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Sedoanalgesia-based anesthesia approach in pediatric extracorporeal shock wave lithotripsy cases

Pediatrik ekstrakorporeal şok dalga litotripsi olgularında ayaktan anestezi uygulamaları

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Pediatric ESWL with Sedoanalgesia
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ABSTRACT

BACKGROUND
The aim of the study is to evaluate the safety, feasibility, and effectiveness of sedoanalgesia in pediatric patients undergoing extracorporeal shock wave lithotripsy (ESWL).

METHODS
This retrospective study included pediatric patients who underwent ESWL under a standardized sedoanalgesia protocol consisting of intravenous midazolam (0.0] mg/kg), fentanyl (1 mcg/kg), propofol (0.5–1 mg/kg), and ketamine (0.5–1 mg/kg) as needed. Any complications or adverse events related to sedoanalgesia were documented.

RESULTS
A total of 190 pediatric patients underwent 453 ESWL sessions. All procedures were completed successfully without conversion to general anesthesia. Spontaneous ventilation was preserved in all patients, and airway instrumentation was not required. Minor complications included transient desaturation (3.3]%) and nausea/vomiting (19.2%). No major anesthesia-related adverse events were observed. The mean stone size was 9 ± 2.86 mm for the kidney and 8 ± 2[14 mm for the ureter. The average number of sessions per patient was 2.4.

CONCLUSION
The fundamental principle of pediatric anesthesia is to use the lowest effective and shortest-acting anesthetic agents through careful titration. Our findings demonstrate that ESWL can be safely and effectively performed in children using a balanced sedoanalgesia protocol.

KEYWORDS
ESWL, fentanyl, ketamine, midazolam,non-operating room anesthesia,pediatric anesthesia,procedural sedation,propofol,sedoanalgesia

ÖZ

AMAÇ
Bu çalışmada, ekstrakorporal şok dalga litotripsi (ESWL) uygulanan pediatrik hastalarda sedoanaljezi kullanımının güvenliği, uygulanabilirliği ve etkinliğinin değerlendirilmesi amaçlanmıştır.

GEREÇ YÖNTEM
Bu retrospektif çalışmada, standart sedoanaljezi protokolü altında ESWL uygulanan pediatrik hastalar incelenmiştir. Kullanılan protokol intravenöz midazolam ([0].[05] mg/kg), fentanil ([1] mcg/kg), propofol ([0].[5]–[1] mg/kg) ve gerektiğinde ketamin ([0].[5]–[1] mg/kg) içermektedir. Komplikasyonlar ve advers olaylar kaydedilmiştir.

BULGULAR
Toplam 190 pediatrik hastaya 453 ESWL seansı uygulanmıştır. Tüm işlemler genel anesteziye geçilmeden başarıyla tamamlanmıştır. Hastaların tamamında spontan ventilasyon korunmuş ve hava yolu enstrümantasyonu gerekmemiştir. Minör komplikasyonlar arasında geçici desatürasyon (%[3],[3]) ve bulantı/kusma (%[19],[2]) yer almaktadır. Majör anesteziye bağlı advers olay gözlenmemiştir. Ortalama taş boyutu böbrek için [9] ± [2],[86] mm, üreter için [8] ± [2],[14] mm olup, ortalama seans sayısı [2],[4] olarak saptanmıştır.

SONUÇ
Pediatrik anestezide temel yaklaşım, en düşük etkili dozda ve kısa etkili ajanların titrasyonla uygulanmasıdır. Bulgularımız, ESWL işlemlerinin dengeli bir sedoanaljezi protokolü ile güvenli ve etkili bir şekilde gerçekleştirilebileceğini göstermektedir.

ANAHTAR KELİMELER
Ameliyathane dışı anestezi, ESWL, fentanil, girişimsel sedasyon, ketamin, midazolam, pediatric anestezi, propofol, sedoanaljezi

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Though urolithiasis is less common in children than in adults, it has shown an increasing incidence in recent years, particularly among children under 15 years of age (1,2). Standard treatment approaches for pediatric urolithiasis have evolved with the development of minimally invasive and non-invasive techniques. Among these, extracorporeal shock wave lithotripsy (ESWL) has become the primary modality for treating upper urinary tract stones in children due to its efficacy and non-invasive natüre (3,4).

The success of ESWL is influenced by several factors, including stone size, location, composition, and number. Despite their relatively small ureters, the stone fragment passage rates in children are higher than in adults, likely due to the flexibility and elasticity of the pediatric ureter, as well as the body's higher fluid content and smaller volume, which improves shock wave conduction (3,5). Numerous studies have confirmed the safety and effectiveness of ESWL in children, including infants (5,6).

However, the success of ESWL also depends heavily on adequate pain control and patient immobility during the procedure. Although ESLW is non-invasive, it is associated with deep and sharp pain that requires appropriate anesthesia or sedation. Unlike adult patients, children often require sedation or general anesthesia to tolerate the procedure and remain immobile (7).

Various anesthetic approaches have been reported to date, ranging from general anesthesia to combinations of intravenous sedatives and analgesics. Each technique has its own advantages and risks. General anesthesia provides deep sedation and complete immobility but it can require a longer preparation and recovery time. When performed properly, , sedoanalgesia offers a more time- and resource-efficient option, especially in outpatient settings. The most commonly used agents for pediatric sedation in ESWL procedures are propofol, ketamine, midazolam, and fentanyl, either alone or in combination (8,9,10).

In this study, we aimed to evaluate the 10-year clinical experience of a standardized sedoanalgesia-based anesthesia protocol in pediatric ESWL procedures. We investigated the feasibility, safety, and effectiveness of this approach, documenting any adverse events or complications that occurred.

Materials and Methods

This retrospective study included pediatric patients under the age of 18 who underwent ESWL at the Dokuz Eylül University ESWL Unit between November 9th, 2009, and November 18th, 2019. Ethical approval was obtained from the Dokuz Eylül University Non-Invasive Research Ethics Committee (Date: 01.06.2020; Decision No: 2020/11-60). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient selection and data collection

A total of 190 pediatric patients were included. Demographic data, stone characteristics (size, location), number of ESWL sessions, anesthetic drugs used, and perioperative parameters were collected retrospectively from electronic medical records, ESWL unit charts, and non-operating room anesthesia documentation.

ESWL procedure

All ESWL procedures were performed using a PCK Stone Lith v3 Lithotriptor, under the supervision of two urologists experienced in the treatment of pediatric stone disease. Shock waves were initiated at low energy and gradually increased to a maximum of 18 kV. The number of shock waves applied per session generally exceeded 1500 pulses. The number of sessions per patient ranged from 1 to 4, scheduled at 7-day intervals. If stone fragments remained after three sessions, ESWL was considered unsuccessful and alternative treatment options were considered. However, a fourth ESWL session was performed for patients whose parents had declined surgical treatment.

Patient positioning was guided by stone localisation, with ESWL performed in the supine, lateral, or prone position as appropriate. Pre-procedural imaging included kidney-ureter-bladder (KUB) radiography and/or urinary ultrasonography.

Anesthesia and sedation protocol

All patients underwent a pre-anesthesia evaluation in the outpatient clinic. In accordance with the United Nations Convention on the Rights of the Child, informed consent was

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obtained from the parents and age-appropriate assent from the children.

On the day of the procedure, patients were accompanied by their parents to the premedication area.

No oral sedative premedication was administered. An intravenous (IV) line was inserted in the presence of the parents to minimize anxiety. After being separated from their parents, sedation was initiated in the ESWL room.

The standardized sedoanalgesia protocol consisted of

IV midazolam (0.05 mg/kg)

IV fentanyl (1 µg/kg)

IV propofol 10% (0.5–1 mg/kg), administered just before the procedure

IV ketamine (0.5–1 mg/kg), used in selected cases when additional sedation was required

IV fluid: 4 mL/kg of 1/3 isotonic solution (Izomix)

Sedation depth was monitored and titrated to maintain a Modified Ramsay Sedation Score of 3–4/6. All patients received oxygen via face mask at 2 L/min during the procedure. The average duration of the ESWL procedure was approximately 15 minutes; however, the total procedural time including IV access, positioning, sedation, awakening, and recovery averaged around 45 minutes.

To prevent postoperative nausea and vomiting, 2–4 mg of IV dexamethasone was administered either before or immediately after the procedure, depending on clinical judgement. Despite prophylaxis, the incidence of nausea and vomiting was relatively high. Potential contributing factors such as opioid use, positioning, and procedure-related stimulation are discussed in the Results section.

Monitoring and discharge

All patients were monitored continuously using pulse oximetry and intermittent non-invasive blood pressure monitoring during and after the procedure. Following the procedure, patients were observed in the recovery area of the ESWL unit for at least 4 hours. They were discharged in the company of their parents once they were clinically stable.

Statistical analysis

Statistical analyses were performed using SPSS version 24.0. Descriptive data are presented as mean ± standard deviation (min–max). Associations between stone size or number of sessions and variables such as gender, age group, and stone location were assessed using the Student's t-test, with $p < 0.05$ considered statistically significant.

Results

Table 1. Demographic and procedural characteristics of pediatric patients undergoing ESWL

Characteristic	Value
Total patients (n)	190
Male (%)	95 (50%)
Female (%)	95 (50%)
Median age (years)	5
Age range (years)	1–17
Mean kidney stone size (mm)	9 ± 2.86
Mean ureter stone size (mm)	8 ± 2.14
Total ESWL sessions	453
Average sessions per patient	2.4
Single-session patients (n)	87
Multiple-session patients (n)	103

A total of 190 pediatric patients 95 males, 95 females who underwent 453 ESWL sessions were included in the analysis. The median age of the patients was 5 years (range: 1–17). The mean kidney stone size was 9 ± 2.86 mm, and the mean ureteral stone size was 8 ± 2.14 mm.

All patients received sedoanalgesia using a combination of intravenous midazolam (0[05 mg/kg), fentanyl (1 mcg/kg), propofol (0.5–1 mg/kg), and ketamine (0.5–1 mg/kg) when needed. The protocol ensured borh spontaneous ventilation and minimal airway intervention. All procedures were completed successfully.

The number of shock waves per session ranged from 1000 to 2000, with most sessions exceeding 1500 shocks. The average number of sessions per patient was 2.4. A single session was sufficient for 87 patients, while the remaining patients required multiple sessions.

In terms of safety, transient desaturation occurred in 15 patients (7.9%) and was managed with supplemental oxygen and airway repositioning. Nausea and vomiting occurred in 87 patients (45.8%) despite the prophylactic administration of dexamethasone (Figure 1).

Ecchymosis at the shock site was observed in 35 patients (18.4%). There were no major complications or need for endotracheal intubation. The method's feasibility was demonstrated by the absence of unplanned hospital admissions and the rapid discharge of all cases. The sedation

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protocol was well-tolerated, with no patients requiring conversion to general anesthesia.

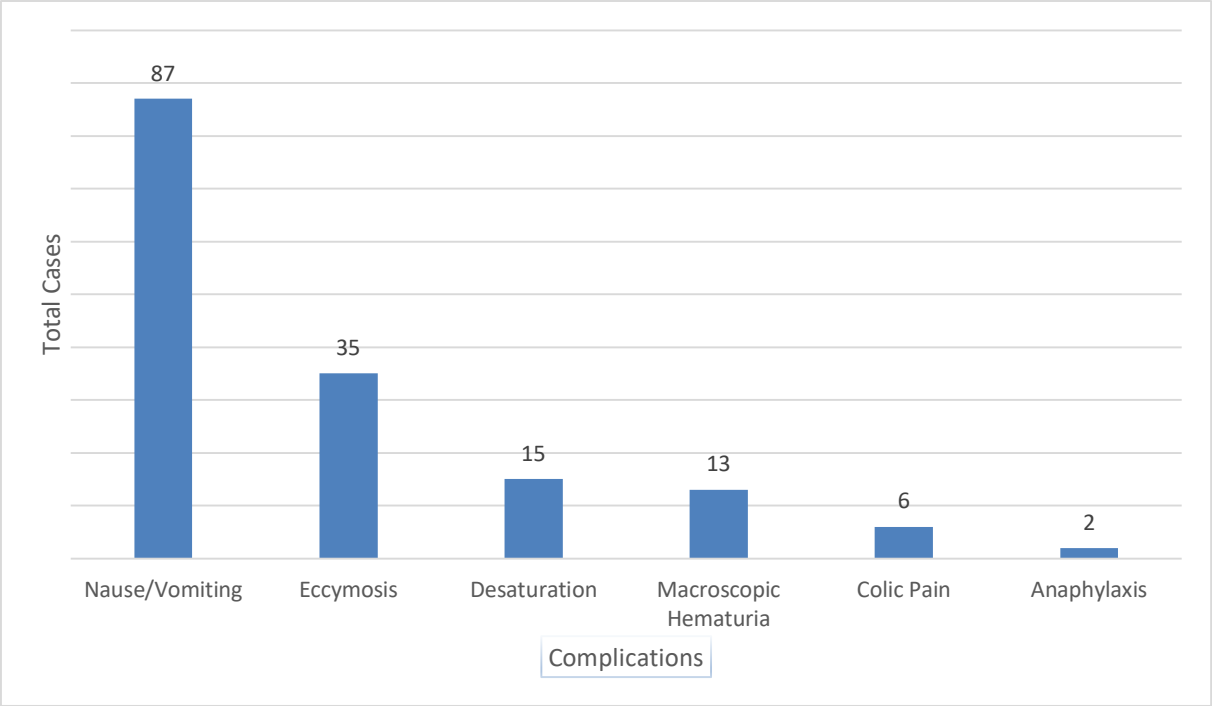


Figure 1. Complications in ESWL cases during Sedoanalgesia.

Discussion

This retrospective study presents a 10-year experience using a sedoanalgesia-based anesthesia protocol during ESWL procedures in pediatric patients. The protocol, which comprises midazolam, fentanyl, propofol, and ketamine, enabled procedures to be completed without conversion to general anesthesia and demonstrated an acceptable safety profile (1).

ESWL is widely employed as a first-line treatment for urinary tract stones in pediatric patients. However, there is no consensus on the optimal anesthesia method, especially in outpatient settings (2). Effective analgesia and immobilization are essential for the successful completion of procedures on children. While general anesthesia can achieve these outcomes, it may be more costly and time-consuming. When administered by experienced teams under appropriate monitoring and standardized protocols, sedoanalgesia offers a practical alternative (3).

In our study, transient desaturation occurred in 15 patients (7.8%), all of whom responded to standard airway maneuvers and supplemental oxygen. No advanced airway intervention was required. This finding highlights the importance of continuous monitoring and preparedness for airway management during the procedure (3,5).

Postoperative nausea and vomiting (PONV) was observed in 35 patients (18.4 %) despite the prophylactic use of dexamethasone. This rate suggests that the current antiemetic prophylaxis may be insufficient, given the emetogenic potential of opioid and ketamine combinations (5). Future applications of multimodal antiemetic strategies may therefore be beneficial. Reducing PONV would enhance discharge efficiency and improve the quality of outpatient care (6).

Local ecchymosis was noted in 35 patients (18.4%) and resolved spontaneously. No major complications, such as perirenal hematoma, severe allergic reactions, or long-term neurological events, were encountered (7). Additional interventions, such asureteral stent placement in 14 patients and hospitalization for renal colic in 6 patients, were attributed

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to underlying urological conditions rather than the anesthesia technique. A notable strength of our protocol is its flexibility. Midazolam provided anxiolysis and amnesia, fentanyl ensured potent analgesia, propofol enabled a rapid onset and easy titration, and ketamine was reserved for cases requiring deeper dissociative anesthesia (8). This combination enabledreduced the dosages of individual agents, thereby lowering the risk of adverse effects. However, ketamine may cause hallucinations or agitation, particularly if not co-administered with benzodiazepines (9).

Compared to general anaesthesia, sedoanalgesia during pediatric ESWL offers advantages such as faster recovery, reduced cost, and compatibility with outpatient or rural healthcare settings (11). However, this approach requires skilled personnel, continuous monitoring, and preparedness for airway intervention. In centers without dedicated anesthesiologists, adherence to established sedation guidelines published by major anesthesia societies is essential (12).

Recent literature suggests the usefulness of novel sedation protocols and risk stratification models for pediatric ambulatory urological procedures (18,19).

When administered under proper monitoring by experienced personnel, sedoanalgesia is a viable alternative to general anesthesia for pediatric ESWL procedures, as supported by recent literature advocating for individualized sedation strategies (13,14). It is safe, practical, and well-suited to outpatient conditions. Recent publications support the development of new sedation protocols and the implementation of risk stratification models in ambulatory urological interventions (15,16,17).

Limitations

This study has several limitations, primarily due to its retrospective design. Important radiological parameters, such as stone density on computed tomography scans, skin-to-stone distance, and infundibulopelvic angle measurements, were unavailable and could therefore not be included in the analysis.

Additionally, the timing of drug administration, premedication duration (including separation time from parents), and the overall procedure duration were not consistently recorded, partly due to technical delays during patient positioning. These factors were influenced by external variables, such as the intellectual and emotional characteristics of the family, as well as the patient's age and gender. Consequently, procedure time was excluded from the analysis.

Moreover, patients were referred from various geographic regions of Turkeyoften only for the ESWL sessions. For this reason, we were unable to conduct follow-ups with all patients after the procedure, meaning that the stone-free rate (SFR) could not be calculated.

Most notably, no objective measurements were taken to evaluate the effectiveness of the analgesia. Parameters such as intra-procedural pain scales, the need for patient repositioning due to movement, sedation-related costs, and total procedural time were not evaluated. These omissions are the main methodological limitations when assessing the effectiveness and feasibility of the sedoanalgesia protocol.

Conclusion

Pediatric anesthesia procedures, particularly those performed outside the operating theatre, such as ESWL,, require careful planning to achieve a balance between efficacy and safety. Our experience demonstrates that for selected paediatric ESWL cases, sedoanalgesia can be a feasible and safe alternative to general anesthesia. This approach, using short-acting agents at minimal effective doses, allowed the completion of procedures without the need for conversion to general or neuraxial anesthesia, thereby reducing anesthesia-related risks and recovery time.

Despite its retrospective limitations, this study suggests that anesthesia practices for pediatric outpatient procedures—particularly remote anesthesia procedures—should continue to evolve towards less invasive yet effective methods. Further prospective studies with standardized analgesia assessment metrics are necessary to validate these findings and optimize sedoanalgesia protocols for broader clinical use.

Disclosure

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