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Original Article

Anesthesia View in Percutaneous Nephrolithotomy: A 3-year Experience of a Referral Hospital

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ABSTRACT

Objective: The aim of this study was to document the use of general anesthesia for patients who underwent percutaneous nephrolithotomy (PNL) during a 3-year period and to examine the current discussion related to anesthesia techniques in the context of the literature.

Methods: Patients scheduled for PNL between 2015 and 2017 were assessed retrospectively. Patient demographic data, the characteristics of the renal stones, the duration of the operation, blood transfusion requirements, and complications of the PNL procedure and general anesthesia were evaluated.

Results: A total of 521 patients were included in this study. The mean age was 48.32±0.61 years. The mean stone size was 22.48±0.47 mm. The mean duration of the operation was 106.30±1.56 minutes, and 79.07% of patients were stone-free after the procedure. The mean fluoroscopy time was 23.30±1.45 seconds and the mean irrigation fluid volume was measured as 8.70±0.23 L. The decrease in the hemoglobin and hematocrit levels after the procedure was statistically significant ($p<0.0001$), with a transfusion rate of 4.99%. Fever after surgery and hemorrhage not requiring blood transfusion were the major complications (13.4% and 10.74%, respectively) seen, using the Clavien classification system. Difficult intubation (1.2%), post-extubation laryngospasm (2.3%), refractory nausea (1.5%), bronchospasm (0.38%), ischemic electrocardiography changes (0.19%), and delirium (0.19%) were the major anesthesia problems.

Conclusion: General anesthesia is a safe and effective method for PNL with well-known risks. Regional anesthesia techniques have also been reported in PNL procedures as an alternative to general anesthesia in recent years. Further clinical trials with large patient groups are needed to demonstrate the safety and efficacy of regional anesthesia in PNL.

INTRODUCTION

Percutaneous nephrolithotomy (PNL) is used to treat large or complex calculi.[1] Fernström and Johansson[2] first reported the removal of a renal calculus through a nephrostomy tract, and since then, the technique has developed with an increasing success rate and decreasing complications and mortality.[3]

There is considerable debate about the anesthesia technique to be used for PNL. Although regional anesthesia has gradually been gaining popularity, the procedure is usually performed under general anesthesia, which protects the patient's airway in the prone position and provides for tidal volume control during the puncture to minimize pleural injury. It also maintains patient and surgeon comfort when there is a need for prolonged anesthesia and allows for the removal of large stones.[4]

This hospital is a referral center for urinary stones and PNL operations have been performed for a long time with a high success rate. The primary goal of this study was to document PNL operations and evaluate the perioperative management of these patients with respect to anesthesia.

MATERIAL AND METHODS

The study group was composed of patients admitted to the hospital for renal stones and scheduled for PNL between 2015 and 2017. According to institute protocol, anesthesiologists performed a routine preoperative risk assessment, evaluating total blood count, coagulation, renal and hepatic function tests, chest X-ray, and electrocardiogram (ECG) results. Further evaluation was performed if any pathological finding was detected in the assessment of the patient history, co-morbidities, and physical examination. Written informed consent was obtained from all patients.

The general procedure was that after premedication with 0.01 to 0.02 mg/kg midazolam and 1 to 2 µg/kg fentanyl, anesthesia was induced with 5 to 7 mg/kg thiopental sodium or 2 to 3 mg/kg propofol. Neuromuscular relaxation was provided with 0.6 mg/kg rocuronium in all cases, and following endotracheal intubation, mechanical ventilation with a tidal volume of 8 to 10 mL/kg and a respiratory rate adjusted to normocapnia was provided. Anesthesia maintenance was secured with sevoflurane or desflurane in a 60% O_2-air mixture. All of the patients were initially administered a crystalloid solution via an 18-G peripheral venous line, and subsequently the fluid need was monitored based on duration and severity of the operation. All of the procedures were performed in the prone position.

Standard monitoring, including continuous ECG, pulse oxymetry, and end-tidal CO_2 was applied to all patients. A right or left radial artery cannula was inserted to assess invasive blood pressure and perform blood sampling during the intraoperative period.

Multimodal analgesia with paracetamol and tramadol was used for postoperative pain control, and metoclopramide was administered to all of the patients to prevent nausea and vomiting, as well as prophylactic antibiotic treatment.

Percutaneous nephrolithotomy procedure

Following general anesthesia, while performing the cystoscopy, a 4- or 5-F open-end ureteral catheter was inserted while the patient was in the lithotomy position. Then a Foley catheter (18- to 20-F depending on patient's age and size) was inserted per urethra and taped to the ureteral catheter prior to the patient being brought into the prone position. An appropriate calyceal puncture was performed under full sonographic guidance with an 18-G percutaneous entry needle (Boston Scientific Corp., Marlborough, MA, USA). Following puncture of the kidney, a 0.038-in guidewire was inserted into the collecting system (the ureter when possible) and mechanical dilators were used for percutaneous tract dilation (Amplatz sheath; Boston Scientific Corp., Marlborough, MA, USA) until 28- to 30-F dilation was achieved. Following the placement of an appropriate access sheath, a standard 26-F nephroscope (Karl Storz GmbH & Co. KG, Tuttlingen, Germany) was placed directly into the kidney through the tract and the stone was disintegrated using an ultrasonic lithotripsy probe (Swiss Lithoclast, EMS Electro Medical Systems S.A., Nyon, Switzerland). Fragments were removed using suction, a basket, or grasping forceps. At the end of the procedure, a re-entry nephrostomy catheter (14-F) was inserted, and an antegrade pyelography was performed to check for possible complications in all cases. Stone clearance was assessed with a fluoroscopic evaluation. During all procedures, 0.9% sodium chloride was used as irrigation fluid.

The data were collected in 4 steps and recorded on pre-prepared forms. First, we searched the hospital electronic database to find patients who underwent a PNL operation. Next, we reviewed the patients' anesthesia records to extract data related to age, gender, American Society of Anesthesiologists (ASA) physical status, duration of the operation, blood transfusion requirements, and any adverse situation during the intraoperative period. Characteristics of the stones and details about the PNL procedure were recorded from the clinical registry in urology and operation notes. Finally, patient hemoglobin level before and after the procedure and the duration of hospitalization were recorded from information in the hospital database.

The study protocol was approved by the scientific research ethics committee of Kartal Dr. Lutfi Kirdar Training and Research Hospital and the research was conducted according to the ethical principles outlined in the Helsinki Declaration.

Statistical analysis

The data were presented as the mean±standard error of the mean. Using the Prism 5.0 program (GraphPad Software, San Diego, CA, USA), a Wilcoxon matched pairs test was used to compare descriptive measures, and to evaluate quantitative data. $P<0.05$ was considered to be significant.

RESULTS

A total of 521 cases (349 males/172 females; male/female: 2.02) were treated with standard PNL for renal stones during the study period. The age of the patients ranged from 5 to 84 years (mean age: 48.32±0.61 years) and the majority of patients were ASA II (66.09%). The patient demographic data are provided in Table 1.

The mean size of the treated stones was 22.48±0.47 mm. Stone lateralization was mostly left-sided (57.58%). The ratio of renal pelvis stones was 35.89% (Table 2).

The mean duration of the operation was 106.30±1.56 min-

Table 1. Patient demographic data

	n	%	Mean±SD
Age (years)*			48.32±0.61
Gender, n (%)			
Male	349	66.99	
Female	172	33.01	
Body mass index (kg/m^2)*			27.48±0.54
ASA physical status, n (%)			
I	98	18.01	
II	349	66.09	
III	68	13.05	
IV	6	1.15	

*Data shown as mean±standard error. ASA: American Society of Anesthesiologists.

Table 2. Stone characteristics

	n	%	Mean±SD
Stone size (mm)*			22.48±0.47
Hounsfield unit*			776±25.46
Degree of hydronephrosis (grade)*			1.56±0.13
Lateralization			
Right-sided	221	42.42	
Left-sided	300	57.58	
Stone location			
Renal pelvis	187	35.89	
Upper calyx	56	10.75	
Lower calyx	104	19.96	
Multiple calyces	174	33.40	

*Data shown as mean±standard error.

utes. The stone-free rate 1 week after the procedure was 79.07%. The mean fluoroscopy time was 23.20±1.45 seconds, and the mean irrigation fluid volume was 8.70±0.23 L. There was a significant decrease in hemoglobin and hematocrit levels after surgery (p<0.0001) (Table 3).

According to the modified Clavien classification,[5] 126 patients demonstrated grade 1 complications: fever after surgery and hemorrhage not requiring blood transfusion were noted in 13.4% and 10.74% of cases, respectively. In all, 26 patients (4.99%) had a blood transfusion, and pulmonary complications were encountered in 2 patients (0.38%). There was only 1 (0.19%) fatal complication due to septic shock in a patient admitted to the intensive care unit (Table 4).

Other problems encountered in the perioperative period were difficult intubation (10 patients; 1.2%), post-extubation laryngospasm (12 patients; 2.3%), bronchospasm after intubation (2 patients; 0.38%), refractory nausea (8

Table 3. Evaluation of the outcome of the procedure in terms of success rate and early postoperative follow-up data

	Overall	p**
Mean duration of the procedure (min)*	106.30±1.56	
Stone-free rate, n (%)		
First week	412 (79.07)	
Third month	429 (82.34)	
Residual stone > 4 mm, n (%)	103 (19.76)	
Unsuccessful, n (%)	6 (1.15)	
Mean hospital stay (days)*	4.58±0.15	
Auxiliary procedures, n (%)	46 (8.82)	
Mean fluoroscopy time (s)*	23.20±1.45	
Irrigation fluid volume (L)*	8.70±0.23	
Mean hemoglobin level (g/dL)		
Before operation	13.76±0.06	<0.0001
After operation	12.16±0.05	
Mean hematocrit level (%)		
Before procedure	41.38±0.20	<0.0001
After procedure	35.79±0.18	

*Data shown as mean±standard error. **p<0.05 was considered significant. Wilcoxon matched-pairs test was used to evaluate quantitative data.

Table 4. Evaluation of the type and grade of complications according to modified Clavien classification

Grade	Complication	n	%
1	Fever >38°C	70	13.4
	Hemorrhage/hematuria not requiring blood transfusion	56	10.74
2	Hemorrhage/hematuria requiring blood transfusion	26	4.99
	Urinary tract infection requiring additional antibiotics	28	5.37
	Urine leakage <12 h	12	2.30
3a	Double-J stent placement for ureteral stone	14	2.68
	Thorax tube for hydrothorax	2	0.38
3b	Endoscopic treatment for ureteral stone	18	3.45
4b	Sepsis	2	0.38
5	Death	1	0.19

patients; 1.5%), ischemic ECG changes (1 patient; 0.19%) and delirium in the post-anesthesia care unit (1 patient; 0.19%).

DISCUSSION

Recently, several studies about the effect of anesthesia type on PNL have drawn attention. Ballestrazzi et al.[6] first reported using regional anesthesia in a study of 112 patients who underwent PNL with epidural anesthesia that had an 88% satisfactory result. In a randomized controlled trial comparing the efficacy of general and regional anesthesia, intraoperative hemodynamic parameters were found to be comparable in both groups, while visual analogue pain scores and the analgesic requirement was comparatively less in the regional anesthesia group.[7] Kuzgunbay et al.[8] found no significant difference regarding operation time, volume of irrigation fluid, intraoperative complications, hemoglobin level, or hospital stay in a comparison of general and combined spinal-epidural anesthesia. It has also been suggested that spinal anesthesia might be a better choice as it offers better hemodynamic maintenance and eliminates some of the complications of general anesthesia.[9]

In the literature, the most emphasized point of regional anesthesia is the reduced analgesic requirement. Mehrabi et al.[10] indicated that this advantage was apparent within a short period and that on the second postoperative day there was no significant difference in the analgesic requirement between patients who underwent general and regional anesthesia. Predictable and unpredictable complications of PNL include hemorrhage, injuries resulting from the collection system, technical complications, hypothermia, fluid overload, sepsis, stricture formation, nephrocutaneous fistula, renal damage, and even death.[11–13] Pain (49%), fever (30%), urinary tract infections (11%), and renal colic (4%) were reported as minor complications in one study, while septicemia (4.1%) and severe hemorrhage (2.7%) were reported as major complications.[14] Lee et al.[15] reported a 12% transfusion rate in 500 PNL patients as the most frequent complication. This rate has also been reported to be as high as 23.8%.[11] In a case of excessive bleeding, clamping of the nephrostomy tube and placement of a larger nephrostomy tube or balloon tamponade may be necessary.[16] In some conditions, angiographic embolization may be a treatment of choice.[17] In our study, the most commonly encountered complication was fever after surgery (Clavien grade 1; 13.43%). The mean hemoglobin and hematocrit level after the procedure was 12.16±0.05 g/dL and 35.79±0.18%, respectively. These levels were significantly less than pre-surgical levels ($p<0.0001$). The overall transfusion rate was 4.99%. This result was significantly lower than previously reported ratios.[11,15] PNL operations have been performed at our center for 16 years, including many complicated cases. The use of ultrasonic guidance with the calyceal system has decreased the hemorrhage and blood transfusion rates in our patients in comparison with many other centers.

In comparative studies of general and regional anesthesia, the most emphasized issue is the hazards of general anesthesia in the prone position. These include accidental extubation, kinking of the endotracheal tube, torsion of the neck veins leading to facial or ocular edema, ecchymosis, and peripheral nerve injuries on pressure points.[4] The prone position is widely used in a variety of surgical procedures and possible complications have been well defined.[18,19] Due to abdominal muscle paralysis during general anesthesia, the functional residual capacity and arterial partial pressure of oxygen are increased, while chest wall and lung compliance remain unchanged. This physiological respiratory change may be advantageous in many conditions.[20,21] In this study, all of the procedures were conducted in the prone position, and no position-related complication was recorded.

Anesthetics affect thermoregulation, and this is an underestimated issue. During general anesthesia, hypothermia can develop in 3 phases. Rapid heat loss can develop within the first hour (phase I). Heat loss exceeds production in phase II after 2 to 4 hours, and in the third phase, a thermal steady-state, occurs after 3 to 4 hours and peripheral vasoconstriction is triggered.[22,23] Thermoregulation is also affected by regional anesthesia. Due to the disruption of thermal input in the blocked region, the patient cannot distinguish between warm and cold. Supplementation of sedatives or analgesics makes the hypothermic condition worse.[23] Due to the large quantity of irrigation fluid used during a PNL procedure, body core temperature may decrease more than expected. Hypothermia occurrence is a limitation of our study. As a result of missing data on this topic, statistical analysis could not be conducted. Further studies monitoring body temperature during a PNL may provide more definitive data about unintended hypothermia in this procedure.

The lungs and the pleura are the most frequently injured organs during PNL, with a ratio of between 2% and 8%.[24,25] In cases of regional anesthesia, during the supracostal puncture, the patient must follow verbal commands and continue breathing. This requires good patient cooperation.[26] This is a disadvantage of regional anesthesia in PNL and it may only be an appropriate alternative to general anesthesia for a selected patient group. Furthermore, in unexpected conditions, such as vascular injury or organ perforation requiring open surgery or urgent airway problems requiring endotracheal intubation, the prone position prevents emergency intervention. These factors have not been adequately discussed in previous reports. In our patients, 1 patient (0.19%) had pleural effusion and

1 patient (0.19%) had hemopneumothorax managed with a chest drain, a significantly smaller ratio than that seen in other reports.[24,25]

Another source of conflicting data is the effect of anesthesia type on fluoroscopic screening time. Our mean fluoroscopic screening time was 23.20±1.45 seconds under general anesthesia. The ultrasonic guidance reducing the fluoroscopy duration in our procedures resulted in decreased radiation exposure for both patients and the environment. Cicek et al.[27] reported that regional anesthesia shortened the fluoroscopy time to 4.56±2.8 vs. 5.06±2.83 minutes. Moawad et al.,[7] however, found that the anesthesia technique had no effect on fluoroscopy time This aspect needs further investigation.

The mean duration of surgery was 106.34±35.69 minutes in our PNL patients. Reddy et al.[24] reported a mean duration of 2.9±0.9 hours (range: 1.5–6 hours) in these procedures. Using an ultrasonographic approach on the renal calyceal system also decreases the operation time.

The mean postoperative length of stay in the hospital after PNL varies and predictors are multifactorial. Patel et al.[28] reported 4.0±3.5 vs 2.7±1.2 days in high-risk and low-risk patients, respectively, with a significant difference. The patient's age was not a predictive factor.[29] The mean length of stay was 5.6 days in a study of 172 patients (range: 1–35 days) and an elevated C-reactive protein level was demonstrated to be one of the causes of longer hospitalization.[30] The mean hospitalization duration was 4.58±0.15 days after general anesthesia in our study. This study did not examine the reasons for the length of stay. This issue may be a subject for new studies.

Another limitation of our study is the evaluation of patients' satisfaction. As a result of retrospective data collection, there were no data on this point. In the literature, some authors have demonstrated a higher level of satisfaction in patients receiving regional anesthesia,[31,32] while others have reported higher satisfaction scores in both patients and surgeons in the general anesthesia group.[7] These studies were conducted with small study groups, so further studies with large case series are needed to address this question.

In conclusion, each anesthesia technique has advantages and disadvantages in all surgical procedures. General anesthesia is a safe and effective anesthesia technique in PNL with close follow-up and awareness of possible complications. Some aspects of regional anesthesia in PNL still remain unclear and need further investigation in large study groups.

Ethics Committee Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the Helsinki Declaration and its later amendments or comparable ethical standards.

Approved by Kartal Dr. Lütfi Kırdar Education and Research Hospital (date: January 30, 2018; decision no.: 2018/514/122/2).

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Authorship Contributions

Concept: B.Ç., B.E.; Design: B.Ç., B.E.; Data collection &/or processing: B.Ç., B.E.; Analysis and/or interpretation: B.Ç., B.E.; Literature search: B.Ç., B.E.; Writing: B.Ç., B.E.; Critical review: B.Ç., B.E.

Conflict of Interest

None declared.

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Anestezi Açısından Perkütan Nefrolitotomi: Bir Referans Hastanesindeki Üç Yıllık Deneyim

Amaç: Bu çalışmada 3 yıllık süre içerisinde perkütan nefrolitotomi (PNL) yapılan hastaların genel anestezi uygulamalarının dokümantasyonu ve anesteziye dair tartışmaların literatür eşliğinde irdelenmesi amaçlandı.

Gereç ve Yöntem: 2015-2017 yılları arasında PNL yapılan hastalar retrospektif olarak değerlendirildi. Hastaların demografik verileri, böbrek taşlarının karakteristik özellikleri, operasyon süreleri, kan transfüzyon ihtiyaçları, PNL girişimi ve genel anestezinin komplikasyonları ele alındı.

Bulgular: 521 hasta bu çalışmaya dahil edildi. Ortalama yaş 48.32±0.61 yıldı. Ortalama taş büyüklüğü 22.48±0.47 mm idi. Ortalama operasyon süresi 106.30±1.56 dak ve hastaların operasyon sonrası taşsızlık oranı %79.07 idi. Ortalama floroskopi zamanı 23.30±1.45 san ve kullanılan irrigasyon sıvı miktarı 8.70±0.23 L olarak hesaplandı. Uygulama sonrası hemoglobin ve hematokrit değerlerinde istatistiksel olarak anlamlı bir düşme saptandı ($p<0.0001$) ve kan transfüzyon oranı %4.99 idi. Clavien sınıflamasına göre ameliyat sonrası ateş ve transfüzyon gerektirmeyen kanama en önemli komplikasyonlardı (%13.4 ve %10.74). Zor entübasyon (%1.2), ekstübasyon sonrası laringospasm (%2.3), tedaviye dirençli bulantı (%1.5), bronkospazm (%0.38), iskemik EKG değişiklikleri (%0.19), deliriyum (%0.19) başlıca anestezi problemleri idi.

Sonuç: Genel anestezi, risklerinin iyi bilinmesi ile PNL girişimleri için güvenli ve etkili bir yöntemdir. Son yıllarda rejyonel anestezi teknikleri PNL girişimlerinde genel anesteziye alternatif olarak bildirilmiştir. Rejyonel anestezinin PNL'de güvenilirliğinin ve etkinliğinin gösterilmesi için büyük hasta gruplarında yapılacak ileri klinik çalışmalar gerektiği kanısındayız.

Anahtar Sözcükler: Anestezi; komplikasyon; perkütan nefrolitotomi.