Predicting surgical outcome of pediatric percutaneous nephrolithotomy

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Purpose The aim was to evaluate the outcome of pediatric percutaneous nephrolithotomy (PCNL) guided by Guy's stone score grading system.

Patients and methods This was a prospective study of children with renal calculi more than 2 cm. They were younger than 18 years and were a candidate for PCNL at our University Hospitals from January 2013 until July 2016. All of them had a low-dose noncontrast enhanced computed tomography. The procedure was performed under general anesthesia with the patients in the prone position guided by fluoroscopy. The stone-free rate and the presence and type of complications were estimated. The demographic and clinical data, stone characteristics, radiologic anatomy as well the PCNL approach and methods of lithotripsy used were evaluated. Comparison was performed through using univariate and multivariate analyses, and factors predicting the PCNL outcome were determined.

Results A total of 110 children with kidney stones were accepted for PCNL. Overall, 95 (86.3%) of 110 children were stone free after one-stage PCNL. Grade 1 Guy's stone score was 97.5% (40/41) ($P<0.05$). Mean hospital stay was 4.01 ± 2.0 days. Operative complications include bleeding in 12 (10.9%), extravasation in seven (6.4%), injury to the colon in one (0.9%), and renal pelvis perforation three (2.7%). In our study, larger Amplatz sheath, stone burden, and longer operative time are related to complications.

Conclusion Guy's stone score correlated with both success and complications and can be used for decision making preoperatively in pediatric PCNL. *Ann Pediatr Surg* 14:174–177 © 2018 Annals of Pediatric Surgery.

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Introduction

Percutaneous nephrolithotomy (PCNL) plays a significant standard role in treating renal stones. Complication rate from the disease and its treatment has reduced. PCNL is accepted as a minimally invasive technique for kidney stones greater than or equal to 2 cm, which is standardized in the EAU guidelines. It is a risky operation associated with many complications. Clavien classification system has the capabilities to grade these complications such as bleeding and injury to the collecting system [1–3].

Akman *et al.* stated that there is no single agreed upon ideal predictive pattern that characterizes the renal stones complex and predicts surgical outcomes after PCNL. A new predictive factor has recently emerged to systematically and quantitatively evaluate kidney stone complexity to emphasize outcomes following PCNL: the Guy's stone score [4,5].

The Guy's stone score has been investigated by Thomas *et al.* [6]. They postulated that the score is correlated with stone-free (SF) rates but is not associated with complications. The grading system is mainly designed according to the multiplicity of stones, the stone situation, and whether the renal anatomical configuration is favorable or unfavorable.

SF rates after PCNL reported in the literature are from 73 to 96%. Extracorporeal shockwave lithotripsy (ESWL) is an effective treatment method for pediatric and adult urinary stone disease; hard urinary stones resistant to ESWL and kidney stones greater than 2 cm in size are best treated by PCNL, with low morbidity [7].

The scoring systems recently used for estimation of the outcome of PCNL are Guy's stone score, nephrolithometry score, a nephrolithometric nomogram of the Clinical Research Office of Endourological Society, and staghorn morphometry. They have attempted to merge an important characteristic in a workable and straightforward method to evaluate renal stone complexity, to predict SF status, which includes stone burden, length of the track (skin-to-stone distance) if there is an obstruction, number of stones and calyces involved, and density of the stone [8–10].

This study was conducted to determine a correlation between Guy's score grading system with success and complications outcome of PCNL in children.

Patients and methods

This study was conducted as a prospective study in Al-Azhar University Hospitals by the Department of Urology staff. After local Medical Ethical Committee approval, an informed written consent was obtained from the patients' guardians.

A total of 110 children with renal calculi being approached for PCNL, from January 2013 to July 2016, were included for evaluation of safety and efficacy of pediatric PCNL. They were younger than 18 years old and had renal stones. Patients with stone burden greater than or equal to 2 cm and patients in whom ESWL failed and underwent PCNL for radio-opaque stones and had low-dose noncontrast enhanced computed tomography were included in this series, where children with coagulopathy disorder, marked vertebral deformity, anatomical obstruction such as pelviureteric junction obstruction, and congenital renal anomalies were excluded.

The demographic, clinical, and operative data were recorded, including, age, sex, stone burden, stone site, presence of hydronephrosis, chronic comorbidity, previous shockwave lithotripsy (22/20%), previous history of renal surgery (8/8.8%), intercostal or subcostal puncture, number of tracts made during the operation, dilatation type (Amplatz or balloon) depending on the surgeon preference, duration of the operation and hospital stay, nephrostomy tube times, assessment of the amount of blood loss and blood transfusion, residual stone fragments, hemoglobin and hematocrit value preoperatively and postoperatively, and results of postoperative urine and blood culture collected.

All children had low-dose noncontrast enhanced computed tomography, stone burden, track length, degree and presence of an obstruction (hydronephrosis), a number of calyces involved, and stone density, measured by a consultant of radiology.

Renal stones were categorized according to Guy's stone score [6]: grade I, a single stone in the mid and lower pole with favorable anatomy or a single stone in the pelvis with favorable anatomy; grade II, a single stone in the upper pole with favorable anatomy or multiple stones in a patient with favorable anatomy or any single stone in a patient with unfavorable anatomy; grade III, patient had multiple stones with an unfavorable anatomy or stones in a calyceal diverticulum or partial staghorn calculus; and grade IV, staghorn calculus or any stone in a patient who had spina bifida or spinal cord injury.

PCNL is performed under general anesthesia, and intravenous antibiotic is given preoperatively as a prophylaxis. After initiation of anesthesia, cystoscopy was performed, and then a ureteral catheter (4–6 Fr) was inserted into the ipsilateral ureter that harbors the stone. Renal puncture was carried out with an 18 G needle and guide wire into the most suitable kidney pole guided by biplane fluoroscopy. This punctured tract was dilated with Alkene's dilators (Amplatz) or balloon dilator of up to 21 depending on the patient's age and stone burden under fluoroscopic guidance. All pressure points were filled out. Nephroscope (size 15 Fr) was used. During percutaneous lithotripsy, a pneumatic lithotripter was used to disintegrate the big stone fragments, following which they were grasped with collecting forceps; a catheter was used for irrigation and to remove the stone fragments that were too small to be grasped. Fixation of nephrostomy tube was done after the procedure was completed. Blood loss was estimated by hemoglobin and hematocrit value in all patients 4 h after the operation. Nephrostomy tube was preserved open for 24 h and closed on the second postoperative day when the child's condition was stable with no fever or abdominal pain, and then the nephrostomy tube was removed.

The SF rates were assessed with a plain urinary tract film on the next day of the operation and repeated at follow-up combined with abdominopelvic ultrasound after 30 days; complications were categorized depending on the modified Clavien system classifications [3].

The residual stone was categorized into three divisions: SF; clinically insignificant residual fragments (CIRF), less than or equal to 4; and clinically significant residual fragments, greater than or equal to 4 mm. The success rate is the combination of SF and CIRF.

Statistical data analysis

Analysis of data was done by using statistical software for the social sciences (SPSS version 20.0; IBM, Chicago, Illinois, USA). Results were expressed as mean ± SE with 95% confidence interval using medians for quantitative variables and using frequencies and percentages for qualitative ones. For comparison between values before surgical intervention and the same variables after intervention, Student's *t*-test was employed for quantitative information and interpretation of the results, which was being considered statistically significant if *P* value of less than 0.05.

Results

A total of 110 children from 250 (44%) children harboring renal stones who met our inclusion criteria were treated from January 2013 to July 2016. PCNL was performed in our University Hospitals. There were 69 (62.7%) boys and 41 (37.3%) girls. Their mean age was 13.11 ± 4.22 years. The mean stone burden was 2.3 ± 1.5 (range: 1.8–3.8 cm). A total of 69 (62.7%) children had solitary stone [grade I: 42 (38.1%) and grade II Guy's stone score: 27 (24.5%)], 28 (25.5%) had multiple stones (grade III), and 13 (11.8%) had grade IV Guy's stone score (Tables 2 and 3).

A total of 95 (86.3%) patients were SF following one-stage PCNL, and 15 (13.64%) children were treated with ESWL for postoperative residual stones.

The success rate and complication rate are important for the determination of the surgical outcome of PCNL. Success rates were estimated with a cutoff point of less than 4 mm to define CIRF. The sum of CIRF and SF is the success rate (95/110; 86.36%).

Postoperative complications were seen in 30 (27%) of 110 patients and were graded according to the Clavien–Dindo classification as follows – Clavian 1: seven (6.4%) patients, with pain in three (2.7%) and fever in four (3.6%); Clavian 2: 22/110 (20%), with postoperative blood transfusion in seven (6.4%), extravasation in seven (6.4%), and leakage in five (4.5%); and Clavian 3b: four (3.6%) patients, with colonic injury in one (0.9%) and pelvic perforation and double J stent (DJ) fixation in three (2.7%). There were no complications of Clavian 4 (0%) and Clavian 5 (0%).

Intraoperative complications included the following: blood loss needing packed red blood cells (RBCs) occurred in 12 (10.9%) children, where seven cases among them needed postoperative packed RBCs owing

Table 1 Variables of operative data

Parameters	Value	*P* value of success	*P* value of complications
Operative time (min)			
Mean ± SD	98.6 ± 41.6		
Range	50 to 180		
Number of tracts			
1	95/86.3	0.16	0.21
2	15/13.6	0.33	0.35
Dilation (*n*/%)			
Amplatz	90/81.8	0.31	0.28
Balloon	20/18.2	0.32	0.39
Intraoperative blood transfusion (*n*/%)	12/10.9		

Table 2 Correlation coefficient between of Guy's stone score with success rate

Guy's score grades	Patients (*n*/%)	Success [*n* (%)]	Success (*P* value)
1	41/37.2	40/41 (97.5)	< 0.05
2	30/27.24	27/30 (90)	< 0.05
3	26/23.6	21/26 (80.7)	0.02
4	13/12	7/13 (53.8)	0.01

Table 3 Correlation coefficient between of Guy's stone score with complications

Guy's score grades	Patients (*n*/%)	Complications [*n* (%)]	Complications (*P* value)
1	41/37.2	3/41 (7.3)	0.03
2	30/27.24	5/30 (16.6)	0.03
3	26/23.6	16/26 (61.5)	< 0.05
4	13/12	11/13 (84.6)	< 0.05

to the continued drop of hemoglobin; extravasation in seven (6.4%) children was retroperitoneal, which was diagnosed intraoperatively and did not need any intervention; colonic injury occurred in one (0.9%) case, which was diagnosed later, that needs needed exploration, and colostomy done with a nephrostomy tube fixation on the kidney, followed by revision of colostomy after 1 month; and pelvic perforation occurred in three (2.7%) children, which necessitated DJ fixation. The entire complications occurred in large stones (partial staghorn stones and staghorn stones) which required additional operative time with Amplatz dilatation (Table 1).

The time of the procedure ranged from 50 to 180 min (mean ± SD: 98.6 ± 41.6), whereas the mean hospital stay was 5 ± 1.6 days (range: 3–7 days).

Amplatz dilatation was done in 90 (81.8%), and balloon dilator was used in 20 (18.2%). No statistical difference was found between both groups regarding operative time (97.9 ± 45.3 min in balloon group vs. 98.5 ± 43.4 min in the Amplatz group; $P=0.43$), preoperative hematocrit value (39.04 ± 4.21 vs. 38.94 ± 4.49, respectively; $P=0.87$), and postoperative hematocrit value (32.74 ± 4.86 vs. 32.48 ± 5.43, respectively; $P=0.73$). Transfusion of packed RBCs was similar (10.9 vs. 10.5%; $P=0.84$) between the balloon and Amplatz groups. The success rate is the same between the balloon and Amplatz dilatation groups. Although in kidneys there are significant x-ray exposure reductions with a balloon procedure as it can be done with ultrasound guidance instead of fluoroscopy, it is costly because the balloon dilator has a higher price than that of the Amplatz dilator.

Early postoperative complications were estimated in 12 (10.9%) patients: Clavian 1 in four (3.6%) children, who had fever and were treated with antibiotics and antipyretics; five (4.5%) children with prolonged urinary leakage from nephrostomy site, who were managed with conservative treatment; and three (2.7%) children complained of agonizing pain and were treated with analgesics.

Late postoperative complications were recorded in 30 (27.2%) cases: 15 (13.6%) developed urinary tract infection, who were diagnosed by urinalysis and culture of urine and managed by antibiotics according to culture and sensitivity report, and 15 (13.6%) patients had residual stone fragments (clinically significant residual fragments), who were diagnosed by postoperative plain urinary tract and abdominopelvic ultrasound and treated by extracorporeal shockwave lithotripsy later on; CIRF were not encountered in any case (Table 1).

Discussion

Endourology is an important field of urology in which technology has played a significant role, transferring open stone surgery to surgical history [2]. Lifetime anticipation has longer in children than adults, so they have a considerable risk of stone recurrence. Thus, procedures of minimally invasive technique are applied in children. ESWL has been accepted as a first-line treatment of urinary tract stones in pediatrics [6] and provides a safe and effective optional treatment for the management of renal calculi [10]. ESWL has some limitations, such as the need for anesthesia, especially in young children; difficulty with large and dense stones; and occurrence of pain owing to obstruction of the urinary tract associated with the passage of stone fragments. PCNL in children is a safe and successful option. The success rate of the procedure is 66–100%, which depends on the diverse structure of the stones, stone burden, and the learning curve of the operator. The size of dilatation is another principal factor in PCNL, especially in younger children as recommended by Samad *et al.* [11], who advise that dilatation in children should be done with not more than 21-Fr catheter, especially in those younger than 8 years of age, and concluded that a larger-sized dilatation might cause more bleeding.

The present work is comparable to most of the published data. Stone burden and renal configurations were the most important preoperative, operative, and postoperative parameters that have a statistically significant correlation both with success rate ($P<0.05$) and complications occurred ($P<0.03$) (Table 2).

Thomas *et al.* [6] stated that the Guy's stone score includes stone number, location, presence of staghorn stones, and abnormal anatomy to determine different grades, and they reported that the stone free rate declined with increasing grades of complexity and that Guy's stone score can portend the stone free rate after PCNL, which they have identified progression of the grading system. They establish that as the degree of Guy's stone score increases, the success decreases and complications are increased. Although grade 1 stones had an 81%, grade 2 had 72.4%, grade 3 had 35%, and grade 4 ahd 29% SF rates, the overall success rate was 62% and complications discovered in 52% of the patients, with most of them having Clavian grade 1 (30%). Success rates were revaluated with a cutoff level of residual stone less than 4 mm to define CIRF, and a combination of CIRF and SF is the success rate. They also postulated that the score correlated with SF rates, but did not associate with complications.

In this work, the success rate of the procedure is 86.3% (Table 2), and Guy's stone scores 1 and 2 showed a statistically significant correlation with success rate ($P<0.05$). However, the postoperative complication rate was 31% and Guy's stone scores 3 and 4 had significant correlations with the complications ($P<0.05$) (Tables 2 and 3). We found that as the score increases, the success rate decreased and complications increased. So in this work, Guy's stone scores system was related to a successful outcome as well as it related to complications.

Hospital stay was 5 ± 1.6 days (range: 3–7 days) for all children, except one child who had a colonic injury, and had to stay in the hospital for up to 30 days. Our work is comparable to the previous studies such as Elderwy *et al.* [12] who record that the range of hospital stay was 3–4 days.

Hüseyin *et al.* [13] found that all children had decreased blood hemoglobin levels during and after PCNL, owing to either hemodilution or bleeding. It is necessary to determine whether blood transfusion is indicated because those young kids cannot tolerate blood loss. Instrument size, operative time, and the stone burden were suggested as clinical variables affecting blood loss in pediatric PCNL. Several punctures have been identified as a cause of bleeding [blood transfusion nine (11.25%), DJ fixation eight (2.74%), fever (2.40%), and urinary infection five (1.71%)].

In this work, complications occurred were bleeding in 12 (10.9%) children blood transfusion rate which is less than Dogan *et al.* [14], but our results higher than, Nouralizadeh *et al.* [15] who concluded that larger Amplatz sheath, stone burden and longer operative time were related to the high transfusion rate. The explanation of this high rate of transfusion may be owing to a lower preoperative hemoglobin level and a lower circulation reserve and the threshold for transfusion. Four (3.6%) children had fever, which correlated with previous studies. However, prolonged leak from nephrostomy site was found in five (4.5%) children, colonic injury was detected in one (0.9%) child, and pelvic injury was diagnosed in three (2.7%) children, which were higher than previous studies, as in our series, there was a larger stone burden which needed more operative time and larger Amplatz size.

The complications were considered minor, and no major complications developed such as pneumothorax, hemothorax, or mortality in our work.

Conclusion

Guy's stone score correlated with both success and complications and can be used for decision making preoperatively in pediatric PCNL.

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Conflicts of interest

There are no conflicts of interest.

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