Taylor & Francis
Taylor & Francis Group

Renal Failure

ISSN: 0886-022X (Print) 1525-6049 (Online) Journal homepage: https://www.tandfonline.com/loi/irnf20

Effect of percutaneous nephrolithotomy on renal functions in children: assessment by quantitative SPECT of ^{99m}Tc-DMSA uptake by the kidneys

Izzet Cicekbilek, Berkan Resorlu, Ural Oguz, Cengiz Kara & Ali Unsal

To cite this article: Izzet Cicekbilek, Berkan Resorlu, Ural Oguz, Cengiz Kara & Ali Unsal (2015) Effect of percutaneous nephrolithotomy on renal functions in children: assessment by quantitative SPECT of ^{99m}Tc-DMSA uptake by the kidneys, Renal Failure, 37:7, 1118-1121, DOI: 10.3109/0886022X.2015.1056063

To link to this article: https://doi.org/10.3109/0886022X.2015.1056063

Published online: 12 Jun 2015.

Submit your article to this journal

Article views: 480

View related articles

View Crossmark data

Citing articles: 7 View citing articles

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=irnf20

RENAL FAILURE

http://informahealthcare.com/rnf
ISSN: 0886-022X (print), 1525-6049 (electronic)

Ren Fail, 2015; 37(7): 1118–1121
© 2015 Informa Healthcare USA, Inc. DOI: 10.3109/0886022X.2015.1056063

informa
healthcare

CLINICAL STUDY

Effect of percutaneous nephrolithotomy on renal functions in children: assessment by quantitative SPECT of ^{99m}Tc-DMSA uptake by the kidneys

Izzet Cicekbilek[1], Berkan Resorlu[2], Ural Oguz[3], Cengiz Kara[4], and Ali Unsal[5]

[1]*Department of Urology, School of Medicine, Bulent Ecevit University, Zonguldak, Turkey,* [2]*Department of Urology, School of Medicine, Canakkale Onsekiz Mart University, Canakkale, Turkey,* [3]*Department of Urology, School of Medicine, University of Giresun, Giresun, Turkey,* [4]*Department of Urology, Ataturk Training and Research Hospital, Izmir, Turkey, and* [5]*Department of Urology, School of Medicine, University of Gazi, Ankara, Turkey*

Abstract

Objective: To determine the impact of percutaneous nephrolithotomy (PNL) on global and regional renal function in children. *Methods*: In total, 40 children (41 renal units) undergoing PNL were included in this prospective study. All patients were evaluated using quantitative single-photon emission computed tomography (QSPECT) with technetium-99 m-dimercapto-succinic acid (^{99m}Tc-DMSA) examinations before and 3 months after surgery. *Results*: The mean age was 9.5 years (range, 3–16), and the mean stone size was 3.4 cm (range, 2–6.5). Of the cases, 39 (95%) were managed as being stone-free after a single session of PNL. After additional treatment procedures, 40 (97.5%) of the cases were managed as being stone-free. Of the 41 renal units, new focal cortical defects on ^{99m}Tc-DMSA scans were seen in 4 (9.7%) patients. Total relative uptake in the treated kidneys increased from 42.3% to 44.1%. The mean creatinine level before PNL was 1.18 ± 0.45 (0.8–1.6) mg/dL compared with 1.16 (0.7–1.5) mg/dL by the end of the follow-up period (not statistically significantly different, $p > 0.05$). *Conclusions*: PNL in children is a safe and feasible method for the maximal clearance of stones. QSPECT of ^{99m}Tc-DMSA confirmed that renal function is preserved or even improved after percutaneous stone removal.

Keywords

Percutaneous nephrolithotomy, renal function, stone disease, renal scintigraphy, renal parenchymal scar

History

Received 23 January 2015
Accepted 16 May 2015
Published online 12 June 2015

Introduction

Because the predisposing factors, such as metabolic disturbances, infections, and/or congenital abnormalities, are more common in childhood, the expected recurrence rate of renal calculi is higher in children than in adults. For this reason, treatment of renal calculi using minimally invasive techniques is more important in children than in adults.

Recently, percutaneous nephrolithotomy (PNL) has become the preferred treatment method for the treatment of kidney stones, including staghorn stones in adults and generally in pediatric patients. However, despite its rapid development, some questions about PNL remain to be answered. One important question is what changes in kidney morphology and function are caused by PNL. It is difficult to perform studies that evaluate the effects of invasive techniques on kidney function over the long term. Moreover, the laboratory analysis of patient results is difficult, because with two kidneys, minor changes in renal functions often cannot be distinguished.[1] For this reason, scintigraphical studies are informative in the determination of renal parenchymal damage. Tc-99 m DMSA is a useful scintigraphical imaging technique, showing the functional mass of the kidney by cumulating in the renal cortex and showing parenchymal scar tissue in the kidney.[2]

High-resolution single-photon emission computed tomography (SPECT), which outputs 360° images and allows image reconstruction using a computer, can provide great detail about renal cortical structure and function.[3] This technology, with coronal, sagittal, and transaxial imaging capacity, has been applied to DMSA images for better determination of renal scars. Targington et al. compared the imaging findings derived from SPECT and standard pin-hole imaging of 33 children with acute and chronic renal pathology. They found that through comparisons with other frequently used imaging techniques, SPECT was more effective for defining cortical defects.[4]

In this prospective study, our objective was to assess damage in the kidney parenchyma using scintigraphic imaging techniques in children 16 years of age and younger who underwent PNL because of renal calculi.

Materials and methods

After obtaining approval from the Institutional Ethics Committee, we performed a prospective analysis of 40

Address correspondnce to Izzet Cicekbilek, Department of Urology, Bulent Ecevit University, School of Medicine, Zonguldak, Turkey. Tel: +90 505 788 06 79; Fax: +90 372 261 01 55; E-mail: izzetcb@yahoo.com

pediatric patients (41 renal units) undergoing PNL operations. Quantitative single-photon emission computed tomography (QSPECT) with technetium-99 m-dimercaptosuccinic acid (^{99m}Tc-DMSA) was performed in all patients the day before surgery. Renal units to be operated on were investigated for the presence of parenchymal scarring. Patients with renal parenchymal scars or obstructed systems were not included in the study.

In all cases, a hemogram, complete urine analysis, urine culture test, blood biochemistry analysis, bleeding and coagulation time assessments, assays for calcium, magnesium, sodium, creatine, uric acid, oxalate, and citrate, and a 24-h urine analysis of creatinine clearance were performed according to standard laboratory methods. For cases with high serum and urine calcium and low phosphorous levels, the parathyroid hormone level was analyzed. In all cases, the stones removed by PNL were analyzed at the Turkey General Directorate of Mineral Research and Exploration, using a Philips PW 3710/1830 with a Cu X-ray rube analysis device, or were analyzed manually using the chemical procedures of the Kecioren Educational and Research Hospital laboratory. All cases were evaluated using intravenous pyelography, and some cases were also evaluated using computed tomography.

On the morning of the operation, 25–50 mg/kg/day cephalosporin was injected intravenously preoperatively. During the PNL operation, location of calculi, degree of dilatation, operation time, access locations, number of entries, and, if any, blood transfused pre- and postoperatively were recorded for all cases.

In all cases, the tract was dilated using Amplatz dilatators, depending on the age of the patient, starting from 8 to 12–24 Fr, depending on the length of the nephroscope used and the Amplatz sheath placed. Depending on the age of the patient, we entered the collecting duct system using an 11-, 15.9-, or 22-Fr nephroscope (Olympus, Hamburg, Germany). A rigid nephroscope was used in all cases. Next, 3- and 2-legged forceps for stone extraction and crushing, as well as a Swiss LithoClast Master (Electro Medical Systems, Nyon, Switzerland) pneumatic and/or ultrasonic lithotripter were used. Before the operation was finished, all calyxes were monitored using a flexible nephroscope to minimize residual calculi, and any fragments detected were lithotripsies using a HoYAG laser lithotripter. In many cases, a 12–16-Fr Nélaton aspirator catheter or a re-entry Malecot catheter was placed postoperatively.

All cases were evaluated in terms of the changes in renal function and the existence of renal parenchyma scarring using QSPECT with ^{99m}Tc-DMSA at the third postoperative month. The mean follow-up time was 7 (3–12) months. Statistical analysis was performed using χ^2 and Student's *t*-tests. *p*-Values <0.05 were considered to indicate statistical significance.

Results

Among the study cases, there were 23 (57.5%) males and 17 (42.5%) females, with an average age of 9.5 (3–16) years. At the time of seeking medical advice, 28 (70%) had hematuria, 28 (70%) had abdominal pain, 12 (30%) had urinary system infections, and 4 (10%) had high fevers. When the renal calculi were assessed, they were in the right kidney in 17 (42.5%) patients, in the left kidney in 17 (42.5%), and bilateral in 6 (15%). The stone burden was calculated by summing the lengths of the longest axis of each stone. The mean stone burden was 34.1 (range, 20–65) mm. Of the stone cases, 22 (53%) were located pelvically and 14 (35%) at the calyx. There was a staghorn stone in five (12%) kidneys. Characteristics of the cases and stones are provided in Table 1.

In all cases, the blood biochemistry, hemogram, bleeding, and coagulation time values were within normal ranges. When the 24-h urine analyses were examined, 21 (52.5%) showed hypomagnesuria, 20 (50%) hypocitraturia, and 17 (42.5%) hypercalciuria.

Stone analyses were available in 23 (56%) cases. The most frequently seen stone type was calcium oxalate (56.5%), followed by struvite (17.4%), uric acid (13%), cystine stones (8.6%), and mixed stones (4.3%; Table 2). Right PNL was applied in 20 (50%) cases, left PNL in 19 (47.5%), and

Table 1. Patient and stone characteristics.

Number of cases (renal units)	40 (41)
Mean age (year)	9.5 (3–16)
Boy/girl	23/17
Clinical findings (%)	
Hematuria	28 (70%)
Abdominal pain	28 (70%)
Urinary system infection	12 (30%)
Fever	4 (10%)
Stone side (%)	
Left kidney	17 (42.5%)
Right kidney	17 (42.5%)
Bilateral	6 (15%)
Stone localization (%)	
Pelvic	22 (53%)
Calyxes	14 (35%)
Staghorn	5 (12%)
Mean stone size (mm)	34.1 (20–65)

Table 2. Operative characteristics.

Side	
Right PNL	20 (50%)
Left PNL	19 (47.5%)
Bilateral PNL	1 (2.5%)
Cases tracted more than 1(%)	2 (4.9%)
Calyxial axes	
Upper pole	4 (9.8%)
Middle pole	14 (34.1%)
Lower pole	21 (51.2%)
Lower + middle pole	1 (2.4%)
Middle + upper pole	1 (2.4%)
Mean fluoroscopy time (min)	2.01 (0.43–8.18)
Mean operation time (min)	47.9 (12–142)
Stone-free rate after single treatment (%)	39 (95%)
Final stone-free rate (%)	40 (97.5%)
Mean nephrostomy time removel (day)	3 (2–8)
Mean hospitalization time (day)	3 (2–8)
Complications	
Hemorrage needing transfusion	1 (2.5%)
Postoperative fever	2 (5%)
Plevral effusion	–
Urinary tract infection	2 (5%)
Mean Hb decline ± SD (g/dL)	1.4 ± 0.22 (0.4–3.7)

bilateral PNL in 1 (2.5%). The mean operation time was 47.9 (12–142) min, the mean fluoroscopy time was 2.01 (0.43–8.18) min, and the mean in-hospital stay was 3 (2–8) days.

The collecting duct system was entered subcostally in 34 (82.9%) cases and intercostally in 5 (12.2%). In two cases, the collecting duct system was entered both subcostally and intercostally. Access into the collecting duct system was from the lower calyx in 21 (51.2%) cases, from the mid calyx in 14 (34.1%), from the upper calyx in 4 (9.8%), and from two entrances in two cases: from the lower and mid calyx in 1 (2.4%) and from the mid and upper calyx in the other case (2.4%).

Of the cases, 39 (95%) were managed as having no renal calculi after a single session of PNL. One of the 2 (5%) cases with residual stones, they were treated by second-look PNL on the fifth postoperative day and then considered stone-free. The other patient was treated by a single shock wave lithotripsy (SWL) session and placement of a double-j stent. Thus, after the additional treatment procedures, 40 (97.5%) of the cases were considered to be stone-free. There was no need for open surgical intervention in any case.

Two cases showed findings of sepsis with high fever as a complication and were treated using convenient antibiotic therapy. There was an average decline in postoperative hemoglobin levels of 1.4 ± 0.22 (0.4–3.7) g/dL. Only one case had a hemorrhage that required a blood transfusion. No major complications—classified as Clavien III–V—occurred in any case. The surgical results are provided in Table 2.

At the third postoperative month, QSPECT with ^{99m}Tc-DMSA showed cortical defects, compatible with scar tissue, in only 4 (9.7%) renal units, in 3 (75%) of which the scar was located in an area near the kidney entrance. Differential renal function was preserved in 31 (75.6%) renal units (a 3% increase or decrease in the preoperatively evaluated differential function was accepted as normal renal function variation). Decreases in renal function were seen in three (7.3%) and seven (17.1%) renal units, and increases in renal function were not noted. The mean total relative uptake was 42.3% preoperatively and 44.1% postoperatively ($p > 0.05$). Mean creatinine levels in these patients were 1.18 ± 0.45 (0.8–1.6) mg/dL before PNL versus 1.16 (0.7–1.5) mg/dL at the end of the follow-up period (the difference was not statistically significant; $p > 0.05$). Creatinine clearance tests were within normal ranges for the ages of the subjects, pre- and postoperatively.

Discussion

Maximal stone clearance with nephron preservation is the primary objective in the treatment of renal calculi. Today, PNL is preferred over open surgery because of the shorter hospitalization time, lower treatment costs, earlier return to work for the patients, and minimally invasive nature of the surgery. The importance of PNL is even greater for children versus adult patients, because the recurrence rate is higher in children. Postoperative measurements indicate that patients tolerate PNL well, but the effects on renal function remain unknown. To determine the effects of PNL on renal function, we assessed our pediatric patients prospectively using QSPECT and ^{99m}Tc-DMSA. To our knowledge, QSPECT and ^{99m}Tc-DMSA have not been used previously to evaluate the effects of PNL on renal function in children.

A DMSA study is a reproducible method for monitoring serial changes in individual renal function. It is a non-invasive way to measure the functioning renal-cortical volume.[5] Previous investigators have evaluated the effects of SWL and percutaneous and open renal surgeries for renal calculi on renal function using ^{99m}Tc-DMSA.[5–10] In their series, Morey et al. used ^{99m}Tc-DMSA scans and demonstrated a relative decrease in renal function after anatrophic nephrolithotomy for staghorn calculi, although the decrease was probably not statistically significant.[8] Several studies have evaluated the renal parenchymal effects of SWL using ^{99m}Tc-DMSA renal scans. Scarring has been observed in kidneys with calculi treated by SWL ~3 months post-treatment; the degree of scarring depended on the number of shockwaves administered. However, some of these lesions were found to be reversible.[2,9,11] The use of ^{99m}Tc-DMSA scans to assess parenchymal damage after SWL in children was reported initially by Lottmann et al. They demonstrated SWL to be a safe modality with no permanent sequelae in children. Renal parenchymal injury, as evidenced by enzyme markers and ^{99m}Tc-DMSA scans, may occur during the early period after SWL but is reversible over time.[2] Previous studies assessing the effect of PNL on renal function and growth found no significant alterations postoperatively.[12] Mor et al. performed radioisotope scans on 10 children before and after PNL and found no change in differential function and no evidence of significant scarring.[13] In another series, Dawaba et al. performed ^{99m}Tc-DMSA scans to detect renal scarring and ^{99m}Tc-DTPA scans to determine selective glomerular filtration rates after PNL in 65 children (72 renal units).[14] There was no evidence of renal scarring in any renal unit, and stabilization or improvement of the selective glomerular filtration rate was observed in all but four renal units. Three of these four units showed improvement over time. Unsal et al. measured the effects of PNL dilatation methods on renal function in adult patients using QSPECT and DMSA uptake by the kidneys.[15] Balloons, metal, and Amplatz dilators were compared, and no difference in renal uptake was found among the three groups pre- or postoperatively. New scarring was detected in 18% of patients, and 66% of these scars were reported to be at the site of the focal defect corresponding to the access site for tract formation during PNL.

Although these studies noted the absence of cortical scars at the access sites in their patients, in view of the potentially more sensitive quantitative SPECT, a DMSA scan showed local functional loss at the site of entry.[12] A single PNL procedure produces a small but permanent parenchymal scar at the site of the nephrostomy tract after several weeks. However, tissue adjacent to, as well as relatively distant from, the tract is also injured during PNL. Such injuries and any associated interstitial inflammation may resolve but may also progress to fibrosis and scarring.[16,17]

In our series, we evaluated the effects of PNL on global and regional renal function using QSPECT with ^{99m}Tc-DMSA in children. New focal cortical defects on ^{99m}Tc-DMSA scans were seen in 4 (9.7%) renal units. In 3 (7.3%) of these kidneys, the site of the focal defect corresponded to the access site for tract formation during PNL. The new scar

formation was not associated with stone size, number of entries in the kidney, surgery time, or bleeding. We did not observe difficulties in establishing the tract in these three patients who had subsequent focal defects at the site of tract formation.

Of the four children with focal cortical defects, none had significant intraoperative issues, except 1 (2.4%) patient who suffered bleeding and required a blood transfusion. Two (4.8%) patients had fevers postoperatively and required antibiotic treatment because of positive urine cultures. In the other renal unit, the patient had unrelated site defects on isotope scans; the reason for the focal defects could include other factors, such as infection, intraoperative instrumental injury, bleeding, or SWL treatment.

PNL is a technically difficult operation. The major complication rate is 1.1–7%, and bleeding requiring transfusion is the most important complication. In children, the most important factors affecting bleeding are dilation diameter and the number of tracts. Especially in patients who undergo dilatation greater than 24 Fr and with multiple entries, there may be a serious decline in hemoglobin levels. Indeed, several studies have reported transfusion rates of 7–24%.[18,19]

In the present study, while renal uptake was preserved in 38 (92.7%) patients, 3 (7.3%) showed a decrease in renal function. The average total relative uptake was not significantly different before versus after surgery (42.2% vs. 44.1%). Possible changes in renal function as an indicator of renal damage, such as serum creatinine and creatinine clearance, have also been evaluated. The mean serum creatinine levels before and after surgery were 1.18 (0.8–1.6) and 1.16 (0.7–1.5) mg/dL, respectively. Preoperative and postoperative (3 months) creatinine clearances of the patients were all within the normal range, according to age group.

Conclusions

These results suggest that QSPECT with ^{99m}Tc-DMSA is a non-invasive method that can assess changes in individual renal function. QSPECT with ^{99m}Tc-DMSA confirmed that renal function was preserved or even improved after percutaneous stone removal.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

1. Webb DR, Fitzpatrick JM. Percutaneous nephrolithotripsy: A functional and morphological study. *J Urol*. 1985;134:587–591.
2. Lottmann HB, Archambaud F, Hella B, et al. 99mTechnetiumdimercapto-succinic acid renal scan in the evaluation of potential long-term renal parenchymal damage associated with extracorporeal shock wave lithotripsy in children. *J Urol*. 1998;159:521–524.
3. Joseph DB, Young DW, Jordan SP. Renal cortical scintigraphy and single photon emission computerized tomography (SPECT) in the assesment of renal defects in children. *J Urol*. 1990;144:595–597.
4. Targington MA, Fildes RD, Levin K, et al. High Resolution single photon emission computerized tomography (SPECT) 99m Technetium-dimer-capto-succinic acid renal imaging: A state of the art technique. *J Urol*. 1990;144:598–600.
5. Moskovitz B, Halachmi S, Sopov V, et al. Effect of percutaneous nephrolithotripsy on renal function: Assessment with quantitative SPECT of (99m)Tc-DMSA renal scintigraphy. *J Endourol*. 2006; 20:102–106.
6. Samad L, Qureshi S, Zaidi Z. Does percutaneous nephrolithotomy in children cause significant renal scarring? *J Pediatr Urol*. 2007;3: 36–39.
7. Chatham JR, Dykes TE, Kennon WG, et al. Effect of percutaneous nephrolithotomy on differential renal function as measured by mercaptoacetyl triglycine nuclear renography. *Urology*. 2002;59: 522–525.
8. Morey AF, Nitahara KS, McAninch JW. Modified anatrophic nephrolithotomy for management of staghorn calculi: Is renal function preserved? *J Urol*. 1999;162:670–673.
9. Al-Tawheed A, Al-Awadi KA, Kehinde EO, et al. Sectorial technetium-99m-dimercaptosuccinic acid scintigraphy for monitoring the effect of extracorporeal piezoelectric lithotripsy for calyceal calculi on regional renal function. *Med Princ Pract*. 2003;12: 145–150.
10. Balbay MD, Varoglu E, Devrim H, et al. Quantitative evaluation of renal parenchymal mass with 99mtechnetium dimercapto-succinic acid scintigraphy after nephrolithotomy. *J Urol*. 1997;157: 1226–1228.
11. Dumont M, Marchand L, Laroche B, et al. Scintigraphic evaluation of renal function after extracorporeal shock wave lithotripsy. *Can Assoc Radiol J*. 1990;41:138–142.
12. Wadhwa P, Aron M, Bal CS, et al. Critical prospective appraisal of renal morphology and function in children undergoing shockwave lithotripsy and percutaneous nephrolithotomy. *J Endourol*. 2007;21: 961–966.
13. Mor Y, Elmasry YE, Kellet MJ, et al. The role of percutaneous nephrolithotomy in the management of pediatric renal calculi. *J Urol*. 1997;158:1319–1321.
14. Dawaba MS, Shokeir AA, IIafez AT, et al. Percutaneous nephrolithotomy in children: Early and late anatomical and functional results. *J Urol*. 2004;172:1078–1081.
15. Unsal A, Koca G, Resorlu B, et al. Effect of percutaneous nephrolithotomy and tract dilatation methods on renal function: Assessment by quantitative single-photon emission computed tomography of technetium-99m-dimercaptosuccinic acid uptake by the kidneys. *J Endourol*. 2010;24:1497–1502.
16. Handa RK, Matlaga BR, Connors BA, et al. Acute effects of percutaneous tract dilation on renal function and structure. *J Endourol*. 2006;20:1030–1040.
17. Marberger M, Stacki W, Hruby W, et al. Late sequelae of ultrasonic lithotripsy of renal calculi. *J Urol*. 1985;133:170–173.
18. Unsal A, Resorlu B, Kara C, et al. Safety and efficacy of percutaneous nephrolithotomy in infants, preschool age, and older children with different sizes of instruments. *Urology*. 2010;76: 247–252.
19. Rahul K, Fanindra S, Piyush S, et al. Safety and efficacy of percutaneous nephrolithotomy in the pediatric population. *J Endourol*. 2008;22:637–640.