# Prediction of Morbidity and Mortality After Percutaneous Nephrolithotomy By Using the Charlson Comorbidity Index

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**OBJECTIVES** To determine whether the Charlson Comorbidity Index (CCI) predicts postoperative medical complications and death in patients treated with percutaneous nephrolithotomy (PCNL).

**METHODS** A total of 1406 PCNL procedures were performed at 4-stone referral centers between September 2004 and March 2011 were reviewed in this multicenter study. Variables included patient and stone characteristics, preoperative comorbidities, intraoperative data, and postoperative complications, including mortality.

**RESULTS** The present study included 868 (61.7%) men and 538 (38.3%) women. Mean patient age was 44.1 years (range 1-81). CCI score was calculated as "0" for 993 patients (70.6%, called group I), "1" for 316 patients (22.5%, called group II) and"≥2" for 97 patients (6.9%, called group III). The incidence of comorbidities increased with age ($P$ = .001). The overall postoperative complication rate was 29.3%. Life-threatening medical complications developed in 2.9% of patients in group I, 7.6% of patients in group II, and 21.6% of patients in group III, ($P$ = .001). There were 3 deaths for an overall 0.2% mortality rate. Perioperative bleeding requiring blood transfusion was observed in 9.5% of patients, and we found an increased risk of hemorrhage associated with CCI score ($P$ = .049). High CCI score, patient age, hemorrhage, and operative time were significantly related to higher medical complication rates after PCNL.

**CONCLUSIONS** CCI is a quick, simple, and reproducible scoring system that accurately predicts the morbidity and mortality of PCNL. UROLOGY 79: 55–60, 2012. © 2012 Elsevier Inc.

Percutaneous nephrolithotomy (PCNL) was first reported in 1976 by Fernstrom and Johannson.[1] Since its introduction, several modifications have been made to reduce its morbidity and expand its indications by developing novel techniques and improving instrumentation. The recently updated American Urological Association Clinical Nephrolithiasis Guidelines Committee on staghorn calculi has recommended PCNL as the most effective approach to large-volume renal stone disease with the superior overall stone-free rate of 78%.[2] It has the advantages of higher rates of stone clearance, cost-effectiveness, and early convalescence compared with other modalities such as shock wave lithotripsy (SWL) and open surgery.

PCNL is regarded as a safe and efficient method of kidney stone removal, with a relatively low incidence of significant complications, such as bleeding, sepsis, damage to extrarenal organs, pulmonary embolism (PE), myocardial infarction (MI), and single- or multi-organ dysfunction.[3-9] The Clavien system has been modified to grade the complications of PCNL.[10,11] However, no currently available method has been accepted for predicting the complications after PCNL. The ideal method must be a scoring system that is quick, simple, and reproducible and has a good correlation with the complication rates. The Charlson Comorbidity Index (CCI), which is a validated prospective method to classify comorbid conditions, may alter the risk of mortality in longitudinal studies.[12] There are some reports of treatment complications in relation to pretreatment comorbid conditions, linking the CCI score to higher complication rates, instance, eg, after radical prostatectomy and radical nephrectomy.[13-15] In this multicenter study, we tried to determine whether CCI predicts the postoperative med-

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ical complications and death in patients who underwent PCNL.

## MATERIAL AND METHODS

### Patients

Between September 2004 and March 2011, 1406 PCNL procedures were performed in 4 large referral hospitals in Ankara, Turkey. Data were collected from the retrospective reviews of hospitals' and physicians' office records, and by contact with the patients. Patients were evaluated with plain film, intravenous urography (IVU), ultrasonography (US), urinalysis, urine culture, complete blood count, serum biochemistry, and coagulation tests before the procedure. Renal scintigraphy and computerized tomography (CT) were not done routinely, but were performed whenever needed. Stone size was determined by measuring the longest axis on preoperative radiologic investigation; in cases of multiple nonstaghorn calculi, stone size was defined as the sum of the longest axis of each stone.

For each patient, we evaluated preexisting comorbidities and calculated the CCI score.[12] The CCI features 19 conditions for which weighted scores equal to 1, 2, 3, or 6 are assigned based on the severity of the condition. The CCI score was derived by adding the weighted scores for all comorbidities. For example, a 52-year-old female with a history of MI and metastatic breast cancer would have 1 point for myocardial infarction and 6 for a solid tumor, for a total of 7 points. The criteria for the CCI score calculation can be found in the Appendix. On the basis of the distribution of CCI score in this cohort, the patients were classified into 3 CCI score categories (0, 1, ≥2).

### Surgical Technique

At all centers, the procedure started with the patient in the lithotomy position with rigid cystoscopy performed to place a ureteral catheter. After ureteral catheter insertion, patients were placed in the prone or supine position, and percutaneous access was achieved under fluoroscopic guidance using an 18-gauge needle and guidewire. Tract dilatation was accomplished using Amplatz, metal or balloon dilators. Fragmentation and stone removal were accomplished in all patients using pneumatic or ultrasound energy and retrieval graspers through rigid 11-F, 15.9-F, 22-F, 24-F, or 26-F nephroscopes. A holmium laser and nitinol basket catheter were used through flexible nephroscopes for locations that were unreachable using the rigid instruments. Stone clearance was determined by a combination of fluoroscopy and rigid or flexible nephroscopy at the end of the procedure and postoperatively by imaging. After completion of PCNL a nephrostomy tube was placed, which was routinely removed on postoperative days 1-3, and the patient was discharged to home the next day. Although tubeless or totally tubeless PCNL was applied in selected patients at 2 centers, the other 2 centers opted for standard PCNL in all patients. The technique used for tubeless and totally tubeless PCNL has been described previously.[16,17] Complete blood counts were performed 24 hours after surgery to determine the decrease in hematocrit. Blood loss was not considered significant unless transfusion was required. Patients with supracostal access had a chest radiograph done to detect any chest complication.

### Follow-Up

The first follow-up evaluation was performed 2-3 months after the operation, after which patients were seen every 3-4 months during the first year and every 6 months thereafter. The follow-up period ranged from 1-46 months (median 11 months). At each visit, urinalysis, serum creatinine, plain film, and abdominal US were performed.

### Statistical Analysis

All analyses were performed using SPSS, version 15.0 (SPSS, Inc., Chicago, IL). The chi-square test was used to evaluate the association between categorical variables. One-way analysis of variance and *t*-test were used to compare the means of continuous variables. A logistic model was used to determine the odds ratios for statistically significant parameters affecting complications. Data were expressed as mean ± standard deviation. Statistical significance was considered at $P < .05$.

## RESULTS

### Patient and Stone Characteristics

The present study included 868 (61.7%) men and 538 (38.3%) women. Mean patient age was 44.1 years (range 1-81) and 153 patients (10.9%) were 65 years old or older. For surgery, general anesthesia was used in 1372 patients (97.6%) and combined spinal and epidural anesthesia was used in 34 (2.4%). CCI score was calculated as "0" for 993 patients (70.6%, called group I), as "1" for 316 patients (22.5%, called group II), and as "≥2" for 97 patients (6.9%, called group III). Mean patient age was 39.9 ±15.5 years (range 1-81) in group I, 52.8 ±12.6 years (range 1-77) in group II, and 58.6 ±13.1 years (range 2-80) in group III. The comorbidity rate increased with age, including 4.3% at ages 1-18, 22.2% at 19-64, and 62.8% at 65-81 years ($P = .001$). The mean stone size was 31.7 ±14.8 mm (range 10-85) in group I, 33.2 ±16.2 mm (range 11-82) in group II, and 35.6 ±16.8 mm (range 12-90) in group III. The most frequent primary location of the stones was in the pelvis (34.8%), followed by the lower pole (33.1%), upper or middle pole (18.1%), and 197 staghorn stones (14%). Staghorn stone was defined as one that either totally filled all calyces and renal pelvis, or filled >80 of the renal collecting system. Stone analysis available in 740 cases revealed calcium oxalate/phosphate in 319 (43.1%), struvite in 62 (8.4%), cystine in 45 (6.1%), uric acid 39 (5.2%), xanthine in 3 (0.4%), and mixed composition in 272 (37.2%). There was a significantly higher percentage of struvite calculi in the CCI = 1 and ≥2 patients than CCI = 0 patients (14.5% vs 5.7%, $P < .01$).

### Operative Findings

The mean number of percutaneous access sites was 1.19 (range 1-3). A total of 1161 (82.6%) patients had a single percutaneous access, whereas 2 accesses were indicated in 209 (14.9%) patients, and 3 accesses were indicated in 36 (2.6%) patients. Tract dilation was performed using a balloon dilator in 8.4%, metallic telescopic dilator in 3.5%, and Amplatz serial dilator in 88.1% of procedures. Mean operative time was 63.8 ± 20.6, 65.1 ± 20.1, and 70.6 ± 23.7 minutes in groups I, II, and III, respectively. This

**Table 1.** Preoperative and operative characteristics and clinical data

| | Total | CCI = 0 | CCI = 1 | CCI ≥ 2 | *P* Value |
|---|---|---|---|---|---|
| No. patients (%) | 1406 | 993 (70.6%) | 316 (22.5%) | 97 (6.9%) | |
| Age (range) | | | | | |
| ≤18 y | 92 (6.5%) | 87 (8.8%) | 4 (1.3%) | 1 (1%) | |
| 19-64 y | 1161 (82.6%) | 849 (85.5%) | 258 (81.6%) | 54 (55.7%) | .001* |
| ≥65 y | 153 (10.9%) | 57 (5.7%) | 54 (17.1%) | 42 (43.3%) | |
| Gender | | | | | |
| Male | 868 (61.7%) | 632 (63.6%) | 185 (58.5%) | 51 (52.6%) | .042* |
| Female | 538 (38.3%) | 361 (36.4%) | 131 (41.5%) | 46 (47.4%) | |
| Stone size ± SD (mm) | 32.7 ± 15.3 | 31.7 ± 14.8 | 33.2 ± 16.2 | 35.6 ± 16.8 | .034* |
| Stone location | | | | | |
| Lower pole | 466 (33.1%) | 331 (33.3%) | 108 (34.2%) | 27 (27.8%) | |
| Pelvis | 489 (34.8%) | 345 (34.7%) | 109 (34.5%) | 35 (36.1%) | .389 |
| Upper/middle pole | 254 (18.1%) | 189 (19%) | 48 (15.2%) | 17 (17.5%) | |
| Staghorn | 197 (14%) | 128 (12.9%) | 51 (16.1%) | 18 (18.6%) | |
| Location of access | | | | | |
| Subcostal access | 1211 (86.1%) | 852 (85.8%) | 272 (86.1%) | 87 (89.7%) | |
| 11th-12th intercostal | 150 (10.7%) | 113 (11.4%) | 29 (9.2%) | 8 (8.2%) | .285 |
| 10th-11th intercostal | 45 (3.2%) | 28 (2.8%) | 15 (4.7%) | 2 (2.1%) | |
| Dilation technique | | | | | |
| Amplatz | 1239 (88.1%) | 865 (87.1%) | 283 (89.6%) | 91 (93.8) | |
| Metal | 49 (3.5%) | 35 (3.5%) | 11 (3.5%) | 3 (3.1%) | .22 |
| Balloon | 118 (8.4%) | 93 (9.4%) | 22 (7%) | 3 (3.1%) | |
| Operative time (min) | 64.6 ± 20.8 | 63.8 ± 20.6 | 65.1 ± 20.1 | 70.6 ± 23.7 | .008* |
| Tubeless (%) | 176 (12.5%) | 119 (12%) | 39 (12.3%) | 18 (18.6%) | .257 |
| Nephrostomy removal time | 1.88 ± 0.98 | 1.89 ± 0.99 | 1.86 ± 0.92 | 1.91 ± 1.09 | .862 |
| Hospitalization time | 3.17 ± 1.19 | 3.15 ± 1.16 | 3.17 ± 1.21 | 3.44 ± 1.4 | .064 |

* Statistically significant at $P < .05$.

difference was statistically significant ($P = .008$). Operative time was calculated from the time of percutaneous needle access to the completion of nephrostomy tube placement. Mean hospital stay was 3.1 ± 1.1 (range 1-13) days. The mean nephrostomy removal time was 1.8 ± 0.9 (range 1-7) days. There was no significant difference between the groups for the mean hospital stay ($P = .064$) and the nephrostomy removal time ($P = .862$). A total of 176 (12.5%) procedures were tubeless. In the tubeless group, mean operative time was 52.5 minutes (range 30-85) and mean stone size was 25.2 mm (range 10-35). Patient and stone characteristics, operative and postoperative data, and stone clearance are detailed in Table 1.

### Postoperative Surgical Complications

The overall incidence of postoperative complications was 29.3%. Of the complications, 259 (24%) were related directly to surgery and the other 74 (5.3%) were medical complications. The most common complication was hemorrhage necessitating blood transfusion in 133 cases (9.5%), but it was mostly clinically insignificant. Eighty-eight (8.9%) patients in group I, 29 (9.2%) patients in group II, and 16 (16.5%) patients in group III needed blood transfusion, with most patients receiving 1 U of blood ($P = .049$). The hemoglobin drop ranged from 0.1-8.1 g/dL but in most patients, it was <2 g/dL. Ninety-five (6.8%) patients had fever requiring antipyretics and 72 (5.2%) patients had urine leakage from the nephrostomy tract after removal of the tube. Major complications included septicemia in 0.7%, renal hemorrhage requiring angiographic intervention in 0.2%, and neighboring organ injury in 1.6%.

### Postoperative Medical Complications

Postoperative medical complications, such as MI, PE, hypertensive crisis, arrhythmia, cerebrovascular disease, single or multi-organ dysfunction, gastrointestinal bleeding or acute pancreatitis, developed in 29 (2.9%) patients in group I, 24 (7.6%) patients in group II, and 21 (21.6%) patients in group III, ($P = .001$). Three patients with postoperative complications died, for an overall 0.2% mortality rate. In 1 patient sudden MI developed 4 hours after surgery. This patient had 3 preoperative comorbidities, including hypertension (HT), diabetes mellitus (DM) with renal insufficiency, and a history of MI. In the remaining 2 patients, postoperative next-day, fatal PE developed. Both of the patients had hypoxia, respiratory findings (dyspnea, tachypnea), lower systolic blood pressure, and higher dimerized plasmin fragment (D-dimer) level. Lung arterial thrombi were detected by pulmonary computed tomography angiography. One of these patients had ischemic heart disease, and the other had HT and DM.

Table 2 lists postoperative complication rates stratified by CCI score group. High CCI score, age, stone size, blood loss, and operative time were significantly related to increased medical complication rates (Table 3). A logistic model adjusted for statistically significant risk factors such as age, operative time, CCI score, and hemorrhage for medical complications showed that the pa-

**Table 2.** Influence of CCI score on morbidity and mortality

| | Total | CCI = 0 | CCI = 1 | CCI ≥ 2 | *P* Value |
|---|---|---|---|---|---|
| No. patients | 1406 | 993 | 316 | 97 | |
| Fever | 95 (6.8%) | 72 (7.3%) | 18 (5.7%) | 5 (5.2%) | .511 |
| Bleeding requiring transfusion | 133 (9.5%) | 88 (8.9%) | 29 (9.2%) | 16 (16.5%) | .049* |
| Septicemia | 10 (0.7%) | 7 (0.7%) | 2 (0.6%) | 1 (1%) | |
| Renal hemorrhage | 3 (0.2%) | 2 (0.2%) | 1 (0.3%) | — | |
| Injury to adjacent organs | 23 (1.6%) | 19 (1.9%) | 3 (1.3%) | 1 (1%) | |
| Lung or pleural | 20 (1.4%) | 17 (1.7%) | 3 (1.3%) | — | |
| Colon, liver or spleen | 3 (0.2%) | 2 (0.2%) | — | 1 (1%) | |
| Medical complications | 74 (5.3%) | 29 (2.9%) | 24 (7.6%) | 21 (21.6%) | <.001* |
| Hypertensive crisis MI | 17 (1.2%) | 7 (0.7%) | 5 (1.6%) | 5 (5.2%) | |
| MI | 5 (0.4%) | 1 (0.1%) | 1 (0.3%) | 3 (3.1%) | |
| Arrhythmia | 18 (1.3%) | 6 (0.6%) | 6 (1.9%) | 6 (6.2%) | |
| PE | 8 (0.6%) | 4 (0.4%) | 2 (0.6%) | 2 (2.1%) | |
| Cerebrovascular disease | 2 (0.1%) | 1 (0.1%) | 1 (0.3%) | — | |
| Organ dysfunction | 3 (0.2%) | 1 (0.1%) | — | 2 (2.1%) | |
| Others | 21 (1.5%) | 10 (1%) | 9 (2.8%) | 2 (2.1%) | |
| Perioperative mortality† | 3 (0.2%) | — | 2 (0.6%) | 1 (1%) | |

* Statistically significant at *P* <.05.
† No statistical tests were applied to perioperative mortality rates, because of the low number of mortalities.

**Table 3.** Influence of clinical data on medical complications

| | No. Patients | Medical Complications | | *P* Value |
|---|---|---|---|---|
| | | Yes | No | |
| Age (range) | | | | |
| ≤18 y | 92 (6.5%) | — | 92 (100%) | |
| 19-64 y | 1161 (82.6%) | 51 (4.4%) | 1110 (95.6%) | <.001 |
| ≥65 y | 153 (10.9%) | 23 (15%) | 130 (85%) | |
| Gender | | | | |
| Male | 868 (61.7%) | 49 (5.6%) | 819 (94.4%) | .462 |
| Female | 538 (38.3%) | 25 (4.6%) | 513 (95.4%) | |
| Stone size (mm) ± SD | | 37.1 ± 17.3 | 32.1 ± 15.2 | .019* |
| Number of accesses | | | | |
| Single | 1161 (82.6%) | 52 (4.5%) | 1109 (95.5%) | |
| Two | 209 (14.9%) | 18 (8.6%) | 191 (91.4%) | .014* |
| Three | 36 (2.6%) | 4 (11.1%) | 32 (88.9%) | |
| Location of access | | | | |
| Subcostal access | 1211 (86.1%) | 66 (5.5%) | 1145 (94.5%) | |
| 11th-12th intercostal | 150 (10.7%) | 6 (4%) | 144 (96%) | .731 |
| 10th-11th intercostal | 45 (3.2%) | 2 (4.4%) | 43 (95.6%) | |
| Operation time (min) ± SD | | 79.2 ± 24.7 | 63.8 ± 20.2 | <.001* |
| CCI score | | | | |
| 0 | 993 (70.6%) | 29 (2.9%) | 964 (97.1%) | |
| 1 | 316 (22.5%) | 24 (7.6%) | 292 (92.4%) | <.001* |
| ≥2 | 97 (6.9%) | 21 (21.6%) | 76 (78.4%) | |

* Statistically significant at *P* <.05.

tients with CCI = 1 had a 1.91987 times higher risk of medical complication compared with the patient with CCI = 0 score (95% CI 1.0460-3.5197, *P* = .0353); the patients with CCI = 2 had a 4.4767 times higher risk of medical complication compared with the patient with CCI = 0 score (95% CI 2.1866-9.1655, *P* <.0001). In addition, the existence of hemorrhage had a 3.7771 times higher risk for medical complications (95% CI 2.0918-6.8202, *P* <.0001), (Table 4).

## COMMENT

PCNL was established as a minimally invasive treatment option for removal of kidney stones in the 1970s.[1] Today, it is the treatment of choice for large-volume stone disease with the advantages of better stone clearance, cost-effectiveness, and early convalescence compared with other modalities like SWL or open surgery. Furthermore, improvements in instruments as well as lithotripsy technology increased the efficacy of percutaneous stone disintegration, yielding stone-free rates of >90%.

Despite PCNL's effectiveness, serious complications such as blood loss, adjacent organ injuries, and life-threatening medical complications have been identified because of it and occur at a reported rate of up to 83%.[2-11] The Clavien system has been modified to grade the complications of PCNL.[10] Overall, complications in PCNL according to

**Table 4.** A Logistic model for prediction of morbidity and mortality of PCNL

| Variables | Coefficients | OR | 95% CI | *P* Value |
|---|---|---|---|---|
| Age | 0.0339 | | 1.0138-1.0557 | .001 |
| CCI | | | | .0002 |
| CCI 1/ref. CCI 0 | 0.6517 | 1.9187 | 1.0460-3.5197 | .0353 |
| CCI 2/ref. CCI 0 | 1.4989 | 4.4767 | 2.1866-9.1655 | .0001 |
| Operative time | 0.0228 | | 1.0111-1.0351 | .0001 |
| Hemorrhage | 1.3290 | 3.777 | 2.0918-6.8202 | <.0001 |

Clavien classification were reported as 43.8% by de la Rosette et al and 29.2% by Tefekli et al.[10,11] Lee and coworkers reported major complications (ie, death, septicemia, injuries to adjacent organs, life-threatening medical complications) in 6% of patients, and minor complications (postoperative fever, bleeding necessitating transfusion, extravasation, prolonged urine drainage, etc.) in >50% of patients undergoing PCNL.[8] In our series, the overall complication rate (29.3%) is in range with the current literature for PCNL, as well as with rates for bleeding (9.5%), postoperative fever (6.8%), prolonged urine drainage (5.2%), urosepsis (0.7%), neighboring organ injuries (1.6%), renal hemorrhage requiring angiographic intervention (0.2%), life-threatening medical complications (5.3%), and death (0.2%).

Careful selection and preparation of the patients are very important for decreasing complications. Therefore, it would be important to try to define which stones could be managed expectantly or should be operated on. However, no method currently available has been accepted for predicting the complications of PCNL. The CCI is one of the most widely used comorbidity measures.[12] Charlson et al defined categories of diseases and assigned a different weight to each category. The CCI encompasses 19 medical conditions weighted from 1-6, with total scores of 0-37 (see Appendix). Certain diseases were assigned a weight of 1, 2, 3, or 6. The sum of the weights of all diseases determined the final index score. CCI is easy to use and can be calculated in the office at the time the patient is making decisions regarding definitive treatment. Some studies have validated the ability of the CCI to predict mortality in urological cases.[12-15] In their study, Arrontes et al evaluated 192 patients with early and advanced-stage renal cell carcinoma and they indicated that CCI was a useful prognostic indicator for localized tumors but not for advanced tumors.[18] Alibhai et al evaluated the 4 comorbidity indexes, including the CCI in 345 men with prostate cancer. They found all indexes to be predictive of mortality and authors also showed CCI to be a significant predictor of the administration of curative therapy.[19] In another study, this index was evaluated to determine whether it predicts death in men who underwent transurethral resection of the prostate (TURP) and was found to be a highly significant predictor of mortality after TURP.[20] To our knowledge, the present study is the first to report about prediction of morbidity and mortality of PCNL using the CCI. Our study showed 0.2% mortality and demonstrated a direct relationship between preoperative comorbidity. Postoperative death has been reported in 0.1-0.7% of patients undergoing PCNL.[4,6-8] Furthermore, we found that patients with higher CCI score had a significantly greater rate of postoperative medical complications, including death, than those with lower CCI. Tefekli et al found that success rates of PCNL were not significantly influenced by DM, HT, serum lipid abnormalities, obesity, or metabolic syndrome. They observed that major complications were 2.5-2.7 times more likely in patients with DM, HT, or metabolic syndrome.[5] However, Duvdevani et al studied patients with DM who underwent PCNL and found that surgical time, complication rates, and stone-free rates were not significantly different compared with nondiabetics.[21]

In this context, advanced age was significantly associated with the increased medical complication rates. In general, older age is associated with a linear loss of function in all organ systems and elderly patients may experience decreased physiological reserve.[19,22] Our results confirm that the preoperative comorbidity and postoperative complication rates increase with patient age. Sahin et al reported that PCNL is a safe and effective therapy for elderly patients, even those with complex stone disease.[23] Stoller et al found a higher blood transfusion rate in elderly patients who underwent PCNL.[24] The elderly population is the fastest growing segment in many parts of the world. Therefore, more prospective work is needed to examine the impact of age on morbidity and mortality after PCNL.

One of the most serious complications is renal hemorrhage. Bleeding is a significant intraoperative complication not only because of blood loss but also because it can impair vision, which may cause premature termination of the procedure. Fortunately, in most cases bleeding can be controlled with conservative measures, such as clamping the nephrostomy, hydration, and hemostatic medications. In the literature, blood loss requiring transfusion is reported in 0.4-23% of cases and is associated with stone burden, sheath size, number of tracts, and operative time.[3,25-27] In this large study, perioperative bleeding requiring blood transfusion was observed in 133 (9.5%) patients, whereas the operation had to be terminated because of severe bleeding in 19 (1.3%) patients. Furthermore, we found an increased risk of hemorrhage associated with high CCI score. Some studies have suggested an increased postoperative bleeding in patients with DM, atherosclerosis, obesity, and HT.[5,27-29] Frisbee showed an impaired hemorrhage tolerance in the rat model of metabolic syndrome.[29] Associated arteriosclerosis with thickened basement membranes may make such patients more prone to bleeding after the initial trauma of tract formation.[24]

There are several limitations in our study. The first is that the study is retrospective in nature. A second drawback is that most of the patients included in this study did not have comorbidities (70.6%) or had only 1 comorbidity (22.5%). Despite the large number of patients, only 6.9% had a CCI score of ≥2. Thus, our results may not be generalizable to settings in which the patients have more comorbidities. Another limitation of the present study is that there are some differences in the postoperative imaging procedures of these 4 centers. However, routine imaging after PCNL has recently been questioned, and studies regarding follow-up after this procedure are controversial.

## CONCLUSIONS

CCI is a quick, simple, and reproducible scoring system to accurately predict the morbidity and mortality after PCNL. Although our study was limited by its retrospective design, our results seem to indicate that this could be a plausible option to avoid surgery and its potential risks in the high-risk patient population. However, more research is needed to identify the optimal tool for determining risk of complications related to existing preoperative comorbidities.

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## APPENDIX

Charlson Comorbidity Index

| Weight | Clinical Condition |
|---|---|
| 1 | MI |
| 1 | Congestive heart failure |
| 1 | Peripheral vascular disease |
| 1 | Dementia |
| 1 | Cerebrovascular disease |
| 1 | Chronic pulmonary disease |
| 1 | Connective tissue disease |
| 1 | Ulcer disease |
| 1 | Mild liver disease |
| 1 | Slight diabetes without complications |
| 2 | Hemiplegia |
| 2 | Moderate to severe renal disease |
| 2 | Diabetes with end organ damage |
| 2 | Tumors |
| 2 | Leukemia |
| 2 | Lymphoma |
| 3 | Moderate or severe liver disease |
| 6 | Metastatic solid tumor |
| 6 | AIDS |