International Journal of Gerontology 12 (2018) 239–243

Contents lists available at ScienceDirect

International Journal of Gerontology

journal homepage: www.ijge-online.com

Original Article

Predicting Percutaneous Nephrolithotomy Outcomes and Complications in Elderly Patients Using Guy's Scoring System and Charlson Comorbidity Index

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ARTICLE INFO

Article history:
Received 21 January 2018
Received in revised form
11 April 2018
Accepted 7 May 2018
Available online 25 May 2018

Keywords:
elderly,
percutaneous nephrolithotomy,
comorbidity,
treatment outcome,
complications

SUMMARY

Background: This study compared the operative outcomes of percutaneous nephrolithotomy in elderly patients with different comorbidity status and different stone complexity.
Methods: A retrospective review of medical records was performed of 113 patients aged 65 years or older with large renal stones who underwent percutaneous nephrolithotomy between 2007 and 2016. Patients were stratified by comorbidity status using the Charlson comorbidity index and by stone complexity using the Guy's score. The demographic data, stone parameters, stone-free rates, and complication rates were compared. Factors associated with complications and stone free rate were analyzed using logistic regression.
Results: Patients with higher Charlson comorbidity index were older, used more anticoagulant medications, had higher ASA score, had longer operative times, and had longer hospital stay. Patients with higher Guy's score had higher stone burden, longer operative times, and a more significant decrease in GFR postoperatively. Logistic regression found that pre-operative pyuria and higher Charlson comorbidity index increased the risk of overall complications, and higher stone burden and higher Guy's score were associated with decreased stone free rates.
Conclusion: This study supported the use of the Charlson comorbidity index in predicting post-operative complications and the Guy's score in predicting stone-free status in elderly patients with large renal stones undergoing percutaneous nephrolithotomy.

1. Introduction

Management of large renal calculi remains an important issue in urological practice. With advances in surgical techniques and instruments, minimally invasive surgery has replaced open surgery in the management of these stones. Percutaneous nephrolithotomy (PCNL) was first introduced in 1980 and soon became the first-line therapy. Despite the advantage of smaller wounds, less blood loss, and shorter recovery time in comparison with open surgery, surgical complications after PCNL are still an important issue, and the possibility of vascular injury, pleural puncture, adjacent organ damage, sepsis, and complications following hours of intubation under prone position needs to be considered. Complications have been reported to occur in 10.3% to over 50% of PCNLs.[1–6] Elderly patients usually have more comorbidities and poorer functional status, which may lead to higher surgical risks.[7–12] Several scoring systems have been used to predict the surgical outcomes.[13–15] However, most of these scoring systems require performing measurements in computed tomography images. Furthermore, while these scoring systems helped predict stone free status, they could not accurately predict complications.[16–20] Among these scoring systems, the Guy's scoring system (GSS) is relatively simple and the stone's morphologic characteristics can be identified using plain X-rays and renal ultrasonography.[15] The Charlson comorbidiy index (CCI) is a simplified health status indicator,[21] which has been reported to be predictive in outcomes of several clinical situations including urological surgery-related complications.[8,9,22–27] In this

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https://doi.org/10.1016/j.ijge.2018.05.001

context, we retrospectively reviewed elderly patients who received PCNL at our institution in the past ten years and analyzed factors affecting post-operative complications and stone free rates.

2. Patients and methods

2.1. Patients

We retrospectively reviewed the medical records of patients aged ≥65 years at the time of receiving PCNL at our institution from June 2007 to December 2016. Patients receiving surgery for bilateral stones and those with incomplete image records or laboratory data were excluded. Clinical, stone-related, and peri-operative parameters as well as post-operative complications were recorded. Clinical parameters included age, sex, body mass index (BMI), use of anticoagulant medications, ASA score, and the presence of pre-operative pyuria. The recorded stone-related parameters included laterality, access location, degree of hydronephrosis, and pre-/post-operative stone burden. Peri-operative parameters included operative times, duration of hospital stay, and pre-/post-operative hemoglobin level and glomerular filtration rate (GFR). We evaluated the pre-existing comorbidities and calculated the Charlson comorbidity index score. The Guy's scores for each stone were also calculated from pre-operative X-rays and renal ultrasonography.

Patients were divided into 3 groups according to the CCI (0, 1, >1) and 4 groups according to GSS (1–4). The CCI features 19 conditions for which weighted scores of 1, 2, 3, or 6 are assigned according to the severity of the condition. The CCI score is the sum of the weighted scores for all comorbidities and ranges from 0 to 37.[21] The GSS classifies renal stones into 4 grades according to morphology[15]:

Guy's 1: a solitary stone in the mid/lower pole or in the renal pelvis with normal anatomy, Guy's 2: a solitary stone in the upper pole; multiple stones in a patient with simple anatomy; or a solitary stone in a patient with abnormal anatomy (cases in which the operating surgeon believes access may be difficult, e.g., abnormal renal anatomy, an abnormal collecting system, or a patient with an ileal conduit), Guy's 3: multiple stones in a patient with abnormal anatomy or in a calyceal diverticulum or partial staghorn calculus (stone involving the renal pelvis and at least 2 calices), and Guy's 4: a complete staghorn calculus (all calices and the pelvis occupied by stones) or any stone in a patient with spina bifida or a spinal injury.

2.2. Surgical technique

Patients routinely received general anesthesia with intubation. Insertion of double-J ureteral stents or retrograde ureteral catheters was performed in most of the cases. Ultrasound-guided puncture was then performed with the patient in prone position either subcostally or intercostally (between 11th and 12th ribs). The access routes were sequentially dilated with Amplatz fascial dilators and maintained with a 24 French Amplatz sheath. Lithotripsy was performed with 18 French nephroscopy and pneumatic ultrasonic lithoclast under continuous saline solution irrigation. Stone fragments were removed with grasps or washed out with irrigating fluids. At the end of the procedure, a 21 French silicone tube was routinely inserted, and was clamped and removed in the 1st or 2nd post-operative day in the absence of fever or marked hematuria.

2.3. Statistical analysis

The clinical characteristics, stone-related parameters, peri-operative parameters, and post-operative complications were compared using chi-square test or fisher's exact test. Univariate and multivariate logistic regression analyses were performed to determine the odds ratios (OR) and 95% confidence intervals (CI) of variables affecting complications, initial stone free status, and final stone free status.

All reported p values were based on two-sided tests, and were considered statistically significant if they were less than 0.05. Data were analyzed using IBM SPSS release 21.0 (IBM, Armonk, New York).

The use of data and the research protocol of the study were permitted and approved by the Mackay Memorial Hospital Institutional Review Board. Patients' consent to review their medical records was not required. According to the regulations of Mackay Memorial Hospital Institutional Review Board, collection of noninvasive materials for routine practice and data prepared retrospectively for future publications does not require informed consent. All personal information was de-identified prior to data analysis, thus covering patient data confidentiality.

3. Results

In total, 113 patients were included this study. The mean age was 69.5 years. Tracing back all the cases, there were no urological surgery which would cause anatomical change except one case received unilateral nephrectomy due to renal cell carcinoma. This patient had post-PCNL sepsis which was treated with a 10-day antibiotic course and was then discharged uneventfully. There was record of only one patient with recurrent urinary tract infection (UTI) history prior to surgery. The patient had several episodes of UTI due to *Pseudomonas aeruginosa* and *Escherichia coli*. That patient had a neurogenic bladder which required long-term catheterization. As a result, UTIs continued to recur in this patient despite removal of the renal stone. There were three cases with history of pulmonary disease: one had lung cancer, which was treated by video assisted wedge resection, another one had chronic obstructive pulmonary disease under regular medical control, and the third one had pneumoconiosis. All these cases had smooth surgical procedures without intra-operative or peri-operative adverse events.

Patient stratification by CCI showed that patients with higher CCI were older ($p = 0.043$), more commonly used anticoagulant medications ($p = 0.023$), had higher ASA score ($p = 0.005$), had longer operative times ($p = 0.031$), and had longer hospital stay ($p = 0.003$). High CCI was also correlated with post-operative fever ($p = 0.017$) and sepsis ($p = 0.018$) (Table 1).

Patients with high Guy's scores had larger stone burdens ($p < 0.001$) and longer operative times ($p < 0.001$). There was a positive correlation between higher Guy's score and decreased GFR ($p = 0.031$), but there was no statistical significant correlation between Guy's score and complications (Table 2).

Complications occurred in 34 patients (30%), including peri-operative blood transfusions in 13 cases (11.5%), post-operative sepsis in 7 patients (6.1%), post-operative urinary tract infection in 4 cases (3.5%), gastrointestinal tract bleeding in 4 cases (3.5%), hydrothorax in 2 patients (1.8%), prolonged urine leak from the wound after tube removal (>24hrs) in 2 patients (1.8%), and cerebrovascular event, non-urological infection (osteomyelitis), ileus, renal artery aneurysm, and ureteral penetration by double-J catheter in 1 case each (0.9%) (Table 1). Fifty-eight patients were stone-free after the surgery (51.3%). An additional 26 patients were also stone-free with further ESWL or secondary PCNL, resulting in a 74.3% final stone free rate (84/113 patients) (Table 2).

Logistic regression analysis of the factors related to overall complications showed that female gender, pre-operative pyuria, and CCI score were significantly associated with increased risk of overall complications after univariate analysis, while pre-operative pyuria (OR = 3.464, 95% CI = 1.25–9.55) and CCI score (CCI = 1 versus 0, OR = 6.836, 95% CI = 1.80–25.91; CCI>1 versus 0, OR = 11.073, 95% CI = 3.02–40.47) remained associated after multivariate analysis (Table 3).

Table 1
Patient demographics by CCI group.

	CCI = 0 n = 43	CCI = 1 n = 35	CCI > 1 n = 35	P value
Age (years, range)	70 (67–72)	68 (66–71)	71 (69–75)	**0.043**
Sex				
Male	20	16	17	1
Female	23	19	18	
BMI	25.5 (22.7–28.3)	25.9 (23.1–28.3)	24.2 (22.5–28.8)	0.819
Laterality				
Left	24	24	16	0.154
Right	19	11	19	
Anticoagulants	1	4	8	0.023
Intercostal access	9	8	10	0.789
Stone burden (mm^2, range)	541 (288–1150)	760 (304–1221)	596 (393–1090)	0.736
Pre-operative pyuria	13	7	16	0.07
ASA score				
1	4	2	0	0.05
2	30	27	16	
3	8	5	16	
Operative time (min.)	108 (74–130)	117 (95–142)	117 (100–170)	**0.031**
Hospital stay (days)	5 (4–6)	6 (4–7)	6 (5–11)	**0.003**
△Hb (g/dL)	1 (0.5–1.6)	1.1 (0.3–1.6)	0.9 (0.3–1.7)	0.933
△GFR	0 (−8.9–9.6)	7.45 (0–15.78)	2.5 (−1.1–11.7)	0.229
Blood transfusion	3	5	5	0.502
Fever	7	12	16	**0.017**
Sepsis	0	2	5	**0.018**
Urine leak	0	2	0	0.188
Pleural effusion	0	1	1	0.524
Infection				
UTI	1	0	3	0.194
Other	0	1	0	0.619
GI bleeding	0	1	3	0.107
CVA	0	1	0	0.619
Ileus	0	0	1	0.619
Aneurysm	1	0	0	1
DJ complication	0	0	1	0.619

Bold: statistically significant.
BMI = body mass index, ASA score = American society of anesthesiologist physical status classification, △Hb = change in hemoglobin level, △GFR = change in Glomerular filtration rate, UTI = urinary tract infection, CVA = cerebral vascular accident, DJ = double-J ureteral catheter.

Spearman's correlation analysis showed that neither of the scoring systems was correlated to the severity of complications stratified according to the Clavien-Dindo classification. (CCI score:r = 0.092, p = 0.552; Guy's score: r = 0.063, p = 0.685).

Smaller stone burden, shorter operative time, and lower Guy's score were associated with higher initial stone free rates after univariate analysis, while lower Guy's score (GSS = 3 versus 1, OR = 0.218, 95% CI = 0.053–0.896; GSS = 4 versus 1, OR = 0.048, 95% CI = 0.004–0.510) remained associated after multivariate analysis.

Univariate analysis showed that stone burden (OR = 0.999, 95% CI = 0.998–0.999) and Guy's score (GSS = 3 versus 1, OR = 0.088, 95% CI = 0.011–0.725; GSS = 4 versus 1, OR = 0.048, 95% CI = 0.055–0.347) were associated with the final stone free rate, but these associations were not seen in multivariate analysis (Tables 4 and 5).

4. Discussion

The main concerns of managing large or complex stones with PCNL are post-operative complications and decreased stone free rates, which may greatly affect elderly patients. Early studies reported identical outcomes between different age groups.[2,28] However, recent studies reported higher risk of overall complications or high Clavien-grading complications in older patients.[7–11] As a result, in elderly patients, predicting peri-operative outcome is of utmost importance in guiding management.

Several scoring systems have been used to describe stone complexity. The most popular scoring systems are the Guy's score, the S.T.O.N.E score, and the CROES nomogram.[13–15] These scoring systems were designed to predict the outcomes of surgical intervention. While proving reliable on predicting the stone free rates, controversy remained regarding the predictive value of these scoring systems for complications.[17,19,20,29] Calculating the S.T.O.N.E score and CROES nomogram is more challenging on daily practice due to the need for detailed image and clinical data (e.g., stone burden, tract length, case volume of the facility, etc.). Limited by the retrospective nature of this study, we only calculated the Guy's score, as most of the cases received plain X-ray, intravenous pyelogram, or renal ultrasonography instead of computed tomography. In our study, the Guy's score was the only predictive factor of stone free status after a single procedure. The Guy's score and stone burden were positively correlated to the final stone free status on univariate analysis. These results were compatible with those of previous studies in non-elderly patients.[5,15,19,20,30,31] In our study, the Guy's score was also correlated to stone burden, operative time, and GFR change. All these clinical factors are directly related to stone complexity. The study groups of Vicenti et al and Mandal et al reported correlations between Guy's score and surgical complications, but their results were not supported by other studies.[5,16–20] A recent multi-center study which included 586 patients reported a weak correlation between the Guy's score and complications, and the statistical significance was found only in univariate analysis.[32] In our study, the Guy's score was not found to be associated with PCNL-related complications. Therefore, the Guy's score was useful for predicting stone free status, but is an unreliable predictor of complications. Instead of using scores for stone complexity, Ali et al used a previously existing scoring system for health status, the CCI, to predict the morbidity and mortality after PCNL.[9] The CCI score is the sum of the weighted scores of 19 medical conditions, and it can

Table 2
Patient demographics by GSS.

	GUY'S 1 n = 30	GUY'S 2 n = 13	GUY'S 3 n = 39	GUY'S 4 n = 31	P value
Age	70 (66–72)	70 (68–73)	70 (67–73)	66 (66–74)	0.693
Sex					
Male	15	5	20	13	0.786
Female	15	8	19	18	
BMI	25.5 (23.1–27.6)	27.6 (23.5–29.1)	24.9 (22.7–28.8)	25.9 (21.7–27)	0.744
Laterality					
Left	18	6	24	16	0.711
Right	12	7	15	15	
Anticoagulants	4	3	3	3	0.496
Intercostal puncture	7	2	9	9	0.824
Stone burden	239 (172–326)	393 (284.5–638)	618 (472–859)	1415 (1191–1946)	**<0.001**
Pre-op pyuria	9	7	9	11	0.216
ASA score					
1	1	0	3	2	0.837
2	22	8	22	21	
3	6	4	12	7	
OP time (min.)	93.5 (73–120)	109 (88–129)	115 (90–130)	141 (112–189)	**<0.001**
Hospital stay (day)	5 (4–7)	5 (4–6)	6 (4–7)	6 (5–7)	0.547
△Hb	0.65 (0.23–1.47)	0.95 (0.38–2.08)	1.1 (0.3–1.65)	0.9 (0.6–1.6)	0.612
△GFR	0 (−11.3–9.6)	−2.45 (−19.4–1.87)	8.4 (0–12.55)	6.5 (0–20.6)	**0.031**
Blood transfusion	2	2	2	7	0.106
Fever	8	3	11	13	0.51
Sepsis	2	1	3	1	0.859
Urine leak	1	0	0	1	0.624
Pleural effusion	1	0	0	1	0.624
Infection					
UTI	0	1	2	1	0.55
Non-urologic	1	0	0	0	0.381
GI bleeding	1	0	2	0	1
CVA	0	0	1	0	1
Aneurysm	0	0	0	1	0.655
DJ complication	0	0	1	0	1

Bold: statistically significant.
BMI = body mass index, ASA score = American society of anesthesiologist physical status classification, △Hb = change in hemoglobin level, △GFR = change in Glomerular filtration rate, UTI = urinary tract infection, CVA = cerebral vascular accident, DJ = double-J ureteral catheter.

be calculated quickly and easily in clinical practice.[21] Studies on other urological surgeries including radical prostatectomy, transurethral resection of prostate, and radical cystectomy also reported significant validation of the CCI score in predicting surgical morbidities or mortalities.[22–26] Unsal et al applied the CCI score on aged patients and found a statistically significant association between CCI and hemorrhagic events and life threatening complications.[8] Our study found the CCI score to be positively correlated to post-operative fever, sepsis, and overall complications.

In addition to the CCI score, pre-operative pyuria was also significantly correlated to overall complications after multivariate logistic regression. Several studies reported that positive urine cultures significantly affected the rate of sepsis after PCNL.[33–35]

Our study showed that higher CCI scores were also correlated with pre-operative use of anticoagulation agents, ASA score, operative time, and length of hospital stay. The most frequently recorded comorbidities leading to higher CCI scores were diabetes, acute

Table 3
Logistic regression analysis of factors associated with overall complications.

Variables	Univariate OR (95% CI)	Multivariate OR (95% CI)
Age	1.029 (0.931–1.138)	
Gender (male/female)	**0.421 (0.181–0.979)**	0.471 (0.177–1.252)
BMI	0.911 (0.809–1.026)	
Laterality (Right/Left)	1.239 (0.552–2.781)	
Anticoagulants	1.530 (0.462–5.070)	
Intercostal puncture	2.327 (0.946–5.727)	
Stone burden	1.000 (1.000–1.001)	
Pre-operative pyuria	**3.812 (1.622–8.959)**	**3.464 (1.256–9.550)**
ASA score	1.825 (0.813–4.096)	
Operative time	1.009 (1.000–1.017)	
CCI-group		
1/0	**5.087 (1.467–17.638)**	**6.836 (1.804–25.911)**
>1/0	**10.324 (3.036–35.109)**	**11.073 (3.029–40.478)**
Guy's score		
2/1	1.460 (0.342–6.227)	
3/1	1.460 (0.493–4.324)	
4/1	1.807 (0.589–5.545)	

Bold: statistically significant.
BMI = body mass index, ASA score = American society of anesthesiologist physical status classification.

Table 4
Logistic regression analysis of factors associated with initial stone free status.

Variables	Univariate OR (95% CI)	Multivariate OR (95% CI)
Age	1.043 (0.950–1.146)	
Gender (male/female)	1.120 (0.535–2.346)	
BMI	0.993 (0.898–1.097)	
Laterality (Right/Left)	0.847 (0.402–1.784)	
Anticoagulants	1.121 (0.352–3.571)	
Intercostal puncture	1.524 (0.634–3.661)	
Stone burden	**0.997 (0.996–0.998)**	0.999 (0.998–1.001)
Pre-operative pyuria	0.786 (0.356–1.736)	
ASA score	1.398 (0.679–2.878)	
Operative time	**0.982 (0.972–0.992)**	0.993 (0.980–1.006)
CCI-group		
1/0	1.533 (0.624–3.766)	
>1/0	1.218 (0.498–2.976)	
Guy's score		
2/1	0.513 (0.097–2.711)	0.662 (0.119–3.695)
3/1	**0.146 (0.043–0.498)**	**0.218 (0.053–0.896)**
4/1	**0.016 (0.003–0.081)**	**0.048 (0.004–0.510)**

Bold: statistically significant.
BMI = body mass index, ASA score = American society of anesthesiologist physical status classification.

Table 5
Logistic regression analysis of factors associated with final stone free status.

Variables	Univariate	Multivariate
	OR (95% CI)	OR (95% CI)
Age	1.028 (0.922–1.146)	
Gender (male/female)	1.119 (0.479–2.612)	
BMI	0.942 (0.841–1.055)	
Laterality (Right/Left)	0.635 (0.272–1.483)	
Anticoagulants	0.505 (0.151–1.691)	
Intercostal puncture	2.357 (0.739–7.512)	
Stone burden	**0.999** (0.998–0.999)	0.999 (0.998–1.000)
Pre-operative pyuria	0.567 (0.236–1.363)	
ASA score	1.453 (0.639–3.307)	
Operative time	0.993 (0.984–1.001)	
CCI-group		
1/0	0.875 (0.310–2.469)	
>1/0	0.758 (0.273–2.099)	
Guy's score		
2/1	0.115 (0.011–1.235)	0.135 (0.012–1.476)
3/1	**0.088** (0.011–0.725)	0.122 (.014–1.072)
4/1	**0.042** (0.005–0.347)	0.109 (0.008–1.399)

Bold: statistically significant.
BMI = body mass index, ASA score = American society of anesthesiologist physical status classification.

myocardial infarction, and cerebrovascular infarction. These comorbidities are the main reason for the higher rate of pre-operative anticoagulant use, longer operative time, and higher ASA score in the higher CCI groups. Nevertheless, changes in hemoglobin level and blood transfusion rates did not differ in the different CCI groups. In some of the patients with multiple comorbidities, treatment of underlying medical conditions resulted in prolonged hospital admissions.

The main limitation of this study is its retrospective nature. Larger patient numbers are required to further corroborate the described associations.

5. Conclusion

PCNL is an efficacious treatment modality for large renal stones in elderly patients, but it may result in surgical complications. This study supports the use of CCI in predicting post-operative complications and Guy's score in predicting stone-free status in these patients.

Conflicts of interest

There are no potential financial and non-financial conflicts of interest.

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