

Percutaneous Renal Access: A Historical Perspective

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Introduction

Percutaneous nephrolithotomy (PCNL) has evolved to become the preferred minimally invasive approach for treating large-burden renal stones. This approach has replaced open renal surgery for stones. It has also evolved into a treatment option for treating noninvasive urothelial tumors of the upper urinary tract. Current percutaneous access techniques involve fluoroscopic or ultrasound guidance with a small-gauge needle for initial access. In selected cases, computed tomography (CT) guidance or blind access by anatomical landmarks may be indicated. The complications of PCNL are minimal and the associated morbidity is far less than for open renal surgery.

History

In 1865 at the Great Ormond Street Hospital, a case report by Thomas Hillier of therapeutic percutaneous renal decompression in a 4-year-old boy with congenital obstruction of the ureteropelvic junction was the first such case of percutaneous nephrostomy [1]. Through the course of the following 5 years, he performed multiple nephrostomies to relieve the recurring abdominal distension from the obstructed kidney. However, there was no suitable trocar available with which to create a permanent nephrocuteaneous fistula. The child subsequently died at the age of 8 after a febrile illness.

The history of modern percutaneous renal surgery began with the first image-guided renal biopsy performed in 1944 by Nils Alwall by means of needle aspiration using a simple radiograph and retrograde pyelogram to localize the kidney with the patient in the sitting position. The procedure was performed at the University of Lund, Sweden. While the initial procedure was performed in 1944, the experience was not published until 1952 [2]. Subsequent series of percutaneous renal biopsy had the patient positioned prone, and the kidneys were localized using landmark distances between the vertebral spinous processes and the 11th and 12th ribs, and palpation for kidney movement [3].

The next reported description of percutaneous renal access was in 1955. Goodwin, Casey, and Woolf presented their experience at Harbor General Hospital of the University of California, Los Angeles, in 16 patients with hydronephrosis managed with percutaneous nephrostomies for drainage. All cases were performed under local anesthesia [4]. This technique followed as a natural extension of their initial report of percutaneous antegrade pyelography [5]. The authors noted in their technique that the procedure should be limited to patients with severe hydronephrosis since it was easier to puncture a larger hydronephrotic sac. The punctures were made with 12–14 gauge needles. It is of interest to note that the authors fashioned polyethylene tubings with several additional lateral holes to increase urinary drainage, allowing 2–4 inches of that portion of the tubing to coil in

the renal pelvis. These early modifications are now the standard design of pigtail nephrostomy tubes that are currently available.

In 1975, Stables published a case series in which he described a technique to convert a standard temporary percutaneous nephrostomy to prolonged or permanent nephrostomy drainage with Foley catheters [6]. This was thought to be of benefit in the management of obstructive nephropathy in cases where the primary lesion was not readily amenable to surgical repair. In a larger series and review of the literature, Stables described the application of the percutaneous nephrostomy in supravescical urinary obstruction, urinary fistulas, and renal calculi [7]. He reported a success rate of over 90% with percutaneous nephrostomies, with major complications limited to 4% and minor complications to 15%. This represented a significant advance because open nephrostomy had been associated with such complications as uremia, hemorrhage, infections, sepsis, and at times difficult access to the renal pelvis.

In another series, Hellsten et al. reported performing percutaneous nephrostomy in 32 patients. Of these, eight patients were for permanent drainage and 24 for temporary drainage. Malignant obstruction of the distal ureter was the most common indication [8]. Access to the renal pelvis was obtained with the aid of fluoroscopy and/or ultrasound. Change to larger catheters was achieved using the Seldinger technique. The most common complication reported was hemorrhage in five patients. Percutaneous nephrostomy has thus remained in use for temporary or permanent drainage of the urinary tract for various indications including infections, obstruction or neoplasm.

Percutaneous nephrolithotomy

In 1976, Fernstrom and Johansson reported on the first percutaneous image-guided nephrolithotomy [9]. The tract was dilated coaxially with graded plastic dilators over the course of a few days. The tract was then used for renal manipulation using grasping tools and Dormia baskets after allowing the tract to mature. Following shortly thereafter in 1979, Smith et al. from the University of Minnesota reported on their experience [10]. By 1984, they reported results from their first 100 patients [11]. Interestingly, the complication rate decreased to 5% as

their experience with the procedure grew, with a reported stone-free rate of 91% for the most recent patients in that series. One year later in 1985, the same group reported on a further 400 patients. This time, the stone-free rate had improved to 99% for patients with renal stones and 94.5% for ureteral stones [12]. Their results compare very favorably to stone-free and complication rates from more modern PCNL series.

Percutaneous transitional cell carcinoma resection

In 1984, Orihuela, Crowley, and Smith from the Long Island Jewish Medical Center in New York extended the techniques for percutaneous renal access to the treatment of upper tract urothelial carcinomas. Two years later, they became the first to report their experience at the annual meeting of the American Urological Association in 1986 [13]. The initial series of patients was a highly selected group suitable for renal-sparing surgery for solitary kidney, bilateral synchronous disease, renal insufficiency, poor surgical risk for open surgery or biopsy evidence of a solitary low-grade superficial tumor. The authors' technique involved an initial resection through a percutaneous nephrostomy, followed by a second-look procedure 2–28 days later to assess the completeness of the initial resection and to remove any residual tumors. Of note, with this initial series of patients, the authors used adjuvant topical therapy through the nephrostomy tube with mitomycin C and bacillus Calmette–Guerin (BCG). Subsequently, the same group published results on their experience with their first nine patients [14]. Other authors emulated the technique and reported similar success [15].

Percutaneous endopyelotomy

The percutaneous renal access technique was also adapted to treatment of the obstructed ureter. With percutaneous renal access, the ureteropelvic junction is easily accessible and made endoscopic incision feasible, avoiding the need for open surgery. In 1983, Whitfield et al. described a procedure of percutaneous incision of the ureteropelvic junction using a modification of the Davis intubated ureterostomy technique. The authors reported a success rate of 64% with their technique [16]. In 1984, Smith reported

on the various adaptations of the nephrostomy tract to renal surgery [17]. He demonstrated that the nephrostomy tract permits antegrade insertion of ureteral stents, ureteral dilation, and insertion of ureteral catheters to which other instruments such as stone baskets, steel stylets, etc. could be attached, thus facilitating controlled stone manipulation, ureteral meatotomy, and retrograde stent insertion. He adapted the technique reported by Whitfield et al. and termed it endopyelotomy. In 1986, Badlani et al. reported on their initial experience in the treatment of ureteropelvic junction obstruction using this modified technique in 31 patients with a cold knife direct-vision urethrotome inserted through a percutaneous nephrostomy tract [18]. A success rate of 87.1% was reported by the authors. Notably, eight of these patients were undergoing endopyelotomy after previous failed open pyeloplasty.

Other applications

The next application of the nephrostomy tract was the attempt to dissolve stones by chemolysis. The instillation of acetylcysteine together with sodium bicarbonate through a nephrostomy tube into the renal pelvis was highly effective for dissolving cystine stones. Subsequently, renacidin was used to dissolve struvite stones. Blaivas et al. attempted chemical dissolution of residual stone fragments in 12 instances via nephrostomy tube irrigation [19]. Solutions containing either hemiacidrin or sodium bicarbonate were used for struvite and uric acid stones respectively, with a 75% success rate (complete dissolution of stones) reported. Pfister and Dretler also reported a considerably higher success rate in the management of renal and ureteral calculi with chemolytic drug irrigation through a percutaneous nephrostomy catheter [20]. Struvite, apatite, and carbonate stones were dissolved with an acidic solution (hemiacidrin, Suby solution G) and cystine stones were dissolved with an alkaline agent (Tham-E, acetylcysteine). A success rate of 85% in more than 150 stones cases was reported. This was particularly advantageous in medical conditions (cardiac, metabolic) where oral alkalinization with sodium bicarbonate or potassium citrate may be contraindicated. However, it took about 3–4 weeks of continuous irrigation to dissolve a stone. Chemolysis has since fallen out of favor due to the excellent outcomes from percutaneous nephrolithotomy.

Conclusion

The evolution of percutaneous renal access became the highway. The early innovations in minimally invasive urological surgery have evolved into what has today become the standard of care for many urological diseases. Those experiences propelled minimally invasive urology in great leaps and bounds. Not long after the early days of percutaneous renal surgery, in 1991 Ralph Clayman, one of the early pioneers, performed the first laparoscopic nephrectomy [21]. That endeavor has driven the evolution of urological surgery to a craft that is accomplished primarily through minimally invasive techniques.

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