31-37. https://doi.org/10.22470/pemj.2018.00290
4. Bae JA, Choi YH, Kim AJ, Lee SH. Administration and efficiency comparison of chloral hydrate during pediatric sedation. Journal of the Korean Society of Clinical Toxicology. 2016;14(1):9-15. https://doi.org/10.22537/jksct.2016.14.1.9
5. Dong SZ, Zhu M, Bulas D. Techniques for minimizing sedation in pediatric MRI. Journal of Magnetic Resonance Imaging. 2019;50(4): 1047-1054. https://doi.org/10.1002/jmri.26703
6. Vinson AE, Peyton J, Kordun A, Staffa SJ, Cravero J. Trends in pediatric MRI sedation/anesthesia at a tertiary medical center over time. Paediatric Anaesthesia. 2021;31(9):953-961. https://doi.org/10.1111/pan.14225
7. Bracken J, Heaslip I, Ryan S. Chloral hydrate sedation in radiology: retrospective audit of reduced dose. Pediatric Radiology. 2012;42 (3):349-354. https://doi.org/10.1007/s00247-011-2279-9
8. Jung SM. Drug selection for sedation and general anesthesia in children undergoing ambulatory magnetic resonance imaging.

Yeungnam University Journal of Medicine. 2020;37(3):159-168. https://doi.org/10.12701/yujm.2020.00171
9. Song JH. Procedural sedation and analgesia in children. Journal of the Korean Medical Association. 2013;56(4):271-278. https://doi.org/10.5124/jkma.2013.56.4.271
10. Chen ML, Chen Q, Xu F, Zhang JX, Su XY, Tu XZ. Safety and efficacy of chloral hydrate for conscious sedation of infants in the pediatric cardiovascular intensive care unit. Medicine. 2017;96(1): e5842. https://doi.org/10.1097/MD.0000000000005842
11. Maeng YJ, Oh SH. An effect of sleeping hours prior to procedure on chloral hydrate sedation for pediatric dental patient. Journal of the Korean Academy of Pedtatric Dentistry. 2011;38(4):355-361. https://doi.org/10.5933/JKAPD.2011.38.4.355
12. Scherrer PD, Mallory MD, Cravero JP, Lowrie L, Hertzog JH, Berkenbosch JW; Pediatric Sedation Research Consortium. The impact of obesity on pediatric procedural sedation-related outcomes: results from the Pediatric Sedation Research Consortium. Paediatric Anaesthesia. 2015;25(7):689-697. https://doi.org/10.1111/pan.12627
13. Spielman AJ, Saskin P, Thorpy MJ. Treatment of chronic insomnia by restriction of time in bed. Sleep. 1987;10(1):45-56.
14. Choi SJ, Kim KS. The effects of sleep restriction-emphasized cognitive behavioral therapy for insomnia on sleep with chronic insomniacs: a preliminary study. Journal of Korean Sleep Research Society. 2010;7(2):49-56. https://doi.org/10.13078/jksrs.10009
15. Kimiya T, Sekiguchi S, Yagihashi T, Arai M, Takahashi H, Takahashi T. Sedation protocol with fasting and shorter sleep leads to magnetic resonance imaging success. Pediatrics International. 2017; 59(10):1087-1090. https://doi.org/10.1111/ped.13371
16. Jang CH, Kim SH, Oh DH. Cognitive behavioral therapy of insomnia. Hanyang Medical Reviews. 2013;33(4):210-215. https://doi.org/10.7599/hmr.2013.33.4.210
17. Jang HY, Jung JH, Kyong YY, Kim KH, Kim DK, Kim MR, et al. Korean guidelines for pediatric procedural sedation and analgesia. Journal of The Korean Society of Emergency Medicine. 2012;23 (3):303-314.
18. Ong HT, Lim KJ, Low PC, Low PS. Simple instructions for partial sleep deprivation prior to pediatric EEG reduces the need for sedation. Clinical Neurophysiology. 2004;115(4):951-955. https://doi.org/10.1016/j.clinph.2003.11.012
19. Alix JJP, Kandler RH, Pang C, Stavroulakis T, Catania S. Sleep deprivation and melatonin for inducing sleep in paediatric electroencephalography: a prospective multicentre service evaluation. Developmental Medicine and Child Neurology. 2019;61(2):181-185. https://doi.org/10.1111/dmcn.13973
20. Volpe AD, Lucia A, Pirozzi C, Pastore V. Comparative study between the use of melatonin and A solution with melatonin, tryptophan, and vitamin B6 as an inducer of spontaneous sleep in children during an auditory response test: an alternative to commonly used sedative drugs. The Journal of International Advanced Otology. 2017;13(1):69-73. https://doi.org/10.5152/iao.2017.3054
21. Cui Y, Guo L, Mu Q, Cheng Q, Kang L, He Y, et al. Sleep deprivation did not enhance the success rate of chloral hydrate sedation for non-invasive procedural sedation in pediatric patients. PLoS One. 2021;16(1):e0245338. https://doi.org/10.1371/journal.pone.0245338
22. Sury MR, Harker H, Begent J, Chong WK. The management of infants and children for painless imaging. Clinical Radiology. 2005; 60(7):731-741. https://doi.org/10.1016/j.crad.2005.02.014
23. Edwards AD, Arthurs OJ. Paediatric MRI under sedation: is it necessary? What is the evidence for the alternatives? Pediatric Radiology. 2011;41(11):1353-1364. https://doi.org/10.1007/s00247-011-2147-7
24. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. PLoS Medicine. 2007;4 (10):e296. https://doi.org/10.1371/journal.pmed.0040296
25. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. Behavior Research Methods. 2009;41(4):1149-1160. https://doi.org/10.3758/BRM.41.4.1149
26. Chernik DA, Gillings D, Laine H, Hendler J, Silver JM, Davidson AB, et al. Validity and reliability of the observer's assessment of alertness/sedation scale: study with intravenous midazolam. Journal of Clinical Psychopharmacology. 1990;10(4):244-251.
27. Aldrete JA. The post-anesthesia recovery score revisited. Journal of Clinical Anesthesia. 1995;7(1):89-91. https://doi.org/10.1016/0952-8180(94)00001-k
28. Brown V, Haak N, Egel RT. Technical tips: age-specific sleep deprivation guidelines. American Journal of Electroneurodiagnostic Technology. 1997;37(3):231-235. https://doi.org/10.1080/1086508X.1997.11079191
29. Seo BK, Kim A, Jung HM, Kim AJ, Han SB. Comparison of sedation outcome according to the dose of chloral hydrate in children requiring laceration repair. Pediatric Emergency Medicine Journal. 2017;4(2):92-96. https://doi.org/10.22470/pemj.2017.00024
30. Seo MH, Park S. Awareness, nursing needs, and nursing satisfaction on conscious sedation as a pretreatment for diagnostic tests in the guardians of hospitalized children. Journal of the Korea Convergence Society. 2021;12(12):573-581. https://doi.org/10.15207/JKCS.2021.12.12.573
31. Choi YS, Son YJ, Song ES, Cho YK, Kim YO, Kim CJ, et al. Effect of chloral hydrate used for pediatric sedation. Journal of the Korean Child Neurology Society. 2008;16(1):78-85.
32. Boyer RS. Sedation in pediatric neuroimaging: the science and the art. AJNR American Journal of Neuroradiology. 1992;13(2):777-783.