Asian Journal of Urology (2015) 2, 26–32

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REVIEW

Advances in percutaneous stone surgery

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Received 15 July 2014; received in revised form 11 August 2014; accepted 18 August 2014
Available online 16 April 2015

KEYWORDS
Nephrolithiasis;
Kidney calculi;
Percutaneous nephrolithotomy

Abstract Treatment of large renal stones has changed considerably in recent years. The increasing prevalence of nephrolithiasis has mandated that urologists perform more surgeries for large renal calculi than before, and this has been met with improvements in percutaneous stone surgery. In this review paper, we examine recent developments in percutaneous stone surgery, including advances in diagnosis and preoperative planning, renal access, patient position, tract dilation, nephroscopes, lithotripsy, exit strategies, and post-operative antibiotic prophylaxis.

1. Introduction

Nephrolithiasis presents a significant health concern for a large number of individuals throughout the world. Increasing rates of comorbidities known to correlate with urinary stone disease, such as diabetes mellitus, hypertension, and obesity, have all led to an increase in the incidence of new stones in these individuals. For example, as the prevalence of diabetes in the United States has nearly doubled in the past 20 years, the number of presentations to the Emergency Department for stone episodes rose from 178 per 100,000 patient visits to 340 per 100,000 patient visits roughly over the same time period [1,2]. This increase in overall stone prevalence has been met with a similar increase in large renal stones.

Recent studies have shown that environmental factors may also play a significant role in the development of nephrolithiasis. For example, Chi et al. [3] demonstrated significant differences in the stone composition of Chinese patients living in North America compared to Chinese patients living in China. They found that patients in China were more likely to have a lower body mass index (BMI), present approximately 9 years earlier than Chinese Americans, and form calcium oxalate stones. This suggests that environmental factors may play a significant role in stone formation, in addition to genetic factors.

Oberlin et al. [4] recently looked at patterns of treatment for upper tract calculi. They found that during 2003–2012 the number of patients treated with ureteroscopy rose from 40.9% to 59.6%, while the number of

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Peer review under responsibility of Chinese Urological Association and SMMU.

http://dx.doi.org/10.1016/j.ajur.2015.04.010
2214-3882/

patients treated with extracorporeal shock wave lithotripsy (ESWL) correspondingly decreased from 54% to 36.3%. The rate of percutaneous nephrolithotomy (PCNL) stayed roughly the same.

Our aim is to review the literature on PCNL and examine new developments in percutaneous stone surgery in recent years.

2. Diagnosis

A number of imaging modalities have been described to diagnose nephrolithiasis, including ultrasound (US), computerized tomography (CT), and plain X-rays. Non-contrast CT has emerged as the imaging study of choice because of relative cost-effectiveness, sensitivity for diagnosing nephrolithiasis, and speed at which it can be performed [5]. Low-dose CT is an acceptable option in patients with a favorable body habitus. In cases in which percutaneous surgery is anticipated for a large stone burden, CT scans aid in classification of stone size, location within the collecting system, and density. Additionally, they help in planning the operative approach a surgeon may take in accessing a stone. In regions in which CT is not readily available, renal US is a reasonable alternative for diagnosing renal calculi, though the sensitivity and specificity of US is not as high as that of CT [6].

Okhunov et al. [7] recently proposed their S.T.O.N.E. nephrolithometry scoring system to standardize reporting for percutaneous nephrolithometry. In 117 patients from a single institution, they measured five variables relating to stone complexity based on pre-operative CT scan, including stone size (S), tract length (T), obstruction (O), number of calyces involved (N), and essence or stone density (E). They found that pre-operative stone score correlated to post-operative stone-free rate, estimated blood loss, operative time, and length of stay. In follow-up, the group recently validated the S.T.O.N.E. scoring system in a multi-institutional study comprising 706 patients. Their results confirmed their prior findings that a greater S.T.O.N.E. score correlated with lower stone-free rates, increased bleeding and estimated blood loss, operative time, length of hospital stay, fluoroscopy time, and overall complication rate [8].

Labadie et al. [9] recently compared three stone scoring systems, including the S.T.O.N.E. scoring system, Guy's stone score, and the CROES (Clinical Research Office of the Endourological Society) nephrolithometric nomogram to determine which was the most predictive of surgical outcomes. They found that each was significantly associated with stone-free status, however Guy's stone score and the S.T.O.N.E. scoring system were significantly associated with estimated blood loss (EBL) and hospital length of stay (LOS), whereas the CROES nomogram was not predictive of EBL or LOS.

Mishra et al. [10] also recently used CT urography and three-dimensional volume rendering to assess staghorn stone volume and correlate stone morphometry with the number of tracts and stages needed to clear patients of their staghorn stones. They then defined stones as one of three types, with type 1 stones having a volume of less than 5000 mm^3 with less than 5% of the stone volume in an unfavorable calyx, while type 3 stones were those with a total volume greater than 20,000 mm^3 and greater than 10% of the stone in an unfavorable calyx. Type 2 stones were those that fell between these two extremes. Through their model they predict that type 1 stones necessitate a single tract and single stage for stone clearance, type 2 stones necessitate single tract-single/multiple stages or multiple tracts within a single stage, and type 3 stones require multiple tracts and stages for clearance.

These results argue that one of the recently developed stone scoring systems should be used in preoperative planning and patient counseling, and that this scoring system should be universally used as a way to standardize PCNL-planning across institutions.

3. Preoperative planning

The number of patients requiring PCNL who are on long-term anticoagulation or antiplatelet therapy with warfarin, aspirin, clopidogrel, and heparin derivatives has increased in recent years due to the use of more drug-eluting cardiac stents, heart valve replacements, treatment of atrial fibrillation, and cardioprotective measures [11,12]. Controversy exists as to which patients may be safely taken off of anticoagulation for a period of time, as well as how to best manage patients who need to remain on anticoagulation perioperatively. In patients with a significant stone burden and in whom cessation of anticoagulation poses an unacceptable risk, performing staged ureteroscopies may be preferable to PCNL. In patients with significant cardiac risk factors, cessation of aspirin may have adverse cardiac consequences during the perioperative period due to the rebound period off of aspirin. Recent studies have also shown that low-dose aspirin can safely be continued in the perioperative period without a significantly increased risk of bleeding [13,14].

In patients undergoing procedures with a high risk of bleeding such as PCNL, it is recommended that they discontinue the use of warfarin 3—5 days prior to the intended procedure. Kefer et al. [15] specifically recommends stopping warfarin 5 days prior to PCNL and waiting to restart it for 5 days following the procedure. Low molecular weight heparin may be used for bridging in the perioperative period. The authors demonstrated this regimen to be safe, with an acceptable major bleeding risk of 7%. The same group demonstrated that stopping clopidogrel 10 days prior to undergoing PCNL and resuming it 5 days postoperatively incurred an acceptable bleeding risk, as well.

Sepsis secondary to urinary tract infection can significantly increase morbidity and mortality in patients who have undergone PCNL. It is standard practice for patients to have a urinalysis and urine culture (UCx) checked prior to undergoing surgery to reduce the risk of sepsis. Gutierrez et al. [16] examined 5354 patients who underwent PCNL and who had preoperative UCx available, and found that 865 (16.2%) patients had a positive UCx. Of the patients with a positive culture, 18.2% developed a post-operative fever in comparison to 8.8% of patients with a negative pre-operative UCx. The type of microorganism was also found to play a role, with as low as 9.7% of patients whose urine was colonized with *Staphylococcus* species developing