Single-stage percutaneous extraction of renal calculi[1]

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The routine application of percutaneous techniques to the management of patients with renal calculous disease is evolving rapidly. Of 74 patients requiring surgery for renal calculous disease, 64 (86%) were deemed suitable candidates for percutaneous stone removal rather than standard open surgical intervention. The percutaneous procedure was successful in 60 (94%) of these patients. Compared to a standard surgical procedure, the percutaneous extraction technique resulted in shorter hospitalization and an earlier return to prehospital activity.

Index term: Kidney calculi, therapy

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The removal of a renal calculus via a percutaneously established tract was first reported in 1976.[1] As initially described, the procedure was performed in several stages, First, a nephrostomy tract was established percutaneously with standard angiographic techniques. The tract was then sequentially dilated over several days to weeks until it was large enough to allow extraction of the calculus with a stone forceps or basket. Finally, nephrostomy tube drainage was maintained for several days.

Similar procedures were then performed sporadically for a short time, though they were generally limited in application to high-risk patients, especially those who had undergone previous renal surgery. However, the recent, rapid development of specific endoscopic instrumentation and adjunctive techniques, such as ultrasonic stone fragmentation, has facilitated percutaneous stone removal from

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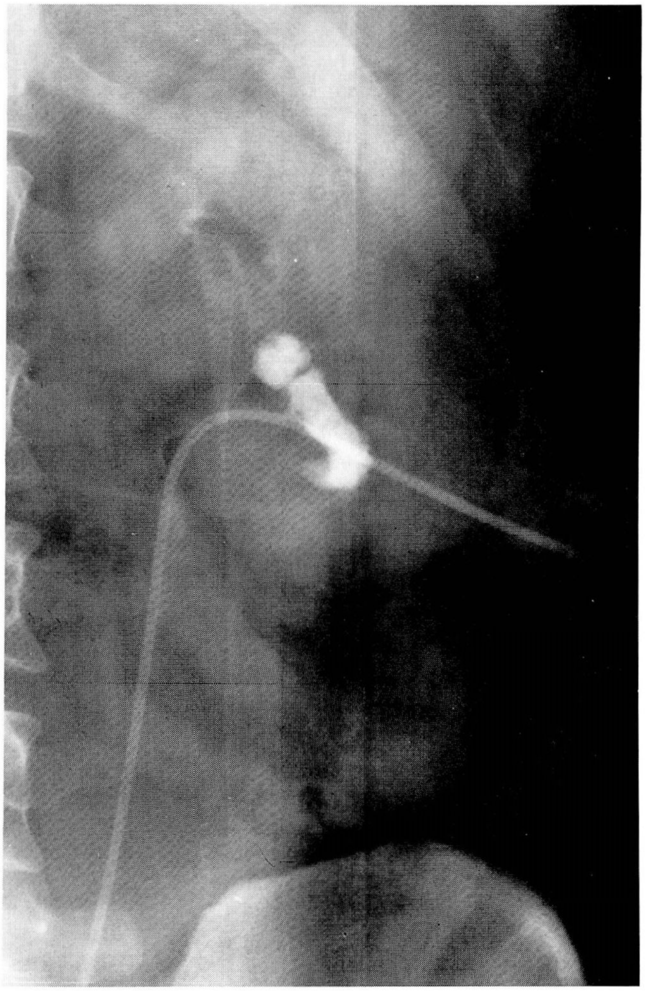


Fig. 1. A 1-cm pelvic calculus and 3 × 1-cm lower infundibular calculus with the pyeloureteral catheter in place. Note the path of the tract through the affected lower lateral infundibulum and down the ureter of the left kidney.

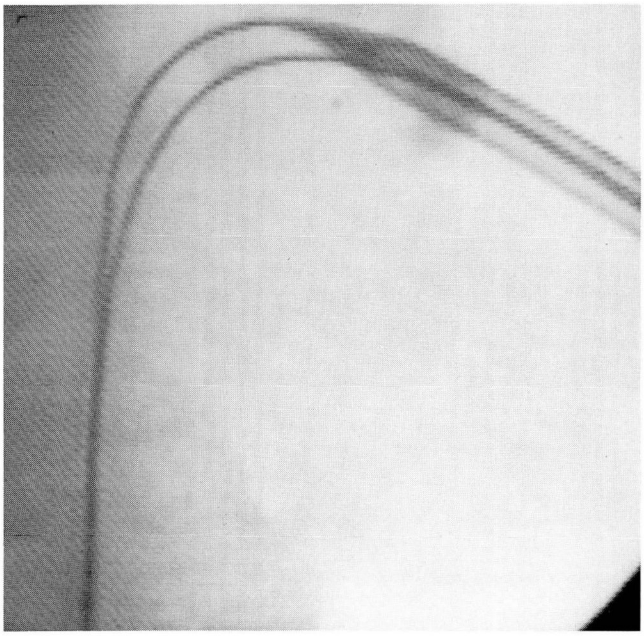


Fig. 2. Fluoroscopic view of fascial dilator. Note the second guide wire in place as a safety wire.

larger numbers of patients.[2] As results improved, some authors suggested that percutaneous stone removal might be the procedure of choice for many if not most patients who would otherwise require standard open surgical intervention.[3-5] However, others believe that open surgical procedures are still superior to percutaneous techniques, especially in terms of shorter operative time and length of hospital stay.[6]

We present our experience with a highly efficient single-stage percutaneous stone removal technique that allows establishment of the percutaneous nephrostomy tract, tract dilatation, and stone removal, all within 24 hours. Our experience suggests that percutaneous stone removal is now applicable to the vast majority of patients who would otherwise require open surgical intervention, and that these techniques may routinely be performed with negligible morbidity in a time- and cost-efficient manner. Furthermore, percutaneous stone extraction allows a return to full prehospitalization activity and employment much sooner than standard surgical intervention.

Materials and methods

Indications for surgical removal of a renal calculus include obstruction, pain, infection or significant bleeding resulting from the stone, or active stone growth despite appropriate medical management. Before October 1983, such patients at the Cleveland Clinic underwent standard open surgical intervention. Since then, however, such patients have been considered for the percutaneous approach. While there is currently no absolute limit on the size of a stone that can be managed percutaneously, calculi larger than 3.0 cm in diameter and branched or "staghorn" calculi with multiple extensions are still generally, though not always, managed with open surgical intervention. Occasionally, some smaller calculi may be deemed inaccessible to a percutaneous approach, especially when they are located in the upper calyces. However, the only absolute contraindication to a percutaneous approach is irreversible coagulopathy.

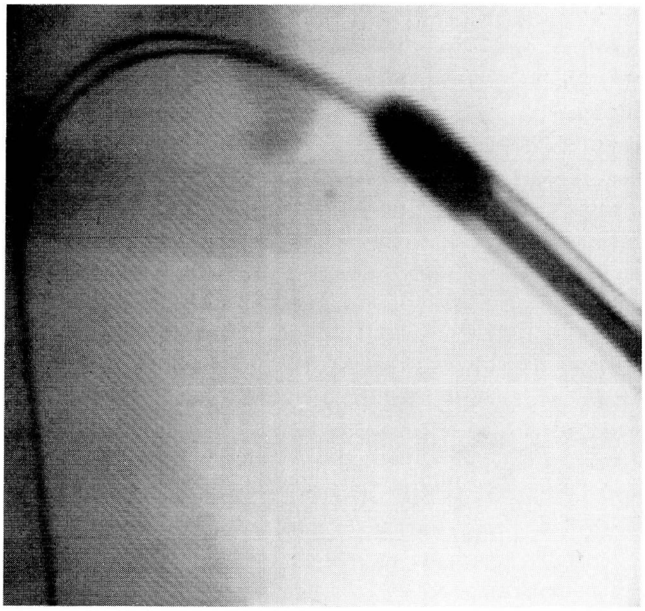


Fig. 3. Fluoroscopic view of 24.5-F nephroscope sheath and obturator.

Fig. 4. Sonotrode has been passed through the nephroscope and is abutted against a calculus too large to extract intact through the nephroscope.

The procedure is similar to that described by Segura et al.[4] The initial step is establishment of the percutaneous tract, which is accomplished in the radiology suite using local anesthesia. The collecting system of the kidney is visualized fluoroscopically following intravenous injection of contrast material. Occasionally, ultrasound, computed tomography, or retrograde pyelography is used to visualize obstructed or otherwise poorly functioning kidneys. With the patient prone, a 20-cm, 21-gauge needle is passed from the dorsolateral aspect of the flank below the 12th rib directly to an inferolateral calyx or infundibulum, though the exact renal entry site is individualized for each patient. A 0.018-inch guide wire is then passed through the needle, which is ultimately replaced with a 6-F angiographic catheter that is passed down the ureter in the antegrade direction as a "pyeloureteral" catheter (*Fig. 1*). The patient is then transferred to the surgical suite, either the same day or the following morning. General anesthesia is given, and the patient is once again placed prone. The tract is dilated to 24 F under fluoroscopic control using sequential fascial dilators over a 0.038-inch guide wire that replaces the pyeloureteral catheter (*Fig. 2*). A second guide wire is placed as a safety measure to prevent inadvertent loss of the tract. The last dilator is replaced with a 24.5-F rigid nephroscope (*Fig. 3*), the stone is visualized, and the first guide wire is removed. Calculi measuring less than 0.7 cm may be extracted with a forceps passed through the nephroscope with direct vision. Larger calculi are fragmented with ultrasonic energy from a sonotrode passed through the nephroscope (*Fig. 4*) under direct vision, and all fragments are aspirated (*Fig. 5*). Occasionally, flexible nephroscopy is necessary to visualize and extract calculi or fragments lying at acute angles in lateral or upper calyces. A plain radiograph is taken to verify that all fragments have been removed. Tamponade and drainage of the tract are accomplished by reinserting a second guide wire over which a 22-F Foley catheter is placed as a nephrostomy tube. The other guide wire is replaced with another 6-F pyeloureteral catheter, which allows rapid re-access to the collecting system if necessary.

A nephrostogram is obtained 48 hours later (*Fig. 6*). If there is no extravasation of contrast material or unexpected stone fragments, the nephrostomy tube is removed the following day and the patient is discharged after one or two days of observation. Minor extravasation is man-

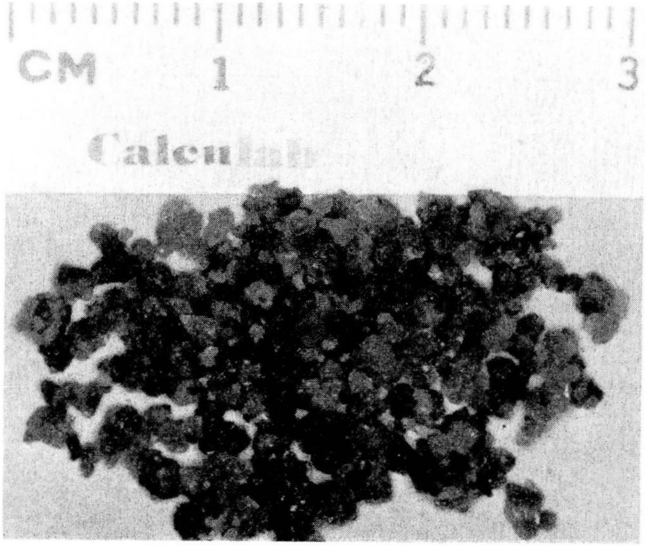


Fig. 5. Calculus, following ultrasonic fragmentation and extraction.

aged with continued nephrostomy drainage until resolved, although residual fragments may require repeat nephroscopy which can easily be performed through the mature tract without anesthesia.

The patient is allowed to return to full prehospitalization activity and employment one week after leaving the hospital. The patient is seen one month later, at which time a postoperative pyelogram is routinely obtained (*Fig. 7*).

Results

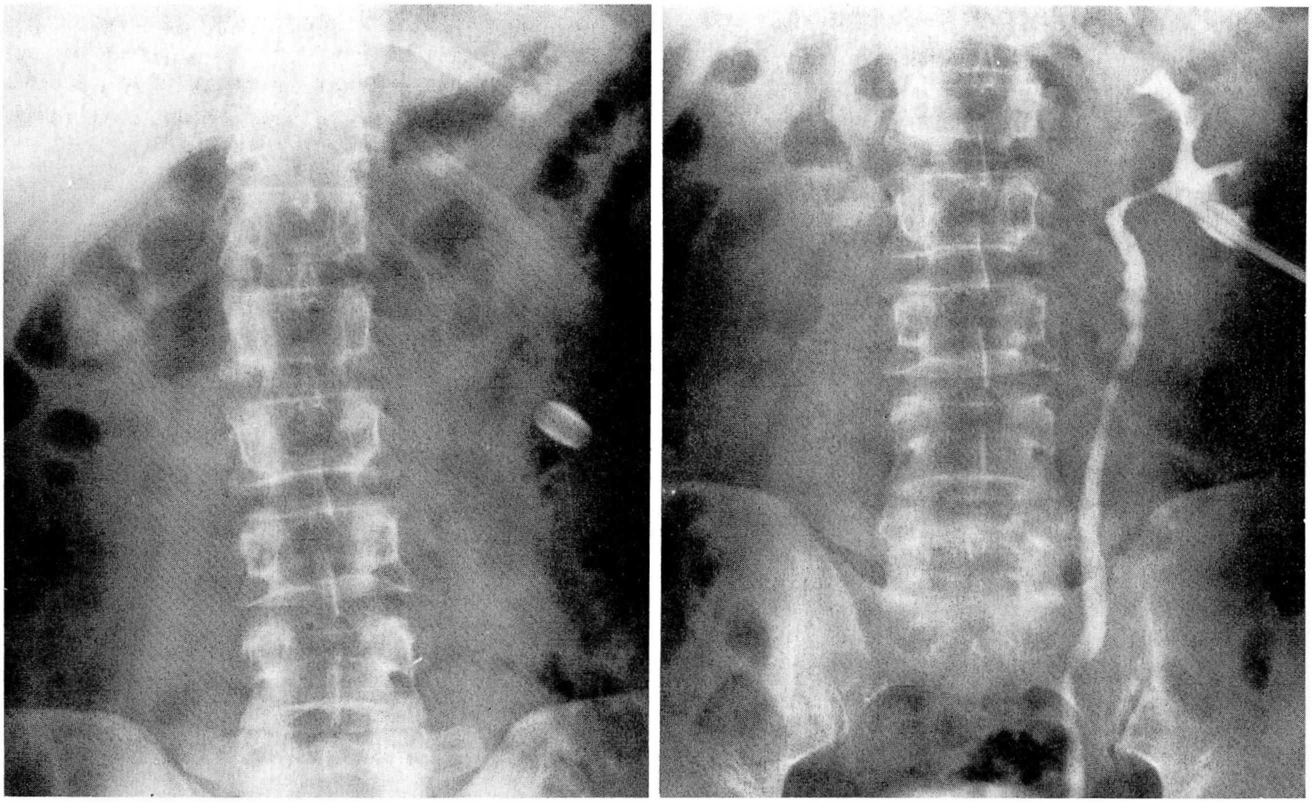
Between October 1983 and July 1984, 74 patients underwent surgical intervention for renal calculous disease. Seven were operated on using a primary open procedure because of an extensive staghorn configuration of the calculus, 2 because the calculus was deemed inaccessible to a percutaneous approach, and 1 because of a need for chronic anticoagulation therapy for a prosthetic heart valve. Four patients were initially scheduled for percutaneous stone removal, but ultimately required open surgical intervention. In 1 of these 4, a percutaneous tract could not be satisfactorily established. In 2 others, significant extravasation developed early in the procedure, which was therefore terminated. In the fourth patient, the calculus could not be adequately seen with the nephroscope. In each case, a standard pyelolithotomy was accomplished without incident at the time of the attempted percutaneous procedure. The remaining 60 patients (81%) were managed with a percutaneous procedure alone. There were 34 men and 26 women, ranging from 19 to 83 years of age (mean, 46 years). Fifteen of these patients (25%) had previously undergone at least one open surgical procedure on the affected side. Two patients had solitary kidneys, and one had a horseshoe kidney; the percutaneous technique was not altered in these cases. Operating room time varied between 45 and 170 minutes, with an average of approximately 75 minutes. Stones removed percutaneously ranged in size from 0.7 to 5.0 cm (mean, 1.2 cm). Thirty-nine patients had a single stone removed, and the remaining 21 patients had multiple calculi extracted. The chemical composition of the stones was similar in distribution to what would be expected for a North American population (*Table*). Pure uric acid calculi were notably absent as these were managed by dissolution.

There was no difference in overall renal function following stone removal. Preoperatively, serum creatinine ranged from 0.7 mg/dL to 2.4 mg/dL (mean, 1.06 mg/dL) and postoperatively from 0.7 mg/dL to 1.8 mg/dL (mean, 1.04 mg/dL). Hemoglobin concentration declined in most patients, with a mean decrease of 1.9 g/dL, although only 2 patients needed a transfusion. Six patients required repeat nephroscopy for residual fragments noted at the time of the postoperative nephrostogram. Three others had mild degrees of extravasation, which responded to a few extra days of nephrostomy drainage. There were no major complications, and no kidneys were lost.

Hospitalization ranged from 5 to 23 days (mean, 7.6 days); most patients (59%) were discharged in six days or less. All were allowed to return to full prehospital activity and employment within one week of discharge. In contrast, hospitalization ranged from eight to 23 days (mean, 12 days) for patients undergoing simple pyelolithotomy alone (either via a posterior lumbotomy or through the flank) in the year preceding percutaneous techniques. Furthermore, these patients were instructed to refrain from physical activity and routine employment for four to six weeks following their hospitalization.

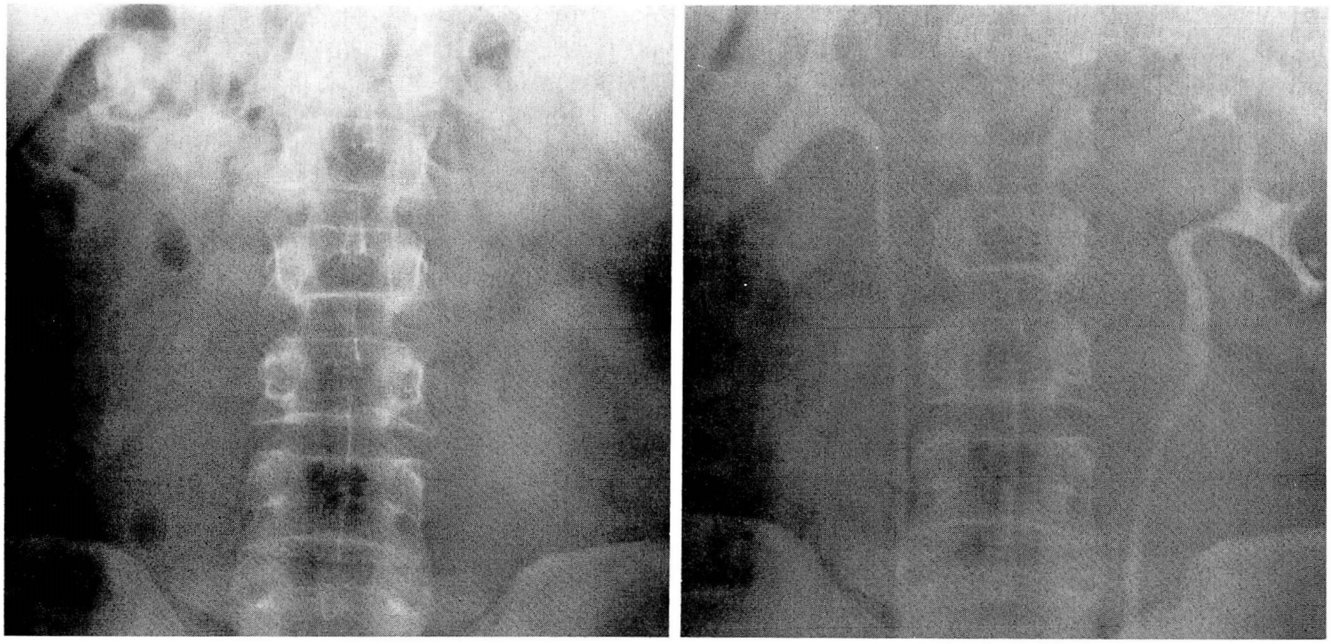
Discussion

Initial reports indicated that percutaneous techniques could benefit a few high-risk patients with renal calculous disease.[1] As techniques improved and experience increased, it became clear that these techniques should, at the least, be



A, B

Fig. 6. Nephrostogram obtained 48 hours after single-stage percutaneous pyelolithotomy.
A. Plain radiograph shows no residual fragments.
B. Contrast material reveals no obstruction or extravasation.



A, B

Fig. 7. Intravenous pyelogram obtained one month later.
A. Scout view reveals no calculi or fragments.
B. Contrast material shows prompt and equal function without any anatomic abnormalities.

Table. Chemical composition of calculi removed percutaneously

Chemical Composition of Calculi	Patients No. (%)
Calcium oxalate and calcium phosphate	31 (52)
Calcium oxalate	22 (37)
Struvite	4 (6.7)
Uric acid and calcium oxalate	1 (1.7)
Ammonium acid urate and calcium oxalate	1 (1.7)
Cystine	1 (1.7)

considered as an appropriate alternative form of management for many more such patients[3,5] or even as the treatment of choice.[4] Our experience supports the latter concept. Of 74 patients requiring surgery for renal calculous disease, 64 (86%) were deemed suitable for a percutaneous approach, which was then successful in 94% of the attempted cases. Furthermore, the relatively short hospitalization time and negligible morbidity associated with the single-stage procedure has allowed us to consider the percutaneous approach as the procedure of choice for the vast majority of patients requiring removal of renal calculi.

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