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Percutaneous Nephrolithotomy: Analysis of 500 Consecutive Cases

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Abstract. The first 500 patients who underwent percutaneous stone removal at our hospital and who have been evaluated for at least 8 months were reviewed. Comparison of the first 100 patients with the entire series showed a sharp improvement in the success rate as the radiologic and urologic team gained experience. The success rate for simple pelvicaliceal stones was 98% in the entire series (vs. 89% in the first 100 cases) and 87% for staghorn calculi. The most common complication was bleeding, with 12% of the patients requiring transfusion. Other complications include infection (0.6%), retained stone fragments (4%), and ureteropelvic junction stricture (1%). There was 1 death, an obese diabetic woman who suffered a myocardial infarction. Successful stone extraction requires a properly placed nephrostomy tract, and radiologic and urologic expertise. The advent of extracorporeal shockwave lithotripsy will not abolish the need for nephrostolithotomy.

Key words: Kidney, calculus — Nephrostolithotomy, percutaneous — Kidney, stone extraction — Lithotripsy, ultrasonic — Nephrostomy, percutaneous.

Percutaneous extraction of stones from the kidney and proximal ureter has evolved into a well-established definitive treatment, with abundant evidence of safety and effectiveness [1–12]. As more experience has been acquired, the indications for the procedure have expanded and the contraindications have declined. At present, percutaneous nephrostolithotomy is indicated in virtually all patients who once would have been candidates for open stone removal, as well as in a few patients with asymptomatic stones that should be removed. The chief remaining contraindications are an uncorrectable bleeding diathesis and untreated urinary tract infection.

As expertise with the nephrostolithotomy operation increases, the success rate rises even though

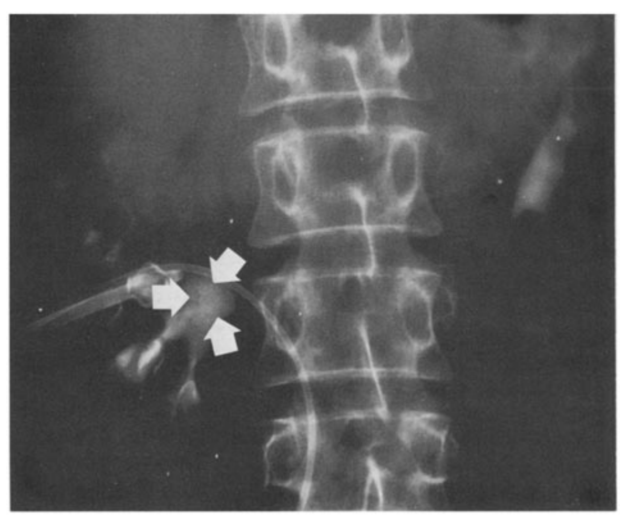

Fig. 1. Final 7 Fr angiogram catheter positioned down the ureter and 14 Fr Malecot nephrostomy for drainage. This was the method we used on the first 100 patients. Drainage catheter is no longer placed unless there is infection or obstruction. A stone is indicated by *open arrows*.

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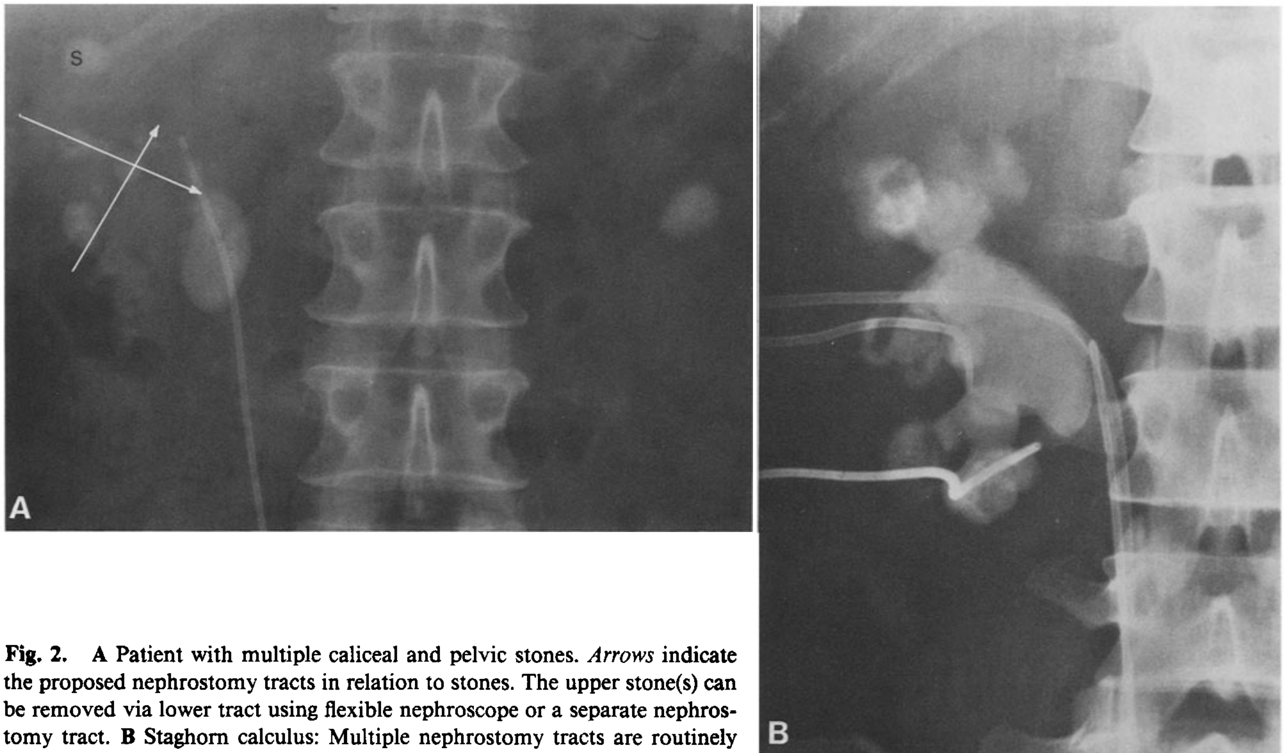

Fig. 2. **A** Patient with multiple caliceal and pelvic stones. *Arrows* indicate the proposed nephrostomy tracts in relation to stones. The upper stone(s) can be removed via lower tract using flexible nephroscope or a separate nephrostomy tract. **B** Staghorn calculus: Multiple nephrostomy tracts are routinely created.

more complex cases are being managed. The literature now contains reports of extraction of multiple caliceal stones [13, 14]; stones in nondilated, duplicated collecting systems, horseshoe kidneys, and ectopic pelvic kidneys [15]; stones trapped by infundibular stenosis or caliceal diverticula [16]; and staghorn stones in solitary or allograft kidneys. As new instruments become available, even more ingenious procedures can be expected.

We have reported our early experience with nephrostolithotomy [8, 10]. We recently completed our 500th case and have reviewed the results and the problems encountered.

Materials and Methods

Patients

From April 1982 through April 1985, 702 calculi in the upper urinary tract, including 46 staghorn stones in 500 patients, were managed percutaneously at our hospital. These 266 men and 234 women were 10–86 years old with an average age of 53 years. The right kidney was involved in 236 patients, the left kidney in 272 patients, and both kidneys in 8 patients; 52 patients had a history of open surgery for stone-related disease. All have been evaluated for at least 8 months since the procedure.

Preparatory and Follow-up Protocol

On the day of admission, the patient has a complete blood count, coagulation studies, urinalysis with culture and sensitivities, and when indicated, a chest radiograph and an electrocardiogram (EKG). Any coagulation abnormalities are corrected. A parenteral broad-spectrum antibiotic, generally cephalosporin, is started and continued for at least 48 hours after stone removal, with appropriate changes as indicated by the sensitivity studies. The next day, the patient undergoes percutaneous nephrostomy (PCN) in the radiology department (Fig. 1), immediately following ureteral catheter placement. Stone extraction is usually carried out the following day in the operating room unless the patient is in acute renal failure or infected, in which case stone extraction is delayed until the patient's condition has stabilized.

Twenty-four to 48 hours after stone removal, a plain abdominal radiograph, a nephrotomogram without contrast medium, and a nephrostogram are performed to look for residual stones, obstruction, and extravasation. If contrast medium drains freely into the bladder, the nephrostomy tube is clamped overnight. If no complications are observed, the tube is removed the next morning and the patient is discharged that afternoon. Oral antibiotics are given for a week, during which time restricted activity is advised. Follow-up excretory urography is performed 3–6 months later.

Technique of Percutaneous Nephrostomy

The PCN is performed with the patient heavily sedated (100 mg meperidine (Pethidine®) and 100 mg secobarbital, with 0.4 mg scopolamine to create amnesia for the procedure). The patient is positioned prone with the stone-bearing side raised 30° to allow a direct posterolateral approach, preferably through Brödel's avascular plane, into the renal pelvis [17]. Using this arrangement, we have been able to make the punctures using single-plane fluoroscopy.

Proper placement of the PCN tract in relation to the calculus is the most important factor in successful stone extraction, es-

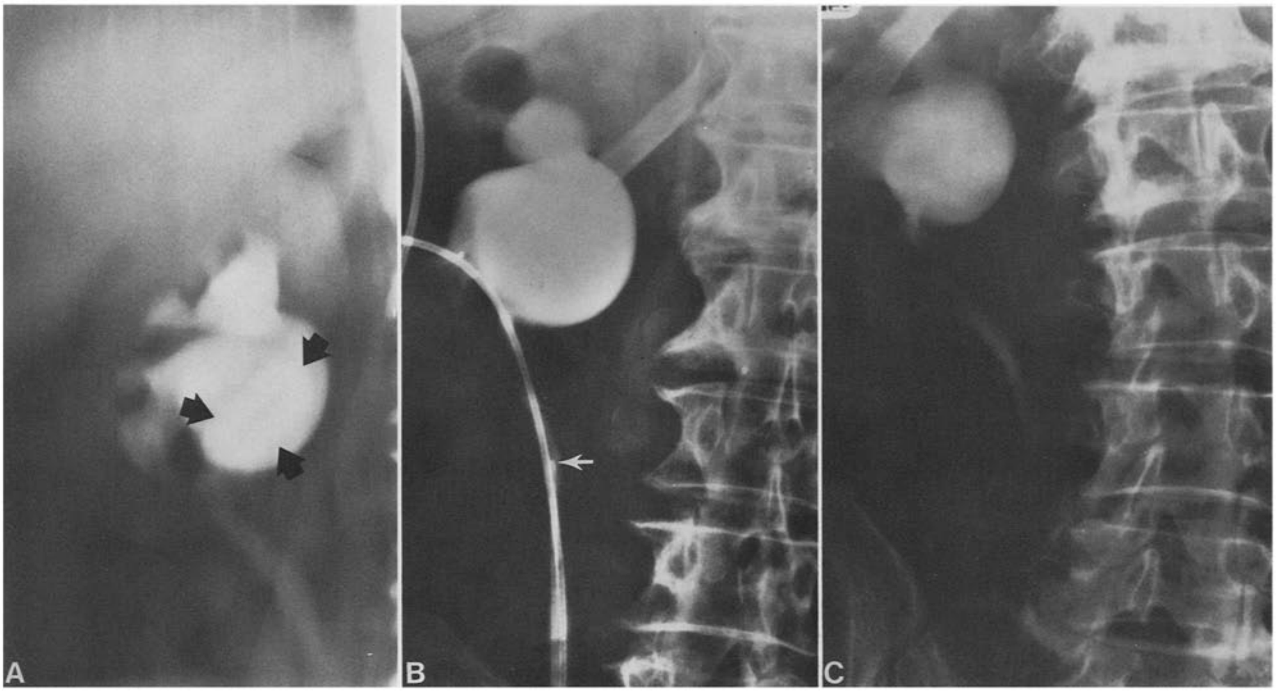

Fig. 3. Findings in a 63-year-old woman with recurrent urinary tract infection. **A** Nephrotomogram prior to PCN shows a 3 × 1.5 cm renal pelvic stone (*arrows*). Tubular radiolucency in the center of the stone represents a broken piece of ureteral catheter. **B** Nephrostogram at the end of the first-stage procedure. Final 7 Fr angiogram catheter passed down ureter. The placement of a retrograde catheter (*arrow*) eliminates the need for localization puncture of the kidney or intravenous injection of contrast medium. **C** Excretory urogram 4 months after percutaneous stone extraction shows normal findings except for ureteropelvic junction deformity from previous open pyeloplasty. We have found no significant morphologic or functional changes following the procedure in uncomplicated cases.

pecially in patients with caliceal stones; improper tract placement may put the stones out of reach. Direct entry into the stone-bearing calix is usually desirable, although upper caliceal stones are usually approached via a lower calix. A renal pelvic stone can be approached via a middle or lower-pole calix (Fig. 2). Nephrostomy-tract placement for stone removal has been reviewed by Coleman *et al.* [18, 19]. Excretory urograms with 1 or more oblique views are invaluable in site selection for the operator with a sound mental image of the internal renal anatomy.

In our first 100 patients, the collecting system was opacified for the definitive PCN puncture by contrast medium injected intravenously or instilled directly via a 22-gauge spinal needle. Since then, we have almost always instilled contrast medium via a ureteral catheter inserted retrograde. This method not only eliminates the need for a localization puncture of the kidney, which can be a source of obscuring contrast extravasation, but also provides controlled opacification and distention of the collecting system, making the PCN puncture easier. In addition, the catheter protects the ureter from debris. Carbon dioxide is substituted for contrast medium in patients who are allergic to the latter [20]. The gas can also be used to push an impacted ureteric stone up into the renal pelvis to make extraction easier. Small amounts of air (less than 20 cc) can be injected without fear of causing air embolism if this is carefully done. In a few patients, the 18-gauge needle was inserted directly onto a caliceal or staghorn calculus, the opaque stone being the target for the puncture. The tract starts near the posterior axillary line and courses under the rib cage through the kidney parenchyma, into the selected calix. A guidewire is used to insert a nephrostomy tube to drain the kidney between procedures. Whenever possible, small, free-lying stones in the renal pelvis are extracted at this time, usually with alligator forceps.

Tract Dilatation and Stone Removal

These procedures are performed in the operating room with the patient under general anesthesia. A urologist and a radiologist work as a team. The tract must be enlarged sufficiently to accomodate the necessary stone-removal instruments; this can be done rapidly under C-arm fluoroscopy with fascial or coaxial dilators or a high-pressure angioplasty-type balloon catheter [21–24]. We prefer the Amplatz coaxial renal dilator system (Cook), the final (34 Fr) dilator of which can be left in the PCN tract as a working sheath [21]. This device not only facilitates instrument insertion but also helps prevent pyelovenous backflow of irrigant into the systemic circulation by keeping the pressure in the renal pelvis below 16 cmH_2O. Metal telescopic dilators are used in patients with extensive scar tissue in the flank. Before tract dilatation is completed, a second safety guidewire is inserted to facilitate reentry into the collecting system if the working guidewire becomes dislodged during manipulation.

Many techniques are available for percutaneous stone extraction [5, 10, 13, 25, 26, 27]. At various times, we have used 3-pronged, Randall's, and the scissoring Mazzaiello-Caprini [28] grasping forceps and several types of stone baskets to remove stones as large as 1.5 cm. Direct vision with a rigid Storz nephroscope has been valuable. Larger stones were broken up by ltrasonic lithotripsy with 0.9% saline as the irrigant. Whenever irrigant is used, the input and output must be monitored.

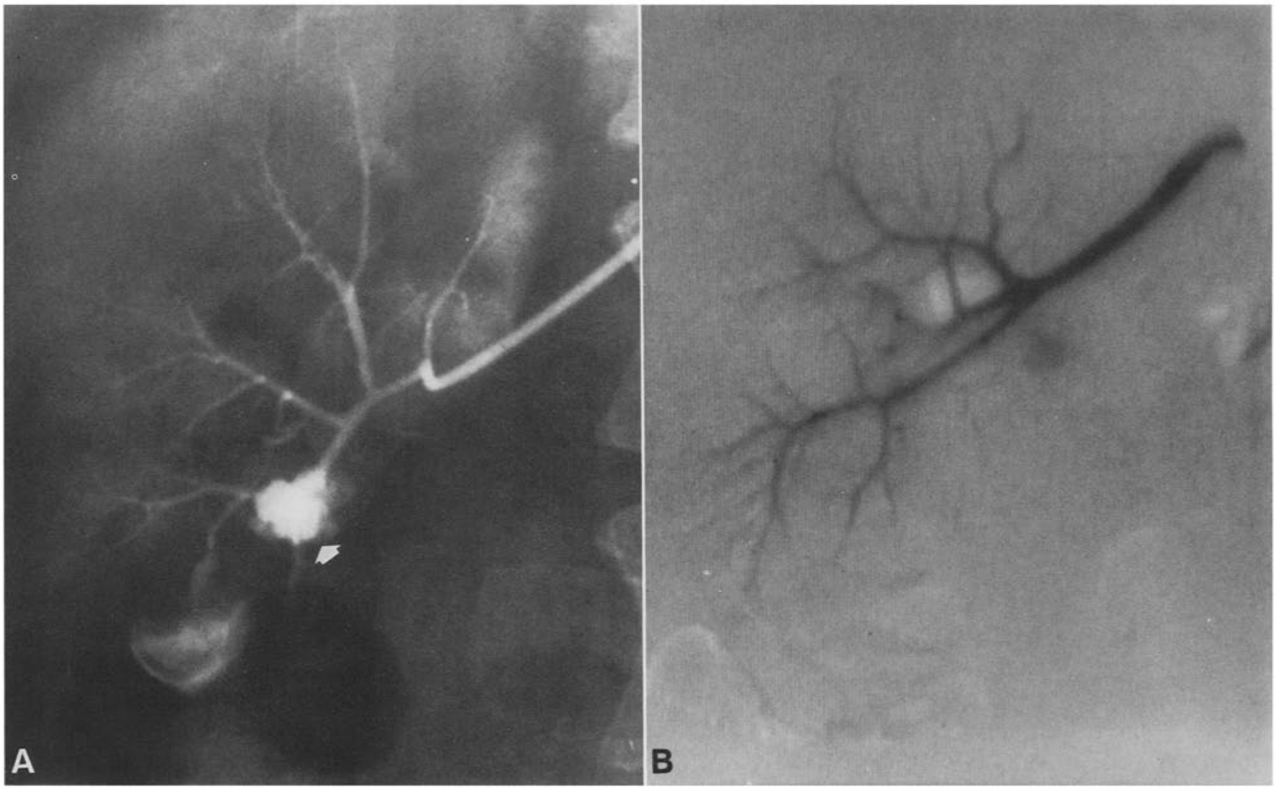

Fig. 4. Findings in a 64-year-old man with intermittent postoperative bleeding following percutaneous stone extraction. **A** Selective renal arteriogram demonstrates a large pseudoaneurysm (*arrow*) with contrast extravasation into the lower calix. **B** Postembolization subtraction angiogram. Bleeding branch of the renal artery has been occluded with Gelfoam®. There is no extravasation. Follow-up excretory urogram showed functioning kidney. There was no hypertension as a result of embolization.

At the end of the procedure, a 14 Fr Malecot or a 24 Fr reentry nephrostomy tube is inserted. Its position and the integrity of the renal pelvis and ureter are confirmed with the aid of contrast medium; if perforation or extravasation is present, the ureter is stented. The nephrostomy tube is then secured to the skin and covered with a pressure dressing. The ureteral catheter that was inserted retrograde is removed in the recovery room.

If residual stones or fragments are found on the postoperative radiographic studies, they can be removed nephroscopically or by chemolysis [29]. Minute fragments are sometimes left *in situ* so as not to subject the patient to another operation.

Results

Success Rates

In patients with simple renal pelvic or caliceal stones, the success rate of stone extraction was 98% and the rate of ureteropelvic junction stones was 95% (Fig. 3). Forty-six patients had staghorn stones for which they underwent lithotripsy; and although 32 (70%) required more than 1 session in the operating room and 6 had adjuvant chemolysis, only 6 had residual stones at discharge.

Overall, there was a 4% incidence of retained fragments in 148 patients who underwent lithotripsy excluding those with staghorn calculi. The salutary effect of experience is evident in comparing these figures with the stone-removal rates in our first 100 patients (110 of 124 stones removed, or 89%) [10] and our first 200 patients (226 of 235 removed, or 96% [8]. Furthermore, 14 of the 17 patients who required open operation after nephrostolithotomy failed were among the first 100 patients. Between the beginning and the end of the series of 500 patients, the average fluoroscopy time required declined from 12 min to 6 min.

The hospitalization time averaged 8.3 days with a range of 4 to 32 days.

Analysis of Failures

Inability to establish a nephrostomy tract was responsible for 3 failures and improper tract placement in 5. Nine failures were caused by technical problems: large perforations of the pelvis or ureter, excessive bleeding, impacted caliceal stones, and inability to visualize stones adequately.

Table 1. Complications of percutaneous stone removal in 500 patients

	No. (%)	Comments
Bleeding necessitating transfusion: total	60 (12)	
Periprocedural	53	
Delayed		
Pseudoaneurysm formation	6	2 total or partial nephrectomy, 4 embolizations
Perirenal/subcapsula hematoma	1	
Infection: total	3 (0.6)	
Pyelonephritis	2	
Sepsis	1	
Urine leak: total	5	
Significant pelviureteral laceration	3	1 open repair
Urinoma requiring percutaneous drainage	2	Symptomatic
Pulmonary problems: total	35 (7)	Multiple problems in 5
Atelectasis	16	
Transient pleural effusion	6	All had PCN above 12th rib
Pneumothorax or hydrothorax	5	All had PCN above 11th rib
Other		
Stone fragments displaced outside collecting system	5	
Prolonged drainage from flank	11	
Ileus	10	No additional management
Low-grade fever for 1–2 days	103 (20)	
Ureteropelvic junction stricture	5 (1)	1 required open repair
Myocardial infarction	1	Fatal

Complications

In published series, significant complications, principally bleeding and sepsis, occur in approximately 4% of patients. In our series, the frequency of bleeding necessitating transfusion (hematocrit < 30%) was strikingly higher: 12%. In 7 patients, this bleeding was delayed 1–4 weeks, and in 6 patients, pseudoaneurysms were documented angiographically (Fig. 4). One patient had a segmental nephrectomy and another a nephrectomy after attempted embolization failed, and the other 4 (the most recent examples of this complication) underwent successful embolization. Delayed bleeding as a result of pseudoaneurysm or arteriovenous fistula formation has been described by other authors [30–32] and has been attributed by 1 group to withdrawal of the nephrostomy tube before the vessels injured by the PCN puncture and tract dilation have sealed [32]. We suspect that the frequency of bleeding in our series is attributable to the large number of complex cases attempted that required more than 1 PCN tract.

Two complications necessitated open repair: 1 severe renal pelvic laceration and 1 ureteropelvic junction stricture. Four other such strictures were managed percutaneously. Other complications are listed in Table 1.

One patient died. In contrast to other series, in which the few deaths have been caused by hemorrhages or infection [33], this woman, an obese diabetic with large staghorn calculi, died from a myocardial infarction. No difficulty was encountered intraoperatively and the preoperative EKG was unremarkable.

Discussion

The percutaneous approach to the urinary tract for diagnostic and therapeutic procedures has gained acceptance rapidly because it has proved to be safe, reliable, and effective. The ability to remove stones in this way has been particularly valuable because even in the uncommon instances, (principally, patients with staghorn stones) when nephrostolithotomy makes greater demands on hospital resources [12] the far shorter recovery time than that required for open operation makes the percutaneous method more cost-effective. Nephrostolithotomy can be performed in patients who have had prior renal surgery and does not preclude such surgery later. The need for simultaneous corrective operation does not necessarily rule out percutaneous procedures either, since many stenoses, strictures, and diverticula can now be managed by percutaneous methods.

The approval of the extracorporeal shock-wave lithotriptor by the U.S. Food and Drug Administration will reduce the demand for nephrostolithotomy. However, contrary to what some radiologists and urologists have believed (or feared), this machine will not be suitable for all patients even when it becomes widely available. First, it is not easy to use in patients with radiolucent stones because of the difficulty in focusing the stone-smashing beam. Second, it is not appropriate for patients with infected or impacted stones. Third, because its effectiveness depends on the stone dust draining down the ureter, large stones are seldom handled: The volume of dust tends to choke the ureter (Steinstrasse). Finally, ureteral stones are not considered appropriate targets. Thus, there will continue to be a need for urologist–radiologist teams skilled in percutaneous stone extraction.

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