Clinical Urology

Brazilian Journal of Urology
Official Journal of the Brazilian Society of Urology

Vol. 26 (6): 579-583, November - December, 2000

EVALUATION OF RESIDUAL STONES FOLLOWING PERCUTANEOUS NEPHROSTOLITHOTOMY

MATTHEW T. GETTMAN, MARGARET S. PEARLE

Department of Urology, University of Texas Southwestern Medical Center, Dallas, Texas, USA

ABSTRACT

Percutaneous nephrostolithotomy (PCNL) constitutes first line therapy for large and complex renal calculi. However, retained calculi generated by intracorporeal lithotripsy remain a concern because of their potential for growth and future symptoms. Liberal use of flexible nephroscopy identifies residual calculi and increases stone free rates. However, historically the sensitivity of radiographic imaging studies to predict the outcome of flexible nephroscopy has been inadequate. With new, helical, computed tomography (CT) technology, post-PCNL imaging can accurately and reliably detect residual calculi and predict the outcome of flexible nephroscopy, thereby allowing the selective use of second look flexible nephroscopy, and reducing cost and patient morbidity. We review the current recommendations for post-PCNL imaging.

Key words: urolithiasis; kidney calculi; nephrostolithotomy, percutaneous; helical CT
Braz J Urol, 26: 579-583, 2000

INTRODUCTION

Percutaneous nephrostolithotomy (PCNL) has become the treatment of choice for large or complex stones. The advantage of PCNL over other noninvasive or minimally invasive treatment modalities is the ability to rapidly and completely clear a large stone burden without the attendant risks and uncertainty associated with fragment passage. Like other minimally invasive modalities, however, PCNL often requires stone fragmentation to enable removal through a 1-centimeter incision. As such, the potential for leaving residual stones is greater with modalities requiring lithotripsy than after intact removal. Indeed, with the advent of shock wave lithotripsy (SWL), the definition of "success" was modified to include "clinically insignificant residual fragments" based on the assumption that these fragments had a high likelihood of spontaneous passage and a low probability of causing symptoms.

The completeness of stone clearance following PCNL, however, is an ongoing concern. A recent review of patient outcomes following SWL suggested that even small residual stone fragments predispose patients to early symptom recurrence and decreased quality of life (1). Similar outcomes can be expected after PCNL when intracorporeal lithotripsy is used. Unfortunately, the presence of residual fragments following PCNL is not accurately predicted by either plain abdominal radiographs or nephrotomograms (2). Thus, many centers have routinely performed second look flexible nephroscopy to assure a stone-free state after PCNL. Advanced radiographic imaging techniques such as non-enhanced, helical, computerized tomography (CT) have significantly improved the accuracy and reliability of radiographic evaluation of residual stones (3,4). Consequently, the efficacy of percutaneous stone removal is enhanced by careful postoperative radiographic evaluation and selective adjuvant surgical intervention. We review the indications and methods of evaluating for the presence of residual stones following PCNL.

IMPORTANCE OF A STONE-FREE STATE

Historically, the goal of surgical intervention for stone disease was complete stone removal, and thus the presence of any residual calculi indicated

failure of the procedure. With the introduction of SWL, however, the presence of small residual fragments after treatment was assumed to be inconsequential and thus was considered acceptable. A recent study addressed the fate of residual stone fragments after SWL and found that small residual stones were frequently associated with future stone problems. Streem et al. evaluated 160 patients with ≤4 mm residual stone fragments at a mean of 23 months post-SWL and found that 43.1% of patients experienced a symptomatic episode or required intervention at an average of 26 months postoperatively (1). Zanetti et al. likewise noted a 22% incidence of symptomatic episodes within 2 years in a group of 129 patients left with ≤ 4 residual fragments after SWL (5).

A number of investigators have noted that patients with residual stones have a higher rate of new stone formation than patients rendered stone free after surgery. Graff et al. reported a 6.2% incidence of stone recurrence after SWL in patients rendered stone free versus a 17.2% recurrence rate in patients with residual stones at an average follow-up of 19.1 months post-SWL(6). Likewise, Newman et al. found that 1 year after SWL, 8.4% of stone free patients developed new stones compared with 21.6% of patients with residual stones who demonstrated new stone growth (7). Zanetti et al. followed 88 patients with residual fragments after SWL and found that at a mean follow-up of 42 months, 65% of patients demonstrated stone growth (8). Yu et al. evaluated 94 patients (106 renal units) at a mean of 75.8 months post-SWL.(9) Among 62 renal units free of stone at 3 months, 79% remained stone free and new stone growth occurred in 21% at long-term follow-up (mean 30.5 months). In contrast, among the 44 renal units with residual stones at 3 months, new stone growth ultimately occurred in 70% of cases. Interestingly, a comparison of stone recurrence rates at 1 and 2 years post-surgery in 298 patients rendered stone free after SWL and 62 patients stone free after PCNL with intact stone removal revealed a higher rate of new stone formation in the SWL group (22.2% at 1 year, 34.8% at 2 years) versus the PCNL group (4.2% at 1 year, 22.6% at 2 years), suggesting that residual "dust" after SWL that may not be identifiable on standard radiographs places patients at higher risk for stone recurrence than when the stone is removed in intact without the potential for residual fragments (10).

Although medical therapy has been shown to reduce the incidence of stone recurrence after SWL, patients with residual fragments remain at higher risk for recurrence compared with patients rendered stone free. Fine et al. retrospectively reviewed stone recurrence rates in 25 patients with (n = 13) or without (n = 12) residual stones treated with medical therapy after SWL (11). At a mean follow-up of 43.2 months, the group with residual stones demonstrated a higher rate of stone recurrence (median 0.47 stones per patient per year) than the group rendered stone free (median 0.09 stones per patient per year).

Incomplete clearance of infection stones poses a particularly high risk for new stone growth as well as a risk of recurrent infection. Zanetti et al. noted persistent urinary tract infections at a mean follow-up of 42 months in 16% of 250 patients treated with SWL; among those patients with recurrent infection, stone re-growth occurred in 74.4% (8). Beck & Riehle found similar results in a group of 33 patients with struvite stones. At a mean of 26.6 months post-SWL, 77.7% of 18 renal units with residual fragments demonstrated stone re-growth versus 20% of 20 renal units rendered stone free; only 1 patient rendered stone free developed recurrent infection compared with 47% of patients left with residual stone fragments (12). These studies underscore the importance of a stone free state in prevention of infection and stone recurrence in this select group of stone formers.

RADIOGRAPHIC EVALUATION OF RESIDUAL STONES

Traditionally, post-PCNL radiographic imaging studies have been used to detect residual stones and determine the need for secondary procedures to achieve a stone free state. However, imaging modalities differ in their ability to detect residual stones, and consequently a determination of "stone free" varies according to the imaging modality used. Plain abdominal radiographs are notoriously insensitive for detecting small stones; overlying bowel gas, bony structures and obesity all reduce the sensitivity of plain films for detecting small stones. The use of plain

nephrotomograms increases the sensitivity by eliminating extra-renal structures that obscure renal calculi. A number of investigators have reported a higher stone detection rate with plain nephrotomograms compared with plain abdominal radiographs; in 12% (7/60)(13), 39% (11/28) (14) and 47% (46/98)(15) of patients, respectively, a greater number of stones were detected by nephrotomograms than by plain film radiographs.

Denstedt et al. confirmed improved stone detection rates with nephrotomograms compared with plain abdominal radiographs but found that direct endoscopic inspection was superior to either radiographic imaging technique for detecting residual stones after PCNL (2). In 29 patients with ≥ 3 cm renal calculi undergoing PCNL, plain films documented residual stones in 34% of patients, nephrotomograms in 52% and flexible nephroscopy in 69% of patients. Consequently, the use of second look flexible nephroscopy was recommended as a routine adjunct to maximize the efficacy of PCNL, independent of radiographic findings.

The application of non-enhanced CT imaging post-PCNL further improved the ability to radiographically detect residual stones after surgery. Marberger et al. demonstrated small calcifications on CT that were not detected by plain radiographs in 11% of 62 patients 12-43 months after PCNL (16). Likewise, Lehtoranta et al. showed superiority of conventional CT over plain film radiography, nephrotomography and renal sonography in detecting residual stones after PCNL (17). Among 35 patients (36 renal units) evaluated 12 to 36 months post-surgery, stone free rates of 47% by CT, 56% by plain films, 58% by nephrotomograms and 72% by sonography were reported.

Waldmann et al. recently reviewed their experience using CT as the sole imaging modality for detecting residual stones after PCNL (4). Among 124 renal units, post-procedure CT demonstrated retained calculi in 41% of cases. The need for further therapy to retrieve residual stones was based on the volume of retained calculi; 23 patients subsequently underwent flexible endoscopy, 8 patients were treated with SWL, and 21 patients were managed conservatively. The authors concluded that, based on CT findings, routine second look flexible nephroscopy in all patients would have resulted in a 75% rate of unnecessary surgery. However, the definitive assessment of residual calculi by flexible nephroscopy was not routinely performed in all cases and therefore the true sensitivity of CT and need for an adjunctive procedure could not be assessed.

Non-contrast, thin-cut, helical CT has replaced the intravenous urogram as the imaging modality of choice for detecting ureteral calculi in patients presenting with acute flank pain (18-21). In contradistinction to conventional CT, the use of overlapping image reconstruction allows for precise identification of even small ureteral calculi, and the rapid image acquisition reduces artifact due to respiration variation, further increasing sensitivity.

Applied to the kidney, this technology provides an exceedingly sensitive means of detecting retained calculi after PCNL. Pearle et al. evaluated the sensitivity of plain film radiography and non-enhanced, helical CT in predicting residual stone fragments after PCNL using flexible nephroscopy as the "gold standard" for detecting retained calculi (3). A total of 36 patients (41 renal units) with stones > 3 cm in diameter underwent post-operative imaging with plain film radiographs and non-contrast, thin-cut (5 mm) helical CT, then returned to the operating room for flexible nephroscopy on postoperative day 2 or 3. The number of stones detected by each modality was recorded and compared. An overall stone free rate of 92.6% was achieved after flexible nephroscopy. On average, 0.7, 3.4 and 2.3 stones per renal unit were detected by plain film, CT and flexible nephroscopy, respectively. CT missed no stones detected by flexible nephroscopy. Sensitivity and specificity for the imaging modalities were 46% and 82%, respectively, for plain film radiographs and 100% and 62%, respectively, for CT. Consequently, selective use of flexible nephroscopy after PCNL based on positive CT findings in this series would have avoided an unnecessary operation in 20% of patients. Indeed, this strategy of selective use of flexible nephroscopy would translate into cost savings of $109,687 per 100 patients at their institution compared with a strategy of flexible nephroscopy in all patients.

CURRENT RECOMMENDATIONS

While second look flexible nephroscopy remains the "gold standard" for evaluation of residual fragments following PCNL, non-enhanced, helical CT accurately predicts the outcome of flexible nephroscopy and best selects patients who would benefit from repeat surgical evaluation. Furthermore, CT in conjunction with antegrade nephrostogram provides an accurate "road-map" with which to precisely locate residual stones at flexible nephroscopy. We recommend that patients with large stones requiring fragmentation at PCNL who constitute a high-risk group for residual fragments undergo non-contrast, thin-cut (5 mm) helical CT and antegrade nephrostogram on the first post-operative day to identify those patients who would benefit from second look flexible nephroscopy.

In patients with residual stones, flexible nephroscopy is performed on post-operative day 2 to retrieve residual fragments. If the antegrade nephrostogram demonstrates good antegrade drainage and the urine is relatively clear at the time of flexible nephroscopy, the nephrostomy tube is removed and the patient is discharged home. Occasionally tiny fragments are identified on CT that are not identified endoscopically and are presumed to have passed or to be located submucosally. In these cases, flexible nephroscopy is performed unnecessarily (15%). However, this low false positive rate assures that no significant stones are missed.

A policy of selective use of flexible nephroscopy based on positive CT findings will maximize stone free rates while avoiding unnecessary procedures in the majority of patients.

REFERENCES

1. Streem SB, Yost A, Mascha E: Clinical implications of clinically insignificant store fragments after extracorporeal shock wave lithotripsy. J Urol, 155: 1186-1190, 1996.
2. Denstedt JD, Clayman RV, Picus DD: Comparison of endoscopic and radiological residual fragment rate following percutaneous nephrolithotripsy. J Urol, 145: 703-705, 1991.
3. Pearle MS, Watamull LM, Mullican MA: Sensitivity of noncontrast helical computerized tomography and plain film radiography compared to flexible nephroscopy for detecting residual fragments after percutaneous nephrostolithotomy. J Urol, 162: 23-26, 1999.
4. Waldmann TB, Lashley DB, Fuchs EF: Unenhanced computerized axial tomography to detect retained calculi after percutaneous ultrasonic lithotripsy. J Urol, 162: 312-314, 1999.
5. Zanetti G, Seveso M, Montanari E, Guarneri A, Del NeroA, Nespoli R, Trinchieri A: Renal stone fragments following shock wave lithotripsy. J Urol, 158: 352-355, 1997.
6. Graff J, Diederichs W, Schulze H: Long-term followup in 1,003 extracorporeal shock wave lithotripsy patients. J Urol, 140: 479-483, 1988.
7. Newman DM, Scott JW, Lingeman JE: Two-year follow-up of patients treated with extracorporeal shock wave lithotripsy. J Endourol, 2: 163-171, 1991.
8. Zanetti G, Montanari E, Mandressi A, Guarneri A, Ceresoli A, Mazza L, Trinchieri A, Pisani E: Long-term results of extracorporeal shock wave lithotripsy in renal stone treatment. J Endourol, 5: 61-64, 1991.
9. Yu CC, Lee YH, Huang JK, Chen MT, Chen KK, Lin AT, Chan, LS: Long-term stone regrowth and recurrence rates after extracorporeal shock wave lithotripsy. Br J Urol, 72: 688-691, 1993.
10. Carr LK, Honey J, Jewett MA, Ibanez D, Ryan M, Bombardier C: New stone formation: a comparison of extracorporeal shock wave lithotripsy and percutaneous nephrolithotomy. J Urol, 155: 1565-1567, 1996.
11. Fine JK, Pak CY, Preminger GM: Effect of medical management and residual fragments on recurrent stone formation following shock wave lithotripsy. J Urol, 153: 27-32, 1995.
12. Beck EM, Riehle RA Jr.: The fate of residual fragments after extracorporeal shock wave lithotripsy monotherapy of infection stones. J Urol, 145: 6-9, 1991.
13. Hjollund Madsen E: The value of tomography for the demonstration of small intrarenal calcifications. Br J Radiol, 45: 203-206, 1972.

14. Schwartz G, Lipschitz S, Becker JA: Detection of renal calculi: the value of tomography. Am J Roentgenol, 143: 143-145, 1984.
15. Goldwasser B, Cohan RH, Dunnick NR, Andriani RT, Carson CC III, Weinerth JL: Role of linear tomography in evaluation of patients with nephrolithiasis. Urol, 33: 253-256, 1989.
16. Marberger M, Stackl W, Hruby W, Kroiss A: Late sequelae of ultrasonic lithotripsy of renal calculi. J Urol, 133: 170-173, 1985.
17. Lehtoranta K, Mankinen P, Taari K, Rannikko S, Lehtonen T, Salo J: Residual stones after percutaneous nephrolithotomy; sensitivities of different imaging methods in renal stone detection. Ann Chir Gynaecol, 84: 43-49, 1995.
18. Fielding JR, Steele G, Fox LA, Heller H, Loughlin KR: Spiral computerized tomography in the evaluation of acute flank pain: A replacement for excretory urography. J Urol, 157: 1071-1073, 1997.
19. Liu W, Esler SJ, Kenny BJ, Goh RH, Rainbow AJ, Stevenson GW: Low-dose nonenhanced helical CT of renal colic: Assessment of ureteric stone detection and measurment of effective dose equivalent. Radiology, 21: 51-54, 2000.
20. Miller OF, Rineer SK, Reichard SR, Buckley RG, Donovan MS, Graham IR, Goff WB, Kane CJ: Prospective comparison of unenhanced spiral computed tomography and intravenous urogram in the evaluation of acute flank pain. Urol, 52: 982-987, 1998.
21. Smith RC, Rosenfield AT, Chloe KA, Essenmacher KR, Verga M, Glickman MG, Lange RC: Acute flank pain: comparison of non-contrast-enhanced CT and intravenous urography. Radiology, 194: 789-794, 1995.

Received: August 8, 2000
Accepted: September 10, 2000

Correspondence address:
Dr. Margaret S. Pearle
Department of Urology
Univ. Texas Southwestern Med. Ctr.
5323 Harry Hines Blvd.
75390-9110, Dallas, Texas, USA
Fax: + + (1) (214) 648-8786
E-mail: margaret.pearle@email.swmed.edu