Int J Clin Exp Med 2015;8(11):21053-21061
www.ijcem.com /ISSN:1940-5901/IJCEM0014312

Original Article

Percutaneous nephrolithotomy in prone position in patients with spinal deformities

Volkan Izol[1], Ibrahim Atilla Aridogan[1], Ali Borekoglu[1], Fatih Gokalp[1], Zehra Hatipoglu[2], Yildirim Bayazit[1], Sinan Zeren[1]

Departments of [1]Urology, [2]Anaesthesiology, Faculty of Medicine, University of Çukurova Adana, Turkey

Received August 8, 2015; Accepted November 5, 2015; Epub November 15, 2015; Published November 30, 2015

Abstract: Introduction: The feasibility, safety and efficacy of percutaneous nephrolithotomy (PCNL) in patients with spinal deformities were evaluated and the results of a single centre experience were reported. Patients and methods: Between July 1999 and December 2014, 16 patients with spinal deformities underwent PCNL. The anomalies included 5 cases with kyphoscoliosis, 4 with post-polio syndrome, 3 with osteogenesis imperfecta, 3 with myotonic dystrophy, and 1 with ankylosing spondylitis. All patients were preoperatively evaluated by an intravenous urogram and computerized tomography to assess the anatomy and appropriate access. The operative details, stone clearance rates, and complications were retrospectivelyanalyzed. Results: A total of 16 standard PCNL procedures were performed on 16 renal-units. The mean age of the patients was 30.7 ± 17.2 (5-62) years, and the mean stone burden was 609.6 ± 526.9 (100-1800) mm^2. The mean operative and fluoroscopy times were 76.6 ± 35.1 (35-150) minutes and 12.5 ± 8.5 (3-34) minutes, respectively. At the end of the surgery, 13 (81.2%) of the patients were stone free. The overall success rate was 93.7% with the inclusion of 2 patients with clinically insignificant residual fragments (<3 mm). Complications (31.2%) included haemorrhage requiring a transfusion in 2 patients, prolonged urine leakage requiring double J catheter insertion in 1, infection in 1, and nephrectomy due to bleeding in 1. Mean hospitalization time was 4.6 ± 2.4 (3-13) days. Conclusion: PCNL is an effective, safe and minimally invasive procedure for the treatment of kidney stones in patients with spinal deformities, and it can be performed with low morbidity and high success rates. To achieve better results and minimizing the risk factors, systematic and anatomic evaluations for anaesthesia and operative planning are crucial before surgery.

Keywords: Spinal deformity, percutaneous nephrolithotomy, nephrolithiasis, kyphoscoliosis

Introduction

Spinal deformity is defined as a pathologic curvature of the thoracic and/or lumbar regions of the spine. Many causes such as congenital spinal deformities, genetic mutations, limb length inequality, and musculoskeletal abnormalities can cause this condition [1]. Additionally, it has been shown that patients with spinal deformities have systemic involvement including cardiac, genitourinary, pulmonary, and neurologic anomalies [2].

The incidence of urogenital pathologies in patients with musculoskeletal deformities is reported to be approximately 21%, and urinary tract problems, including infection, stone formation, and renal impairment, can occur in these patients [3-5]. Although, the data are limited in the literature about the management of renal stones in patients with spinal abnormalities, open surgery, extracorporeal shock-wave lithotripsy (SWL), percutaneous nephrolithotomy (PCNL), retrograde intra renal surgery (RIRS), and a laparoscopic approach are the possible interventions for the treatment of renal calculi [5-8].

PCNL is considered the gold standard for the treatment of kidney stones, and it can also be used in patients with abnormal body habitus and musculoskeletal abnormalities. Additionally, the management of urolithiasis is challenging in these patients due to anatomic variations and cardio-respiratory dysfunction [9]. It is important to preoperatively identify the risk factors for surgery (stone burden, location of the stone, function, location and anatomy of kidney,

Table 1. Aetiology of spinal deformities in patients

Anomalies	n (%)
Kyphoscoliosis	5 (31.3%)
Post polio syndrome	4 (25%)
Osteogenesis imperfecta	3 (18.7%)
Myotonic dystrophy	3 (18.7%)
Ankylosing spondylitis	1 (6.3%)
Total	16 (100%)

experience) and anaesthesia, which can result in high stone clearance rates with minimal morbidity.

In this study, we evaluated the effect of spinal deformity on the results of PCNL which we performed in prone position.

Patients and methods

Between July 1999 and December 2014, 16 patients with spinal deformity who were admitted to our clinic for nephrolithiasis underwent PCNL. The anomalies included 5 cases with kyphoscoliosis, 4 with post-polio syndrome, 3 with osteogenesis imperfecta, 3 with myotonic dystrophy, and 1 with ankylosing spondylitis (**Table 1**). The records of the patients were retrospectively reviewed for patient characteristics, preoperative investigations, operative details, complications, stone clearance rates, and additional procedures. The patients were informed that the clinical and laboratory data would be used for scientific purposes, and written consent was obtained before the procedure.

The upper urinary tract and the anatomic position of the intra-abdominal organs were preoperatively evaluated by an intravenous urogram (IVU) and non-contrast-enhanced computerised tomography (CT) in all patients (**Figure 1**). A careful and detailed systematic evaluation was performed by the proper specialist to exclude any cardiac or respiratory problems before surgery to prevent intraoperative and postoperative complications. Complete blood count, serum biochemistry, electrocardiography, pulmonary function tests, and chest radiography were performed routinely for anaesthesia and/or CT scan, and echocardiography was performed if necessary. Urine cultures were obtained, and patients with positive urine cultures before the operation were treated according to the antibiogram results.

All operations were performed under general anaesthesia by experienced urologists in PCNL. In the lithotomy position, a 5F open-end ureteral catheter was inserted into the ureter and fixed to a urethral Foley catheter allowing the injection of contrast dye to visualise and distend the collecting system. The patient was then placed in a prone position, and appropriate structural support with soft padded bolsters and silicone rolls were used to obtain the best position for percutaneous access. These patients require additional padding since they can be prone to nerve injuries or pressure ulcers. Silicone rolls, bolsters and cushions should be used to fill the spaces between the patient's body and the operating table. Then the operative area was prepared with Betadine. An18 G needle puncture through the appropriate calyx was performed by the urologist under fluoroscopic guidance while moving the C-arm to observe the calyx in different planes. A 0.038 inch super stiff polytetrafluoroethylene-coated guidewire was placed into the collecting system, and the tract was dilated to 24-30F using Amplatz dilators, followed by the placement of a 24-30F Amplatz sheath (Boston Scientific, USA). A 26F rigid or flexible nephroscope was used in the operation. Stones were fragmented with a pneumatic lithotripter and extracted with percutaneous forceps. At the end of the operation, residual fragments were assessed by fluoroscopic evaluation, and a 14-20F re-entry catheter was inserted into the renal pelvis. An antegrade nephrostogram was routinely performed 2-3 days after surgery, and the re-entry catheter was removed if haematuria, fever, extravasation, and ureteral obstruction were not present (**Figure 2**).

For each procedure, the operative details, including stone size and location, operation and fluoroscopy time, the number and location of renal access sites, intraoperative and postoperative complication rates, nephrostomy removal and hospitalisation time, and the use of flexible nephroscope were analysed. Stone size was calculated by digitised surface area, as previously described, and was computed as the sum of the products of the maximum dimensions of stones on a plain X-ray [10]. The existence of residual stones was evaluated postoperatively by nephrostography and abdo-

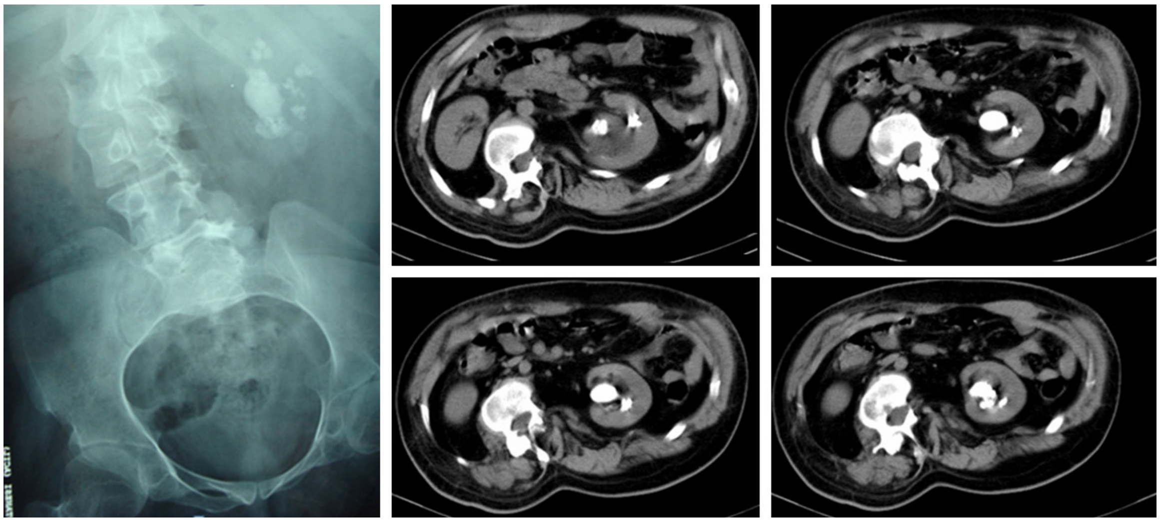

Figure 1. Preoperative CT scan and of a patient with left scoliosis and renal stones.

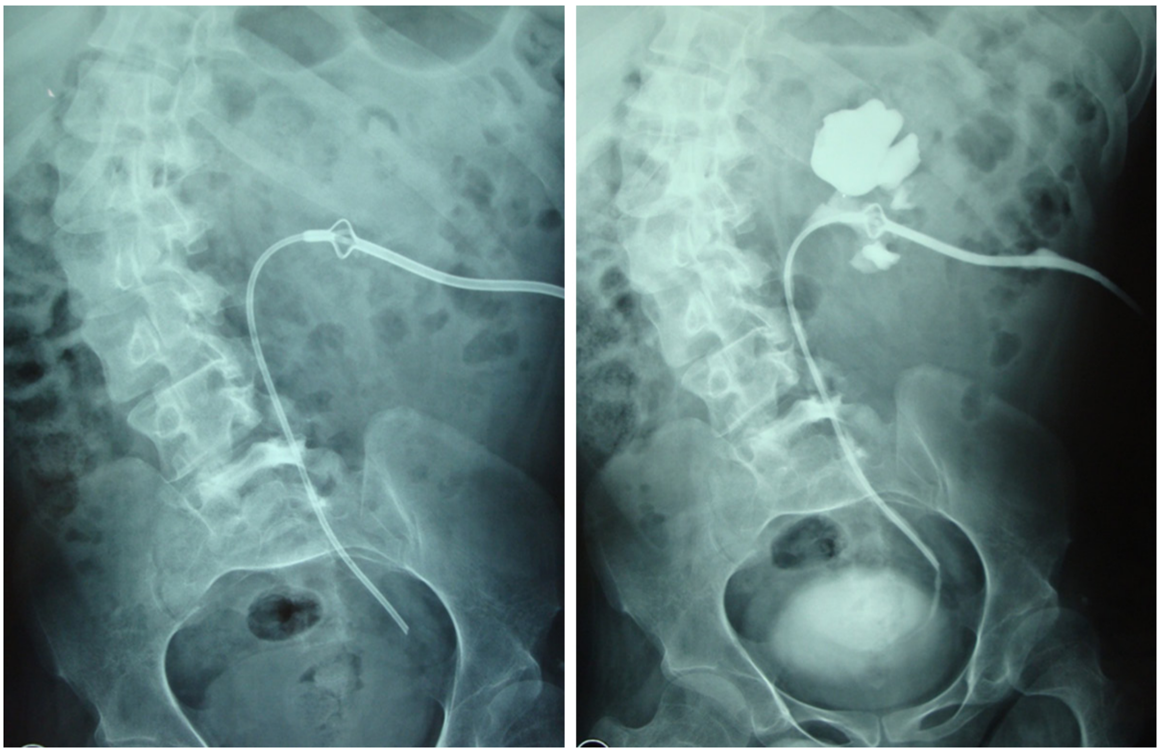

Figure 2. Postoperative nephrostogram of a patient.

minal ultrasonography. In the case of suspicious findings, non-contrast-enhanced CT was performed. Fragments >3 mm were considered as significant residue. All patients were re-evaluated at 3 months with computerized tomography. Descriptive statistics of the data were obtained. Data were expressed as mean ± std and range for continuous variables and as n (%) for categorical data.

Results

A total of 16 standard PCNL procedures were performed on 16 renal units. Of the patients,

Table 2. Renal stone locations

Location	n (%)
Renal pelvis	6 (37.4%)
Partial Staghorn	4 (25%)
Complete Staghorn	2 (12.5%)
Upper pole	2 (12.5%)
Pelvis and middle calyx	1 (6.3%)
Lower pole	1 (6.3%)
Total	16 (100%)

10 (62.5%) were male, and 6 (37.5%) were female. The mean age of the male patients was 30.7 ± 17.2 (5-62) years, whereas that of the female patients was 30.6 ± 22.4 (3-54) years. The left kidney was affected in 9 (56.3%) patients, and the right was affected in 7 (43.7%). The mean stone burden was 609.6 ± 526.9 mm^2 (100-1800). The stones were located in the renal pelvis in 6 cases, the pelvis and middle calyx in 1, the lower pole in 1, the upper pole in 2, and the partial and complete staghorns in 4 and 2 cases, respectively (**Table 2**). Three patients had a history of previous surgery due to nephrolithiasis, and 1 patient had a solitary kidney. In our patients with kyphoscoliosis, the degree of curvatures in the coronal plane was very severe as it can be seen in **Figure 1**.

Access was gained subcostally in prone position in all patients; a single tract was used in 13 patients, and 2 tracts were used in 3 patients. These patients' position is crucial for PCNL, since the area for access is limited. Punctures were performed in the lower calyx in 9 (56.3%) patients, the middle calyx in 2 (12.5%), the upper calyx in 2 (12.5%), and the lower and upper calyx in 3 (18.7%). In our series, we were able to access to the middle or upper calyx subcostally since the kidney was contralateral to the concavity. A 30F dilatation was performed in 9 (56.3%) operations, while a 24F dilatation was performed in 7 (43.7%) operations. Additionally, 16F and 20F re-entry catheters were used in 10 and 6 patients, respectively. The mean nephrostomy removal time was 2.2 ± 0.4 (1-4) days. A flexible nephroscope was required only in two cases. The mean operative and fluoroscopy times were 76.6 ± 35.1 (35-150) minutes and 12.5 ± 8.5 (3-34) minutes, respectively. At the end of the surgery, 13 (81.2%) of the patients were stone free. The stone-free rate was 93.7% with the inclusion of 2 patients with clinically insignificant residual fragments (<3 mm). No additional intervention was performed, and the mean hospitalisation time was 4.6 ± 2.4 (3-13) days.

Conversion to open surgery and nephrectomy was performed in 1 patient with myotonic dystrophy due to severe bleeding and uncontrolled hypotension. This case was one of the initial cases and at that time we were unable to perform superselective angiographic embolization. Complications included haemorrhage requiring a transfusion in 2 patients, prolonged urine leakage requiring double J catheter insertion in 1 and infection in 1. None of the patients required the intensive care unit, and no surrounding tissue injury or bowel perforation was observed. The patient demographics and the operative parameters, results and complications of PCNL in patients with spinal deformity are shown in **Table 3**.

Discussion

The risk of urolithiasis is significantly increased in patients with spinal neuropathy due to abnormal renal anatomy, recurrent urinary tract infection, restricted mobility and urinary stasis [8, 11, 12]. Various interventions have been used for the treatment of renal calculi, including open surgery, SWL, PCNL, RIRS and laparoscopic procedures [5-8]. The management of nephrolithiasis by PCNL has rapidly become the standard treatment of choice for kidney stones >2 cm over the last two decades. With increased experience, the indications have been expanded, and it can be used as monotherapy in patients with renal anatomic variations, a solitary kidney, previous renal surgery, large and complex stones, morbid obesity, and abnormal body habitus such as spinal deformities [5, 13, 14]. Additionally, patients with spinal deformities require detailed investigations for anaesthesia and preoperative planning due to their anatomic properties before surgery, and the case management should be considered individually for each patient [9]. In this study, we evaluated the safety and efficacy of PCNL in prone position in patients with spinal deformity.

The data are limited in the literature for the treatment of renal stones in patients with spinal neuropathy by PCNL but suggest that these patients are at increased risk and require spe-

Table 3. Patient demographics and the operative parameters, results and complications of PCNL in patients with spinal deformity

Number of patients	16
Male/Female	10 (62.5%)/6 (37.5%)
Mean age of males (years)	
(mean ± std) (range)	30.7 ± 17.2 (5-62)
Mean age of females (years)	
(mean ± std) (range)	30.6 ± 22.4 (3-54)
Number of renal units	16
Left/right kidney	9 (56.3%)/7 (43.7%)
Stone burden (mm^2)	
(mean ± std) (range)	609.6 ± 526.9 (100-1800)
Access localisation	
Lower calyx	9 (56.3%)
Middle calyx	2 (12.5%)
Upper calyx	2 (12.5%)
Lower and upper calyx	3 (18.7%)
Tract dilation	30F (56.3%), 24F (43.7%)
Mean operative time (min)	
(mean ± std) (range)	76.6 ± 35.1 (35-150)
Mean fluoroscopy time (min)	
(mean ± std) (range)	12.5 ± 8.5 (3-34)
Mean nephrostomy removal time (days)	
(mean ± std) (range)	2.2 ± 0.4 (1-4)
Mean hospital stay (days)	
(mean ± std) (range)	4.6 ± 2.4 (3-13)
Stone Free (%)	
After PCNL	13 (81.2%)
Over All	15 (93.7%)
Complications n (%)	5 (31.2%)
Transfusion requiring haemorrhage	2 (12.5%)
Conversion to open surgery due to severe bleeding and nephrectomy	1 (6.2%)
Prolonged urine leakage requiring a double J catheter	1 (6.2%)
Infection	1 (6.2%)

cial consideration for therapeutic strategies. There are many important preoperative considerations for patients with spinal deformities. Depending on the severity of the deformity, already-present cardiac and pulmonary problems may be exacerbated during the operation. Cardiac abnormalities, including ventricular septal defects, atrial septal defects, patent ductus arteriosus, tetralogy of Fallot, transposition of the great arteries, pulmonary stenosis, and sick sinus syndrome, have been observed 10-16% of cases [4]. Additionally, pulmonary involvement is important in these patients due to restrictive lung disease with reduced lung volume, impaired ventilatory function, atelectasis, and ventilation-perfusion mismatch [15, 16]. Therefore, a pulmonary function test and radiologic evaluation of the chest should be routinely performed [16]. Additionally, difficulties in tracheal intubation may be observed in patients with extreme spinal deformities, and spinal-epidural anaesthesia can be performed successfully as an alternative to general anaesthesia in this condition [17, 18]. Due to restriction to gas flow and reduction of lung volume the presence of kyphoscoliosis can adversely affect gas exchange. This may result combination of both restrictive and obstructive pulmonary disease and the reduced vital capacity and the severity of the scoliosis are the most important predictive factors in the prognosis [19]. Kundra et al [19] made an algorithm for ventilatory management in patients with severe kyphoscoliosis.

In a study by Goumas-Kartalas et al [20], 8 patients with spinal deformity underwent PCNL in supine and prone positions. No anaesthesia-related or cardiopulmonary complications were observed, and they concluded that the supine position provides some advantages, including patient comfort, protection of cardiac function, better airway control, improved pulmonary ventilation and the ability to perform a simultaneous combined procedure. However, they could not state that prone PCNL in patients with spinal deformities is contraindicated and that supine PCNL is always the best choice. Kara et al [5] have reported that 2 of 5 patients with a reduced force vital capacity required a stay in the intensive care unit for 24 hours, although detailed investigations were performed before the surgery. Additionally, in patients with spinal cord injury, Culkin et al [21] encountered complications including respiratory arrest in 1 patient, a perirenal abscess in 1, and hydrothorax in 2. In our study, all operations were performed under general anaesthesia via tracheal intubation. No complications related to anaesthesia or the cardiopulmonary system was noted. We routinely use the prone position, and therefore, the benefits of the supine position were not evaluated due to our lack of experience with this position.

The appropriate percutaneous access to the collecting system is crucial for achieving better success rates with minimal morbidity. Renal puncture can be performed safely under fluoroscopic, ultrasonographic (US), or CT guidance, and laparoscopy-assisted guidance by urologists or radiologists after the kidney, bowel and surrounding tissues have been preoperatively imaged by IVU and non-contrast enhanced CT [11, 22, 23]. In our series, all punctures were performed by an urologist under fluoroscopic guidance while moving the C-arm to observe the calyx in different planes. Although the risk of injury to the surrounding tissues is increased in patients with spinal deformities, no complications associated with percutaneous access were observed in our patients. According to the literature, CT- or US-guided puncture may be used as an alternative in patients with severe anatomic deformities [22-24].

Kara et al [5] evaluated their experience in PCNL for treating nephrolithiasis in 5 patients with scoliosis and analysed the operative details. The stone-free rates were 60% after the initial procedure and 100% after the auxiliary interventions (ureteroscopy in 1 patient and second-look PCNL in 1 patient). No major complication was observed, and the reported minor complications were fever, prolonged urinary leakage, and blood transfusion. The authors concluded that PCNL can be performed safely and effectively in these patients with low morbidity if a comprehensive evaluation was performed preoperatively.

One of the largest series from two centres on percutaneous nephrolithotomy in patients with spinal neuropathy was published by Symons et al [11]. Twenty-nine patients with traumatic spinal cord injury, spina bifida, and other heterogeneous causes for their spinal neuropathy were evaluated. Percutaneous access was performed by a radiologist in all patients, and 62% were rendered stone free after the initial PCNL. In the postoperative period, nine patients required a stay in the intensive care unit, and the mortality and postoperative morbidity rates were high in this group. Additionally, the average American Society of Anesthesiologists score of these patients was 3, indicating that they had severe systemic disease. In their series, two patients died due to electromechanical dissociation arrest and aspiration pneumonia. Nephrectomy, hypotension, fever, seizures and prolonged drainage were also reported as complications. At the end of the study, they emphasised 2 important points. First, a team approach should be considered in preoperative planning for appropriate puncture to kidney. Second, technical difficulties and potential complications should be discussed carefully among urologists, radiologists, and anaesthesiologists before the surgery. Srivastava et al [23] performed PCNL in 6 patients with musculoskeletal deformities. Nephrostomy tubes were preoperatively placed under US or CT guidance. No complications were observed, and complete stone clearance was achieved in the single-procedure setting.

In a study by Goumas-Kartalas et al [20], 8 patients with spinal deformity underwent 5 supine and 5 prone PCNLs. US-guided fluoroscopic-adjusted renal access was performed by an experienced urologist in all patients following a detailed preoperative evaluation. The mean stone burden was 372 mm^2, and the mean operative and hospitalisation times were 103 minutes and 13.2 days, respectively. Additionally, 55.5% of the renal units were rendered stone free after 1 PCNL, and 66.6% were stone free after 2 PCNLs. The success rate was 88.8% with the combination of auxiliary procedures such as SWL, RIRS, and PCNL at the 3rd month. Complications were observed in 40% of the procedures, including transient fever in 2, blood transfusion in 1 and superselective angiographic embolisation required haemorrhage in 1 patient. Colonic injury, pneumothorax, and anaesthesia-related complications were not observed. Although a lower stone-free rate and a higher incidence of bleeding were observed, they concluded that PCNL has a significant role in the treatment of urolithiasis in patients with spinal deformities; stone-free rates can be improved by combination therapy with either SWL or RIRS after PCNL. The best position for PCNL could not be suggested due to the small number of patients. In the literature, a supine position has been shown to have some advantages in terms of patient comfort, less risk of postural damage, protection of cardio-respiratory function, and the ability to perform simultaneous combined interventions for complex stones. Since, there is limited published data describing PCNL in severe kyphoscoliosis, no universally accepted appropriate position has been present. However, a prone position provides a larger area for multiple percutaneous renal accesses and instrument manipulation [25-27].

In our series, all renal punctures were performed subcostally by the urology team under fluoroscopic guidance with the help of the C-arm. The mean stone burden was 609.6 mm^2, which was higher than other studies [5, 13, 20, 23]. We also had to treat small stones of between 100 to 400 mm^2 by PCNL, since it was not appropriate to give position for SWL due to abnormal body habitus. The mean operative, fluoroscopy and hospitalisation times were 76.6 minutes, 12.5 minutes, and 4.6 days, respectively. These results and the stone location in the collecting system were similar to those in the literature, but the fluoroscopy time was longer, which might have resulted from a high stone burden and access technique [5, 19]. The stone-free rate was 81.2% after the first PCNL, and the overall success rate was 93.7% with the inclusion of 2 patients with clinically insignificant residual fragments (<3 mm). No additional intervention was required. In the literature, the stone-free rates in patients with spinal deformities have been reported to range from 60% to 100% with auxiliary procedures [5, 11, 20, 21, 23, 28].

We encountered 5 (31.2%) complications in patients with spinal deformities. A haemorrhage requiring a transfusion was observed in 2 patients, and nephrectomy was performed in 1 patient with myotonic dystrophy due to severe bleeding whom we were unable to perform superselective angiographic embolization. The total rate of haemorrhage was 18.7%, and this rate was acceptable for patients with a high stone burden. In the literature, blood transfusion rates between 0% and 49% have been reported in patients with spinal cord injury and/or abnormal body habitus [5, 11, 20-23, 28]. Urine leakage requiring double J catheter insertion in 1 patient and infection in 1 patient were also reported as complications. No patient required a stay in the intensive care unit, and no surrounding tissue injury or bowel perforation was observed. The rate of complications of these patients was not higher than the patients without spinal deformities in our series.

There are some major issues that should be addressed before percutaneous surgery in patients with spinal deformities, such as anesthesiologic and cardiorespiratory problems, positioning of the patient on the operating table, and percutaneous access modality. It is also important to prevent new stone formation, which may lead to additional interventions. This study had some limitations including a short-term follow up, and the lack of a stone analysis and a metabolic work up to prevent stone recurrence.

Conclusions

PCNL is an effective, safe and minimally invasive procedure for the treatment of kidney stones in patients with spinal deformities, and it can be performed with low morbidity and high success rates. To achieve better results and prevent intraoperative and postoperative complications, systematic and anatomic evaluations for anaesthesia and operative planning are crucial before surgery. Potential complications can be avoided by the collaboration of urologists, radiologists and anaesthesiologists. High stone clearance with a low incidence of complications can be achieved in dedicated, high volume, experienced centres.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Volkan Izol, Department of Urology, Faculty of Medicine, University of Çukurova, Adana 01330, Turkey. Tel: +90 322 3386305; Fax: +90 322 4573072; E-mail: volkanizol@yahoo.com

References

[1] Pehrsson K, Larsson S, Oden A and Nachemson A. Long-Term Follow-up of Patients with Untreated Scoliosis-a Study of Mortality, Causes of Death, and Symptoms. Spine 1992; 17: 1091-1096.
[2] Purkiss SB, Driscoll B, Cole WG and Alman B. Idiopathic scoliosis in families of children with congenital scoliosis. Clin Orthop Relat Res 2002; 401: 27-31.
[3] Bernard TN Jr, Burke SW, Johnston CE 3rd and Roberts JM. Congenital spine deformities. A review of 47 cases. Orthopedics 1985; 8: 777-783.
[4] Basu PS, Elsebaie H and Noordeen M. Congenital spinal deformity: a comprehensive assessment at presentation. Spine 2002; 27: 2255-2259.
[5] Kara C, Resorlu B, Ozyuvali E and Unsal A. Is percutaneous nephrolithotomy suitable for patients with scoliosis: single-center experience. Urology 2011; 78: 37-42.
[6] Resorlu B, Ozyuvali E, Oguz U, Bozkurt OF and Unsal A. Retrograde intrarenal surgery in patients with spinal deformities. J Endourol 2012; 26: 1131-1135.
[7] Nakada SY. Controversial cases in endourology. J Endourol 1999; 13: 465-469.
[8] Levy D and Resnick M. Management of urinary stones in the patient with spinal cord injury. Urol Clin North Am 1993; 20: 435-442.
[9] Chan G and Dormans JP. Update on congenital spinal deformities: preoperative evaluation. Spine 2009; 34: 1766-1774.
[10] Raj GV, Auge BK, Weizer AZ, Denstedt JD, Watterson JD, Beiko DT, Assimos DG and Preminger GM. Percutaneous management of calculi within horseshoe kidneys. J Urol 2003; 170: 48-51.
[11] Symons S, Biyani CS, Bhargava S, Irvine HC, Ellingham J, Cartledge J, Lloyd SN, Joyce AD and Browning AJ. Challenge of percutaneous nephrolithotomy in patients with spinal neuropathy. Int J Urol 2006; 13: 874-879.
[12] Chen Y, DeVivo MJ, Stover SL and Lloyd LK. Recurrent kidney stone: a 25-year follow-up study in persons with spinal cord injury. Urology 2002; 60: 228-232.
[13] Türk C, Knoll T, Petrik A, Sarica K, Straub M and Seitz C. European Association Guidelines on Urolithiasis. 2013 ed. http://www.uroweb.org/gls/pdf/21_Urolithiasis_LR.pdf.
[14] Skolarikos A, Alivizatos G and De La Rosette J. Percutaneous nephrolithotomy and its legacy. Eur Urol 2005; 47: 22-28.
[15] Buyse B, Meersseman W and Demedts M. Treatment of chronic respiratory failure in kyphoscoliosis: oxygen or ventilation? Eur Respir J 2003; 22: 525-528.
[16] Campbell RM, Smith MD, Mayes TC, Mangos JA, Willey-Courand DB, Kose N, Pinero RF, Alder ME, Duong HL and Surber JL. The characteristics of thoracic insufficiency syndrome associated with fused ribs and congenital scoliosis. J Bone Joint Surg Am 2003; 85: 399-408.
[17] Ozyurt G, Basagan-Mogol E, Bilgin H and Tokat O. Spinal anesthesia in a patient with severe thoracolumbar kyphoscoliosis. Tohoku J Exp Med 2005; 207: 239-242.
[18] Karacalar S, Bilen CY, Sarihasan B and Sarikaya S. Spinal-epidural anesthesia versus general anesthesia in the management of percutaneous nephrolithotripsy. J Endourol 2009; 23: 1591-1597.
[19] Kundra P, Joseph A, Kumar S and Chandran BS. Double-lumen tube for ventilation in severe kyphoscoliosis. J Anesth 2008; 22: 317-321.
[20] Goumas-Kartalas I and Montanari E. Percutaneous nephrolithotomy in patients with spinal deformities. J Endourol 2010; 24: 1081-1089.
[21] Culkin D, Wheeler J Jr, Nemchausky B, Fruin R and Canning J. Percutaneous nephrolithotomy in the spinal cord injury population. J Urol 1986; 136: 1181-1183.
[22] Marcovich R and Smith AD. Percutaneous renal access: tips and tricks. BJU Int 2005; 95: 78-84.
[23] Srivastava A, Gupta P, Chaturvedi S, Singh P, Kapoor R, Dubey D and Kumar A. Percutaneous nephrolithotomy in ectopically located kidneys and in patients with musculoskeletal deformities. Urol Int 2010; 85: 37-41.
[24] Matlaga BR, Shah OD, Zagoria RJ, Dyer RB, Streem SB and Assimos DG. Computerized tomography guided access for percutaneous nephrostolithotomy. J Urol 2003; 170: 45-47.
[25] de la Rosette JJ, Tsakiris P, Ferrandino MN, Elsakka AM, Rioja J and Preminger GM. Beyond prone position in percutaneous nephrolitho-

my: a comprehensive review. Eur Urol 2008; 54: 1262-1269.

[26] Ibarluzea G, Scoffone CM, Cracco CM, Poggio M, Porpiglia F, Terrone C, Astobieta A, Camargo I, Gamarra M and Tempia A. Supine Valdivia and modified lithotomy position for simultaneous anterograde and retrograde endourological access. BJU Int 2007; 100: 233-236.

[27] Scoffone CM, Cracco CM, Cossu M, Grande S, Poggio M and Scarpa RM. Endoscopic combined intrarenal surgery in Galdakao-modified supine Valdivia position: a new standard for percutaneous nephrolithotomy? Eur Urol 2008; 54: 1393-1403.

[28] Nabbout P, Slobodov G, Mellis AM and Culkin DJ. Percutaneous nephrolithotomy in spinal cord neuropathy patients: a single institution experience. Eur Urol 2012; 26: 1610-1613.