Complications of Percutaneous Nephrolithotomy

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Of 582 patients who underwent percutaneous nephrolithotomy, 4% had complications. The most common complications were fever (23%) and bleeding necessitating transfusion (12%). Extravasation was seen in 7% of patients and transient ureteral obstruction in 6%. Other complications included pneumothorax or hydrothorax, pneumonia/atelectasis, paralytic ileus, nephrostomy-tube dislodgment or urine drainage from the flank lasting more than 1 week, significant infection, urinoma formation, renal pelvic laceration, ureteral avulsion, ureteropelvic or ureteral stricture, bowel injury, or escape of stone fragments into the retroperitoneum. Seven patients (1%) required immediate surgery: four to repair renal pelvic lacerations, one to repair a ureteral avulsion, and two to control bleeding after nephrostomy-tube removal when embolization failed. Four patients required delayed surgery for ureteral or ureteropelvic junction strictures, which may have been caused by a tissue reaction to the stones rather than by the procedure itself. There were two deaths—one from respiratory failure in a patient with severe interstitial pulmonary fibrosis and chronic renal failure and the other from myocardial infarction in an obese diabetic patient with hypertension.

Since its introduction in the late 1970s, when it was primarily used to treat kidney-stone patients who were poor operative risks, percutaneous nephrolithotomy (nephrostolithotomy) has virtually replaced open-stone operations in patients of all ages and for nearly all types of stones. The advantages of the percutaneous method include lower rates of mortality and morbidity, a faster convalescence, greater ease of repeat procedures, and greater cost effectiveness. Nevertheless, the recent approval by the Food and Drug Administration of extracorporeal shock-wave lithotripsy (ESWL) mandates a critical new look at the percutaneous methods. While ESWL is neither free of morbidity nor suitable for all cases [1], it does create a new standard by which percutaneous nephrolithotomy and its complications must be judged. In this article, we examine the complications in one of the largest series of percutaneous nephrolithotomy cases reported to date (582 patients) and offer several recommendations for minimizing these problems. Previous reports based on this series were concerned with techniques and results rather than with complications [2–4].

Materials and Methods

Since April 1982, all stones in the renal pelvis, calyces, and middle-to-upper ureter have been initially treated by percutaneous means. Thus, the indications for percutaneous nephrolithotomy are the same as those for open surgery. This report includes 582 consecutive patients—312 men and 270 women—aged 18–96 years (average, 57 years) seen from April 1982 through September 1985. Seventy-five of these patients had staghorn calculi, including one in an ectopic pelvic kidney and one in a solitary allograft kidney. Nine patients had bilateral stones and 14 had associated ureteropelvic junction obstruction necessitating endopyelotomy [5]. All patients in whom a percutaneous nephrostomy (PCN) was attempted for extraction of upper urinary stones are included in this study.

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Our methods for visualization of the collecting system, tract dilatation, and stone removal, and our technique of PCN access route have been described previously [2, 4]. Briefly, we inject contrast material, usually through a cystoscopically placed retrograde ureteral catheter, to outline the collecting system. The PCN is performed in the radiology suite by using local anesthesia supplemented with IV analgesics. We prefer direct entry into the calyx for calyceal stones and puncture of middle or lower calyces for stones in the pelvis or upper ureter. A 7-French angiogram catheter is passed down the ureter over a guidewire and is sutured to the skin. Tract dilatation and stone removal generally are performed the next day in the operating room with the patient under general anesthesia. A safety guidewire is routinely placed into the distal ureter. Over the working wire, the tract is dilated (usually to 34 French) with Amplatz renal dilators (Cook Inc., Bloomington, IN). The stones are removed under direct nephroscopic vision by using various grasping forceps, baskets, and ultrasonic lithotripsy, depending on their size and location. Normal saline is used as the irrigant. When the stone has been removed, a 14-French Malecot nephrostomy tube is inserted, unless urinary-tract perforation or extravasation is apparent, in which case a 24-French reentry nephrostomy tube (Van Tec Inc., Spencer, IN) is inserted to tamponade, stent, and preserve the tract. Within 48 hr after stone removal, a plain abdominal radiograph, a nephrotomogram, and a nephrostogram are obtained in order to verify that the stone has been completely removed and that the collecting system has remained intact. The nephrostomy tube is clamped overnight and subsequently is removed. A follow-up IV urogram is obtained 3–6 months later.

Results

Gross hematuria occurred in all 582 patients, but only bleeding that required transfusion was considered a complication. Bleeding occurred in only one patient after PCN alone but in 64 patients after stone extraction (Table 1). An additional seven patients had bleeding either immediately or 1 day after nephrostomy-tube removal. This was the result of pseudoaneurysm or arteriovenous fistula formation in six patients, as shown angiographically. In the remaining patient, a large perinephric hematoma occurred as a result of intermittent bleeding. Percutaneous embolization stopped the bleeding in four patients and failed in two patients who underwent nephrectomy or segmental nephrectomy. One patient who had a retroperitoneal hematoma responded to conservative therapy.

Temperature elevation above 38.5°C was considered a febrile complication and occurred in almost one-fourth of the patients (Table 2). In most cases, the fever began during the procedure or within 4–6 hr afterward, suggesting retrograde flow of urine, irrigant, or both as a significant factor [3]. Antipyretics were rarely needed. Fever was clearly associated with significant infection in only five patients. In two of these patients, pyelonephritis caused by an organism not previously isolated from the patient occurred after PCN puncture; in another patient, a previous infection was reactivated by the puncture. The other two patients suffered septic shock 4–6 hr after stone removal. All of these patients recovered with appropriate antibiotic treatment. Approximately 6% of the remaining patients had urinary infections that responded to antibiotics.

Extravasation was visible radiographically in 42 patients (7%) after stone removal, but urinomas formed in only three patients and were drained percutaneously. Thirteen patients had renal pelvic lacerations, but only four required open repair. Ureteral and ureteropelvic junction strictures generally followed extraction of an embedded stone. Transient urinary obstruction occurred in 35 patients (6%) as a result of ureteral edema and was easily managed by nephrostomy drainage.

Pneumothorax or hydrothorax occurred in 18 patients (3%), most often in those who had nephrostomy tracts created above the 12th rib to facilitate access to the stones. In 13 cases, a chest tube was inserted for 2–3 days; in the other cases, the fluid was aspirated. There have been no sequelae.

Prolonged (>1 week) drainage of urine from the flank was seen in nine patients (2%). Ureteral-catheter insertion or continued nephrostomy drainage led to an uneventful recovery in all cases.

There were two deaths in this series. The first patient, a 59-year-old man who had systemic sarcoidosis with severe interstitial pulmonary fibrosis and chronic renal failure, presented with bilateral kidney stones, which were extracted with the patient under general anesthesia. On the fourth postoperative day, his respiratory function began to deteriorate and he died. An autopsy revealed a large right-sided retroperitoneal hematoma and some bloody ascites. The second patient, a 67-year-old obese woman with hypertension and diabetes mellitus, presented with an enormous staghorn calculus. Two sessions of lithotripsy and fragment extraction were completed without problems, but after the third session, the patient died of myocardial infarction in the postanesthesia recovery room. Preoperative ECGs showed mild ischemic changes. Neither of these patients would have been a candidate for ESWL.

TABLE 1: **Major Complications of Percutaneous Nephrolithotomy in 582 Patients**

Complication	PCN (%)	NLT (%)	Late (%)	Total (%)
Death		2 (0.3)		2 (0.3)
Bleeding necessitating intervention	None	6 (1.0)	1 (0.2)	7 (1.2)
Significant infection	3 (0.5)	2 (0.3)	None	5 (0.8)
Urinary tract injury				
Urinoma formation	1 (0.2)	2 (0.3)	None	3 (0.5)
Pelvic laceration	None	5 (0.9)	None	5 (0.9)
Ureteral avulsion	None	1 (0.2)	None	1 (0.2)
Ureteropelvic junction or ureteral stricture	None	None	5 (0.9)	5 (0.9)
Injury to adjacent organs:				
Pneumothorax/hemothorax	1 (0.2)	17 (2.9)	None	18 (3.1)
Bowel	1 (0.2)	None	None	1 (0.2)

Note.—Some patients had more than one complication; overall, 4% of the patients had significant complications. PCN = percutaneous nephrostomy; NLT = nephrolithotomy; late = delayed complications.

TABLE 2: **Minor Complications of Percutaneous Nephrolithotomy in 582 Patients**

Complication	PCN (%)	NLT (%)	Total (%)
Low fever (38.5°C)	18 (3.0)	113 (19.4)	131 (22.4)
Bleeding necessitating transfusion	1 (0.2)	64 (11.0)	65 (11.2)
Extravasation	None	42 (7.2)	42 (7.2)
Tube dislodgment	2 (0.3)	32 (5.5)	34 (5.8)
Pneumonia/atelectasis	None	16 (2.7)	16 (2.7)
Transient urinary obstruction	None	35 (6.0)	35 (6.0)
Paralytic ileus	None	15 (2.6)	15 (2.6)
Urine drainage from flank for >1 week	None	9	9 (1.5)
Stone fragments escaping into retroperitoneum	None	6 (1.0)	6 (1.0)

Note.—PCN = percutaneous nephrostomy; NLT = nephrolithotomy.

Discussion

Urinary Tract Injury

Two questions arise in connection with urinary-tract injury by PCN and stone removal: How many accidental injuries occur during the manipulations, and how much damage attends the creation of a PCN tract?

Extravasation of contrast medium during or immediately after the procedure may or may not indicate a complication. For example, 26% of the patients described by Clayman et al. [6] had extravasation, but many of these patients were seen early in the Minnesota study, when opacification of the renal pelvis for PCN puncture was often achieved by instilling contrast medium through a Chiba needle—the "2-stick" PCN method. This method increases the risk of contrast loss through a deliberately created hole. Later in the series, contrast medium was instilled through a ureteral catheter that was inserted retrograde, thereby reducing the risk of extravasation (while permitting distension of the renal pelvis for easier manipulation) and preventing the escape of stones into the ureter, a method we use routinely. Of greater interest are the unquestionable injuries such as lacerations, avulsions, and perforations. We observed five significant renal-pelvic lacerations, one ureteral avulsion, three instances of urine leakage sufficient to form urinomas, and six escapes of stones into the retroperitoneum, suggesting perforation. Four of the significant pelvic lacerations occurred early in our series and were explored immediately; the other healed with nephrostomy drainage. Indeed, most small leaks and tears will seal quickly without assistance if the urinary tract is adequately drained. The avulsion was surgically managed. The urinomas and escaped stones were managed conservatively. Segura et al. [7] reported one case of ureteral separation necessitating operation, one case of ureteral perforation with stone escape into the retroperitoneum, and two cases of renal parenchymal laceration by dilators that necessitated open operation.

The formation of strictures may be a response to the stone rather than an effect of stone removal. In our series, most of the strictures formed at sites where stones had been embedded, and one of our patients with stones at the ureteropelvic junction already had strictures that had to be incised before the stones could be removed. It is not possible to test this hypothesis of stone-induced stricture by comparison with the results of ESWL, since embedded stones or obstructed urinary tracts are not treated with ESWL.

Bleeding

Approximately 1% of patients who undergo PCN puncture will bleed enough to require transfusion [8, 9]. The higher frequency of transfusions in our series as compared with other reports [6–8] may be due to the frequency of staghorn calculi (and hence of more extensive manipulation) or to the performance of intrarenal surgery, such as an endopyelotomy in several cases. If formation of a subcapsular or perirenal hematoma visible by CT is the criterion, presumably the frequency would be higher, although there are few data on this point. Clayman et al. [6] found perirenal hematomas not requiring treatment in two of their 100 patients without using CT, and we found one large and two small collections in three of the 20 patients we studied by CT.

Delayed bleeding from an arteriovenous fistula or a ruptured pseudoaneurysm occurs in less than 1% of patients undergoing PCN with or without stone removal [7, 8, 10–12]. In these patients, gross hematuria may be followed by hypertension and anuria, and embolization or nephrectomy may be needed to control the bleeding. Both Segura et al. [7] and Reddy et al. [8] reported one patient with delayed serious bleeding necessitating partial or total nephrectomy; we had two such cases.

Several steps can be taken to minimize the frequency of serious blood loss after PCN puncture and stone removal: (1) a clotting profile should be obtained and any abnormalities corrected before the procedures; (2) the operator should have a clear mental image of the renal vasculature when choosing the puncture site and try to puncture through Brodel's avascular line; (3) if any intrarenal surgery is to be done to free trapped stones or correct anomalies that encourage stone formation, the area to be incised should first be examined under direct vision to be certain there are no arterial pulsations [13]; (4) through (two-wall) punctures of the renal pelvis, which can injure the anterior segmental renal artery, should be avoided—biplane or C-arm fluoroscopy is invaluable; and (5) punctures close to a rib also should be avoided, because they may damage the intercostal vessels. Because significant bleeding may occur despite these precautions, equipment, cross-matched blood, and surgical back-up must be readily available.

Bleeding is much less common after stone removal by ESWL. Chaussy et al. [14] found only six subcapsular hematomas by routine sonography of more than 1000 patients, and only two of these patients required transfusions.

Injuries to Other Organs

The organs most often injured during PCN and stone removal are the lungs and pleura, with possible pneumothorax or hydrothorax. These problems are especially likely with PCN puncture above the 12th rib, yet experienced operators do not hesitate to make such a puncture when it provides the best access to a stone [8, 15]. In these cases, it is especially important to use a working sheath in the PCN tract to prevent the escape of fluid. A chest tube or percutaneous drainage will be necessary in a few cases.

Bowel perforation can be a serious complication of PCN puncture. In a series of 250 patients reported from France

[16], perforation of the left side of the colon led to rectal hemorrhage and shock in one patient and passage of gas through the PCN tract in another. Both patients required operative repair. The authors of that report suggest that bowel perforation is most likely in patients with mobile kidneys (a condition found in both cases) and when the PCN tract is placed far laterally. Surveillance is the appropriate treatment only when the perforation is extraperitoneal and no predisposition to complication is present.

Puncture of the spleen has occurred in several patients undergoing PCN with or without stone removal. In some cases, no treatment was required; in a few, splenectomy was necessary. Liver injuries are less common and seldom require treatment. Indeed, we are aware of one instance in which a transhepatic PCN tract was inadvertently created, dilated, and used to extract a stone without sequelae.

Infection

A PCN puncture and stone removal may reactivate infection, as in two of our patients. Bacteriuria is common in patients with large stones subjected to lithotripsy; it occurred in one-fourth of our patients with staghorn stones. In many cases, the bacteria probably are released from infected stones as they disintegrate, a contention supported by the fact that reactivated infection and the appearance of bacteriuria in patients with previously sterile urine have occurred in several patients receiving ESWL [14]. A few cases of septic shock have been reported, generally in association with extravasation and absorption of irrigating fluid [7]. The occurrence of this potentially fatal complication even when broad-spectrum antibiotics are being given reinforces the long-standing admonition that antibiotics cannot be expected to replace good technique, especially when, as in the case of infected stones, the operating field will inevitably become contaminated.

Deaths

Early in the use of PCN punctures in endourology, bleeding was the usual cause of the few deaths that were reported. This is no longer the case. One of the deaths in our series was caused by respiratory failure in a patient with previous pulmonary disease and the other by myocardial infarction. The single fatality in the Mayo Clinic series resulted from acute myocardial infarction and refractory arrhythmia in a 64-year-old quadriplegic woman who had undergone removal of staghorn calculi bilaterally. Autopsy revealed two previous myocardial infarctions. None of these patients would have been considered a good operative risk, and percutaneous nephrolithotomy was the only option available at the time. A single death from acute cardiac decompensation has been associated with ESWL; the autopsy revealed several areas of old infarcts, and the pathologist found no evidence of a direct relation between the death and ESWL. The shock-wave–dependent arrhythmias seen in 80% of the early patients treated by ESWL have since been minimized by synchronizing the shock wave with the R wave of the ECG [14].

Conclusion

Some of the early comparisons of percutaneous nephrolithotomy (PNL) and ESWL had the effect of making PNL look less effective and the ESWL more effective; this has been the case in large series. That is, the earliest percutaneous stone removals were done in patients for whom that procedure (highly experimental at that time) was the only option; whereas during the development of ESWL, the first patients were, of necessity, those with small uncomplicated stones who were in better physical condition than those subjected to percutaneous methods [14]. Moreover, some of the instruments that have been most useful in percutaneous stone removal (such as the flexible nephroscope) were not available for the early cases. Therefore, only in the last few years has it become possible to compare the results of the two methods in similar populations.

It is becoming clear that ESWL will not supplant PNL. Chaussy et al. [14] estimate that 15% of patients will need percutaneous manipulation in addition to ESWL and that another 15% will not be candidates for ESWL. At present, a far higher percentage of patients are not candidates because of lack of availability of ESWL. Thus, continued study of the complications of PNL is mandatory.

REFERENCES

1. Chaussy C, Fuchs GJ. World experience with extracorporeal shock-wave lithotripsy (ESWL) for the treatment of urinary stones: an assessment of its role after 5 years of clinical use. *Endourol Newsletter* **1986**;1(1):7–8
2. Lee WJ, Loh G, Smith AD, et al. Percutaneous extraction of renal stones: experience in 100 patients. *AJR* **1985**;144:457–462
3. Snyder JA, Smith AD. Staghorn calculi: percutaneous stone extraction versus anatrophic nephrolithotomy. *J Urol,* in press
4. Lee WJ, Smith AD, Cubelli V, Vernace FM. Percutaneous nephrolithotomy: analysis of 500 consecutive cases. *Urol Radiol* **1986**;8:61–66
5. Badlani G, Eshghi M, Smith AD. Percutaneous surgery for ureteropelvic junction obstruction (endopyelotomy): technique and early results. *J Urol* **1986**;135:26–28
6. Clayman RV, Surya V, Miller RP, et al. Percutaneous nephrolithotomy: extraction of renal and ureteral calculi from 100 patients. *J Urol* **1984**;131:868–871
7. Segura JW, Patterson DE, LeRoy AJ, et al. Percutaneous removal of kidney stones: review of 1,000 cases. *J Urol* **1985**;134:1077–1081
8. Reddy PK, Hulbert JC, Lange PH, et al. Percutaneous removal of renal and ureteral calculi: experience with 400 cases. *J Urol* **1985**;134:662–665
9. Stable DP. Percutaneous nephrostomy: technique, indications and results. *Urol Clin North Am* **1982**;9:15–29
10. Savant ML, Gold RE, Church JC. Delayed rupture of renal pseudoaneurysms: complication of percutaneous nephrostomy. *AJR* **1982**;138:948–949
11. Cope C, Zeit RM. Pseudoaneurysms after nephrostomy. *AJR* **1982**;139:255–261
12. Clayman RV, Surya V, Hunter D, et al. Renal vascular complications associated with the percutaneous removal of renal calculi. *J Urol* **1984**;132:228–230
13. Clayman RV, Hunter D, Surya V, Castaneda-Zuniga WR, Amplatz K, Lange PH. Percutaneous intrarenal electrosurgery. *J Urol* **1984**;131:864–867
14. Chaussy C, Schmidt E, Jocham D, Schuller J, Brandt H, Liedl B. Extracorporeal shock-wave lithotripsy (ESWL) for treatment of urolithiasis. *Urology* **1984**;23(May Suppl):59–66
15. Young AT, Hunter DW, Castaneda-Zuniga WR, et al. Percutaneous extraction of urinary calculi: use of the intercostal approach. *Radiology* **1985**;154:633–638
16. Vallanicien G, Capdeville R, Viellon B, Charton M, Brissel JM. Colonic perforation during percutaneous nephrostomy. *J Urol* **1985**;134:1185–1187