

Effect of sedation using Ketamine for primary closure of pediatric facial laceration

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Abstract

Pediatric lacerations are frequently encountered by plastic surgeons in the emergency room. Since pediatric patients cannot cooperate due to the anxiety and pain occurring during the suture procedure, sedation is induced. Since commonly used drugs inducing shallow sedation such as chloral hydrates are insufficient to perform procedures, the need for deep sedation has been increased. In our experience, inducing sedation with ketamine is safe and allows for accurate procedures.

A total of 106 pediatric patients aged between 3 months to 5 years who visited the emergency room between August 2020 and January 2021 were included in this study. Of the 106 patients, 54 were sedated using ketamine, and the remaining 52 patients who did not cooperate were operated under local anesthesia, and these were set as the control group. The patients were intravenously injected with ketamine 1.5–2.0 mg/kg ketamine while monitoring the blood oxygen saturation, end-tidal CO₂, and other vital signs. The patients were discharged as a complete awakening was confirmed by physicians.

The number of patients who received sedation induced by ketamine was 54 and the number of patients who underwent the procedure without sedation was 52. The mean induction time of a single injection was 35.3 ± 11.3 minutes, and that of additional injection was 253.5 ± 54.1 minute. The total procedure time of the ketamine group was 20.3 ± 11.85 minutes, and that of the nonketamine group was 19.31 ± 10.50 minutes ($P = .454$). No statistically significant differences were found between the 2 groups.

The need for sedation during the suture procedure in an emergency room has been arising not only for reducing pain and anxiety, but also for safe and accurate procedures and scar minimization.

Based on the parental satisfaction and the safety of the procedure, using ketamine is more effective than other drugs and should be used more actively.

Abbreviations: ASA class = American Society of Anesthesiologists class, IV = intravenous, SpO₂ = blood oxygen saturation, ET CO₂ = end-tidal CO₂, HR = heart rate, RR = respiratory rate, BP = blood pressure, CHWSS = Children's Hospital of Wisconsin Sedation Scale, GABA = gamma-aminobutyric acid.

Keywords: deep sedation, emergencies, ketamine, lacerations, pediatrics

1. Introduction

Pediatric lacerations are commonly encountered by plastic surgeons in the emergency room. Physicians have difficulty conducting various examinations and procedures for pediatric patients in the emergency room because they cannot cooperate. Pediatric patients with lacerations cannot cooperate due to the anxiety and pain occurring during the suture procedure.^[1] In some cases, suturing is performed after local anesthesia in a physically restrained state; however, unless in the case of contraindication, a procedure that would be painful should be performed in the state of sedation.

Chloral hydrate, ketamine, propofol, and midazolam are commonly used to induce sedation; additionally, drugs appropriate for the patient are chosen considering various factors,

such as the administration route, sedation level, and side effects.^[2] Chloral hydrate is the most commonly used drug because it is administered orally and is known to have few side effects.^[1] However, it does not have an analgesic effect and can only induce a low level of sedation. Since pediatric patients are often awakened by various stimuli, such as pain or noise, sutures are continued under local anesthesia and in a restrained state in several cases.

As the need for drugs with a deeper sedative effect during suture procedures increases, recent guidelines recommend the use of ketamine as the first option.^[3] In practice, deeper sedation using ketamine in the emergency room is not widely used due to many restrictions, such as difficulty in intravenous administration, additional people for monitoring and medication, complications, and longer stay hours.^[4]

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All data generated or analyzed during this study are included in this published article.

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In our experience, inducing sedation with ketamine during the suture procedure allows for a safer and more accurate procedure. The aim of this study was to evaluate the safety and effectiveness of ketamine use and to introduce the protocol used in our center.

2. Materials and Methods

2.1. Patient information

A total of 106 pediatric patients aged 3 months to 5 years who visited the emergency room of Kangnam Sacred Heart Hospital for 6 months from August 2020 to January 2021 were included in this study. Among 106 patients, 54 patients were induced to sedation using ketamine, and 52 patients who could not be sedated by ketamine such as line failure, rejection by parents, and presence of acute respiratory or cardiac symptoms, were anesthetized using local anesthesia, and this was set as a control group. The chief complaint was facial laceration, excluding the scalp and neck regions.

Only American Society of Anesthesiologists (ASA) classes 1 and 2 were targeted. Patients with underlying diseases, such as active lung and heart disease, and previous sedation with an experience of side effects were excluded. Cases in which the guardian refused sedation and only wanted local anesthesia in the restrained state were excluded. Cases of intravenous (IV) line failure were also excluded.

Prior to the induction of sedation, the plastic surgeons explained the necessity of sedation, drugs to be used, possibility of additional administration, monitoring, process of sedation and suture procedure, and complications, and obtained a consent form.

2.2. Protocols of sedation process

The procedure was performed according to the protocol established in cooperation with the Department of Emergency Medicine. At first, the IV line was inserted, and normal saline (0.9%) was administered through the IV line. All patients were monitored for blood oxygen saturation (SpO_2 , %), end-tidal CO_2 ($ETCO_2$, mm Hg), heart rate (HR, /min), respiratory rate (RR, /min), and blood pressure (BP, mm Hg) before drug administration. O_2 (3L) was administered using a nasal prong.

Under the evaluation of the emergency medicine doctor, the patient was intravenously injected with ketamine 1.5 to 2.0 mg/kg at an initial dose. A score ≤ 2 on the Children's Hospital of Wisconsin Sedation Scale (CHWSS) was defined as sedation success. If an avoidance reaction was present after the injection, 0.5 to 1.0 mg/kg of additional administration was administered up to 2 times.

One physician and nurse monitored the patient every 5 minutes from the time point immediately preceding administration to a completely awakened state; additionally, all the data were written on a sedation record form. Complete awakening was defined as an Aldrete score of ≥ 8 . The induction time is defined as the time taken from ketamine administration to sedation success, and the total procedure time is the time taken from sedation success to dressing.

The patients were discharged after complete awakening, and possible symptoms, such as motor imbalance, gastrointestinal effects, agitation, and restlessness were explained before returning home. The patients were observed in the outpatient clinic of the plastic surgery, and the guardians were requested to complete the 5 point Likert scale questionnaire about their degree of satisfaction with the suture procedures performed in the emergency room (Fig. 1).

In the nonketamine group, under the same monitoring condition as the test group, the body was restrained using a restraining band, and the same local anesthetic as in the test group was

injected into the wound and the procedure was performed with 1 nurse holding the head. If the anesthetic effect was poor, additional anesthetic was administered as needed. Surveys and follow-ups to guardians were undertaken in the same manner.

We also prepared for possible complications. In case of hypersalivation, guedel airway tube application and suction were performed, and in case of desaturation, jaw thrust maneuver was undergone and high flow O_2 was applied in oxygen mask immediately.

The effectiveness of ketamine was evaluated based on the parental satisfaction through the questionnaire and the safety including the complication rate and duration of procedure.

2.3. Suture procedure

The suture procedure was performed by a plastic surgeon. When sedation was successfully induced, 1:100,000 epinephrine mixed with 1% lidocaine solution was injected around the wound for analgesia and hemostasis. Approximately 0.5–1 ml was injected at 1 cm intervals, and there was no case of injection in excess of the maximum dose (5 mg/kg).

After the injection, wound evaluation, such as the length, depth, and surrounding organ injuries, was performed. Irrigation was carried out with normal saline, and nonviable tissue was minimally excised using a scalpel and Metzenbaum scissors. The wound was closed in 2 layers: buried suture with Vicryl #6-0 and skin suture with ethylon #6-0 and mild compressive dressing using foam (mepilex lite®, Mölnlycke Health Care, Sweden) was performed.

2.4. Statistical analysis

All the analyses were performed using SPSS (version 26.0; IBM Corporation, New York) was used, and nominal variables were expressed using frequency and percentage; when continuous variables did not follow a normal distribution, median and quartile ranges were used. A comparative analysis was performed to determine the homogeneity of the 2 groups. A P value < 0.05 was statistically significant.

2.5. Ethics statement

This study conformed to the ethical guidelines of the 1975 Declaration of Helsinki and was reviewed and approved by the Institutional Review Board of Kangnam Sacred Heart Hospital, College of Medicine, Hallym University (IRB number 2021-04-003).

3. Results

A total of 106 pediatric patients were included in the study. The number of patients who underwent the induction of sedation with ketamine during the suture procedure was 54, and that of the patients in the restrained state with local anesthesia was 52. The reason why the local anesthesia group underwent local anesthesia without sedation was when the guardian refused to sedate, failed to start the intravenous line, the patient had acute respiratory and circulatory symptoms, or had a history of sedation. The patient demographics are summarized in Table 1.

There were 40 boys (74%) and 14 girls (26%) in the ketamine group and 37 boys (71%) and 15 girls (29%) in the nonketamine group ($P = .736$), respectively. The mean weight of the 2 groups were 14.21 ± 3.25 and 14.10 ± 3.46 ($P = .874$), respectively. All cases were single lacerations. The mean lengths of laceration were 1.7 ± 0.82 in the ketamine and nonketamine groups were 1.67 ± 0.84 ($P = .788$) in the nonketamine group. There were no statistically significant differences between these factors.

Satisfaction Survey on Suture procedure in sedation state

Name :	Date:
Sex/Age:	

Please indicate whether you agree or disagree with the statements using a 5-point scale. Please circle a number
 - 1=Strongly disagree; 2=Disagree; 3=Neutral; 4=Agree; 5=Strongly agree

1. I had adequate information about sedation and procedure before the procedure	1 2 3 4 5
2. The suture procedure was performed safely	1 2 3 4 5
3. The suture procedure was performed properly	1 2 3 4 5
4. The sedation process was performed safely	1 2 3 4 5
5. The sedation process was performed properly	1 2 3 4 5
6. I was satisfied with the time of procedure	1 2 3 4 5
7. I was satisfied with the time of stay	1 2 3 4 5
8. I was satisfied with the overall experience here for the procedure	1 2 3 4 5
total	

Please give us any suggestions for developing process for you and other patients
 : _____

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Figure 1. The guardians were requested to complete the 5 point Likert scale questionnaire about their degree of satisfaction with the procedure in the emergency room.

Table 1			
Demographics of the patients			
	Ketamine	Local anesthesia	P value
Number of patients (n)	54	52	
Age (mo)	29.07 ± 11.07	30.37 ± 12.86	0.580
Sex (n)			
Male	40	37	
Female	14	15	
Weight (kg)	14.21 ± 3.247	14.10 ± 3.464	0.874
Length of laceration (cm)	1.7 ± 0.82	1.67 ± 0.84	0.788

In this study, sedation with ketamine was successful in all the patients. If sedation was not induced after drug administration within 1 minute, up to 2 additional doses were

allowed; however, sedation was successfully induced in all patients within 1 additional dose. The number of patients who needed additional doses was 14 (26%). The mean induction time in cases requiring only single injection was 35.3 ± 11.3 minutes, and that in cases requiring an additional injection was 253.5 ± 54.1 minute. The total procedure time of the ketamine group was 20.3 ± 11.85, and that of the nonketamine group was 19.31 ± 10.50 minutes ($P = .454$). The mean duration from visit to discharge of the ketamine group was 29.07 ± 11.07 minutes, and that of the nonketamine group was 30.37 ± 12.86 minutes ($P = .580$). No statistically significant differences were found between the groups (Table 2). In the questionnaire of the satisfaction, the mean score of the ketamine group was 4.23 ± 0.59 and 3.78 ± 0.65 in the nonketamine group ($P < .05$), which showed a statistically significant difference (Table 3).

Table 2
Data related to sedation (mean ± SD).

	Ketamine	Local anesthesia	P value
Sedation success rate (%)	100	–	
Anesthesia failure rate (%)	0	–	
Induction time (s)		–	
Single injection	35.3 ± 11.3	–	
Additional injection	253.5 ± 54.1	–	
Additional injection rate (n, %)	14 (26%)	–	
Total procedure time (min)	20.3 ± 11.85	19.31	0.454

Table 3
Degree of satisfaction with anesthesia and the procedure.

	Ketamine	Local anesthesia	P value
Satisfaction score	4.23 ± 0.59	3.78 ± 0.65	<0.05

A total of 19 patients presented with complications, including irritability in 7 cases (12.9%), hypersalivation in 6 cases (11.1%), retching/vomiting in 5 cases (9.2%), and desaturation in 1 case (1.8%) in ketamine group. Total of 44 patient presented with complications, including irritability in 38 cases (73.0%), hypersalivation in 2 cases (3.8%), Retching/vomiting in 2 cases (3.8%) in nonketamine group (Table 4).

4. Discussion

The majority of the lacerations should be primarily closed to prevent infection, rapid healing, and acceptable scarring. Since suture procedures include adequate examination of major structures to be repaired, irrigation, debridement of nonviable tissue, and sutures, which induce various stimuli, such as pain and anesthesia is necessary. Local anesthesia with esters and amides (such as lidocaine) is generally sufficient if the wound is not very long or without injuries to major structures.

However, in the case of pediatric patients, they never cooperate with the suture procedure due to pain and anxiety. Conventionally, the procedure is performed only with local anesthesia in a physically restrained state in unawareness of the need to control the pain and anxiety of pediatric patients. The need for sedation during the suture procedure in an emergency room has been arising not only for reducing pain and anxiety, but also for safe and accurate procedures, and minimizing scarring.^[5]

There are 4 stages of sedation depending on the degree of sedation^[2]: minimal sedation (anxiolysis), moderate sedation, deep sedation, and general anesthesia. Deep sedation is a state of decrease in the consciousness from which patients cannot be easily awakened, but respond to repeated or painful stimuli. The cardiovascular function is generally maintained; however, the ventilatory function may require assistance.^[6]

The depth and methods of sedation were chosen by weighing the benefits and complications. As deep sedation or general anesthesia is accompanied by a depression in the cardiovascular or ventilatory functions, it is selected in cases where the patient's cooperation is difficult due to pain or fear, the operation time is long, the field is excessive, or there is a possibility of instability of the vital signs due to excessive bleeding. Children are an indication for general anesthesia by themselves because of their poor cooperation.^[6,7]

Local anesthesia is generally sufficient for adults to undergo treatment for facial lacerations in the emergency room. In children, even with simple facial lacerations, pain and anxiety are excessive, and cooperation is difficult; therefore, most children require sedation. However, since the complications of sedation are relatively higher than those of adults, deep sedation is usually not performed.

Table 4
Complications.

Complications (n, %)	Ketamine (n = 54)	Nonketamine (n = 52)
Total	19 (35.1%)	44 (84.6%)
Irritability	7 (12.9%)	38 (73.0%)
Hypersalivation	6 (11.1%)	2 (3.8%)
Retching/vomiting	5 (9.2%)	2 (3.8%)
desaturation	1 (1.8%)	0 (0%)

n = number of cases.

Conventionally, suture procedures are performed in a state of minimal sedation using a drug, such as chloral hydrate; however, this method has limitations. The success rate of sedation induction is low; it takes a long time to induce sedation, the patient is easily awakened by various stimuli, and there is little or no effect on pain relief and memory loss. Therefore, in order to compensate for this, the need for deeper sedation is required.^[6]

Chloral hydrate, ketamine, propofol, and midazolam are mainly used to induce sedation; the appropriate drug is selected for the patient in consideration of the level of sedation, administration method, depth of sedation, and side effects.

The drugs commonly used for sedation are as follows: Chloral hydrate is a drug that is most often used for examinations and procedures in emergency rooms because it can be administered orally and does not require close monitoring.^[8] However, according to Olson,^[9] since it has no analgesic effect and the sedation level is low, there is a possibility of sedation failure due to various stimuli during the procedures. Chloral hydrate has been reported to result in a 71% sedation success rate.^[10] Midazolam binds to the postsynaptic gamma-aminobutyric acid (GABA) receptors and increases the permeability to chloride ions, leading to hyperpolarization and stabilization of the neuronal membrane.^[11] However, it has no analgesic action and can cause side effects, such as hypotension, respiratory depression, and paradoxical effects. Propofol is a hypnotic sedative agent that exerts its action through the activation of GABA with fast and short-acting anesthetic properties.^[8] However, propofol also has no analgesic action and may cause complications, such as hypotension, apnea, and airway obstruction.^[12,13]

Ketamine is a derivative of phencyclidine. Its mechanism involves the dissociation of the central nervous system from external stimuli by inhibiting the cerebral cortex and simultaneously stimulating the limbic system.^[2,7,14] As a result, powerful analgesia, deep sedation, and amnesia occur due to sensory isolation. For intravenous injection, the optimal dose is to give an initial dose of 1.5–2.0 mg/kg over 30–60 seconds, and a repeat dose of 0.5–1.0 mg/kg q 5–15 minutes. It is recommended as needed.^[15] The administration of ketamine can increase blood pressure and heart rate; however, it has a lower effect on respiratory suppression than other sedatives. Therefore, *self-breathing is well maintained during the procedure. Side effects, such as opening eyes, movement, vomiting, or hypersalivation, may appear.^[16]

Sedative drug most commonly used is chloral hydrate. It can be administered by mouth, so it is easy to take, and the depth of sedation is shallow, so the risk of complications is low. However, it takes a long time to induce sedation, and patients wakes up even with a small stimulus, so it is not currently used in our hospital and it was used only for sedation for radiologic studies such as computed tomography.^[7]

As the need for sedation increased after comparing various sedative drugs, we chose ketamine for its advantages of deep sedation, anesthetic effect, and low complication occurrence.^[5,17] Among the various types of sedative drugs, ketamine was chosen in our clinic. The main reason is that ketamine has a strong analgesic effect and rare occurrence of respiratory complication.^[18] The other drugs mentioned above especially chlorhydrate most commonly used drug do not have an analgesic effect. As the pain

of the anesthetic itself is also significant, the patients feel pain and the sedation can be relieved.^[19]

Analyzing the statistics in the result, ketamine group shows a total sedation success, including 14 cases requiring only 1 additional injection. Although an exact comparison cannot be made between chloral hydrate and ketamine since there were no cases using chloral hydrate during the period of this study, ketamine has a very high sedation success rate and the time of inducing sedation is very short with average of 35.3 ± 11.3 seconds in the cases of success in 1 attempt, and an average of 253.5 ± 54.1 seconds for 1 more injection.

The rapid success of sedation reduces the waiting time and workload of the physicians and nurses, and the time the patients wait unnecessarily in the emergency room. Physicians had preferred to perform suturing without deep sedation because the process required for deep sedation had been thought to take more time and workload. In this study, there was no statistically significant difference in the time of the procedure between ketamine and local anesthesia group. We assume that without sedation, the time is often delayed because the patients struggle with fear or pain and physicians have to wait for patients to calm down. On the other hand, with sedation, the patients rarely woke up within 20.3 ± 11.85 minutes, which is the average time to finish the procedure. Even in case of waking, the patients did not feel pain because local anesthesia was already done just after sedation. So there was no time delay due to irritability.

Complications occurred in 35% of the total sedation group and were minor complications that could be treated immediately except for desaturation in 1 patient. In the nonketamine group, hypersalivation, retching/vomiting, and desaturation were less frequent, but irritability occurred in 73% of patients.

Ketamine is commonly used for sedation in adults and is well known as an adequate drug suitable for use in various examination and procedures in pediatric patients in the emergency room.^[20] However, in actual clinical application, there are many limitations due to the lack of monitoring manpower, misunderstandings about skills and extended stay time, and refusal by guardians.

Although there are limitations in that a sufficient number of test groups were not included and that the study was conducted retrospectively, with adequate monitoring and protocols for procedures and complications, we have demonstrated that sedation using ketamine is safe and much more effective than without ketamine during primary closure of pediatric lacerations.

We expect that more common use of ketamine for sedation will make primary closure of pediatric lacerations safer and more effective in the emergency room.

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