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■ REVIEW ■

Nonvascular Interventions of the Urinary Tract

Nonvascular intervention of the urinary tract is a well-established uroradiologic subspecialty, which is more important for avoiding invasive open surgery in the age of rising demand about the value of less invasive treatment. Various kinds of nonvascular intervention are recently performed under image-guidance and are as follows: percutaneous nephrostomy, percutaneous nephrostolithotomy, percutaneous dilatation of the urinary tract, sclerotherapy for renal cysts, percutaneous catheter drainage, percutaneous foreign body retrieval and biopsy. Percutaneous nephrostomy is a basic technique to provide a direct access to urinary tract, which makes it possible to perform other interventional procedures. Although nonvascular intervention may produce some complications, it is generally considered to be less invasive than open surgery and has advantages such as short hospital stay, early return to normal life and therefore economic savings. This review is described to help clinicians easily understand the procedures, indications, techniques, and complications with figures of cases the authors experienced.

Key Words : *Nonvascular Intervention; Urinary Tract*

Byung Kwan Park, Seung Hyup Kim, Min Hoan Moon

The Department of Radiology, Seoul National University College of Medicine, Institute of Radiation Medicine, SNUMRC, Clinical Research Institute, Seoul National University Hospital, Seoul, Korea

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Address for correspondence
Seung Hyup Kim, M.D.
Department of Radiology, Seoul National University Hospital, 28 Yongon-dong, Chongno-gu, Seoul 110-744, Korea
Tel : +82-2-760-3259, Fax : +82-2-743-6385
E-mail : kimsh@radcom.snu.ac.kr

INTRODUCTION

Nonvascular intervention of the urinary tract, which usually needs percutaneous procedures under image-guidance, is a well-established uroradiologic subspecialty, getting the highest marks for avoiding invasive open surgery in the age of rising demand about the value of less invasive treatment. In addition, uroradiologic intervention brings short hospital stay and therefore economic savings with the same effectiveness as open surgery.

In this article, various kinds of procedures widely performed in the nonvascular intervention of genitourinary tract are described to help clinicians understand the procedures, indications, techniques, and complications with figures of the cases the authors experienced.

PERCUTANEOUS NEPHROSTOMY

Percutaneous nephrostomy (PCN) is a basic technique in uroradiologic intervention, providing a direct access to the urinary tract (1). Further interventional procedures of the urinary tract as well as urodynamic study (i.e. Whitaker test) are possible via the route established by PCN. PCN is usually performed to relieve urinary obstruction and thus is considered to be an effective treatment of urosepsis.

There is no absolute contraindication in PCN, except for a severe bleeding tendency, which may be corrected prior to the procedure (1, 2). The administration of antibiotics is needed in the presence of urinary infection before and after PCN. The use of sedatives and narcotic analgesics is effective but needs cautions particularly in uremic patients.

The imaging tools to guide the needle for puncture depend on equipment availability, patient body habitus, and the radiologist's personal preference (1, 2). After the initial puncture, fluoroscopy is most commonly used to keep monitoring the manipulation of guidewires and catheters. Various types and sizes of PCN catheters can be chosen according to the viscosity of the urine encountered and underlying abnormality of the urinary tract. Eight-to-ten pigtail-shaped French catheters of self-retaining type are usually used for simple external drainage. The basic techniques for PCN are described in Fig. 1.

The entry site of skin for PCN needs aseptic dressing every day since the tract can be a route to infection. The amount and color of drained urine should be frequently checked because they are important indicators of function of catheter. The catheter is periodically changed every two or three months after PCN (1, 2).

Major complications of PCN occurs in about 4% of patients and include septicemia, hemorrhage, pneumothorax/hemothorax, and bowel injury (1, 2). Gross hematuria commonly drains through catheter and usually disappears within two or three days. When the bleeding cannot be controlled by conservative management, renal angiography is indicated to identify any arterial trauma such as pseudoaneurysm or arteriovenous fistula, which should be treated with embolization (Fig. 2).

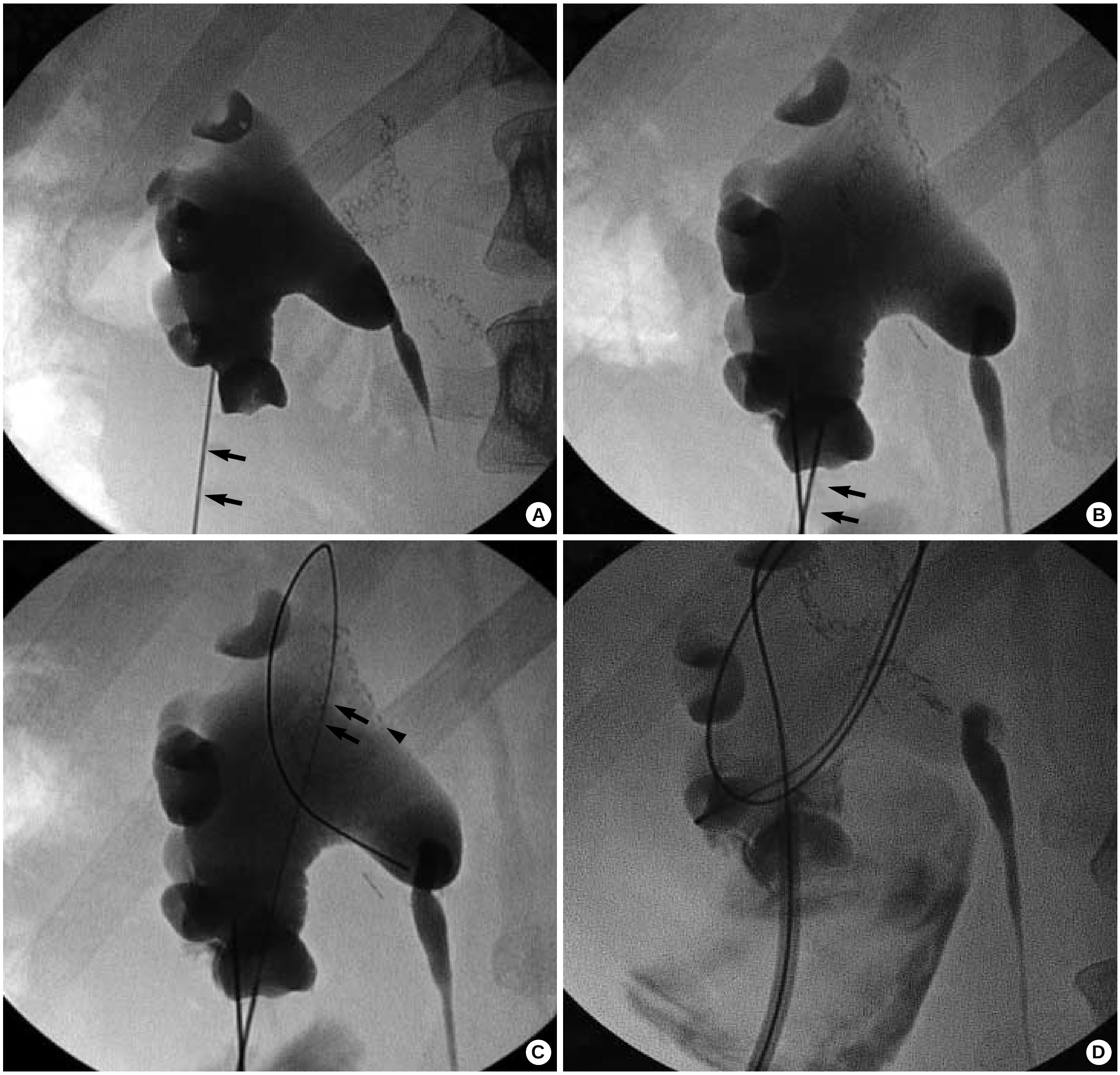


Fig. 1. Procedures and techniques of percutaneous nephrostomy. (A) A 22-gauge needle (arrows) is inserted into the left kidney under the guidance of ultrasonography. Puncture of the pelvocalyceal system is the most basic step prior to percutaneous urological interventions. Contrast material is infused to visualize left pelvocalyceal systems of the patient in prone position. The needle directly punctures the left pelvis. (B) Another needle (arrows) is inserted towards the lower polar calyx with posterior projection under fluoroscopic guidance. (C) A guidewire (arrows) is introduced into the left pelvis. (D) The tract is progressively dilated along the guidewire up to 10 F. *(Fig. I. continued next)*

PERCUTANEOUS NEPHROSTOLITHOTOMY

Percutaneous nephrostolithotomy (PNL) is one of the treatment options for renal calculi, which include open surgery, ureteroscopic removal, and extracorporeal shock wave lithotripsy (ESWL) (3-6). The introduction of PNL, ESWL, and ureteroscopy has almost replaced open stone surgery. The choice of treatment depends on the efficacy, cost, goals, and preference of the physician. ESWL, which is a noninvasive technique, serves as an effective monotherapy covering approximately 75% of patients with urinary stones. PNL is an ideal modality of treatment to remove complex stones such as staghorn calculi and calculi larger than 2 cm in diameter.

The indications of PNL are as follows: a large stone volume within the kidney, failure of previous ESWL, obstruction distal to a stone, large lower-pole calculi, stones in a horse-shoe kidney, pelvic kidney, transplanted kidney, stones in calyceal diverticula or hydrocalycosis, cystine stones, and infected

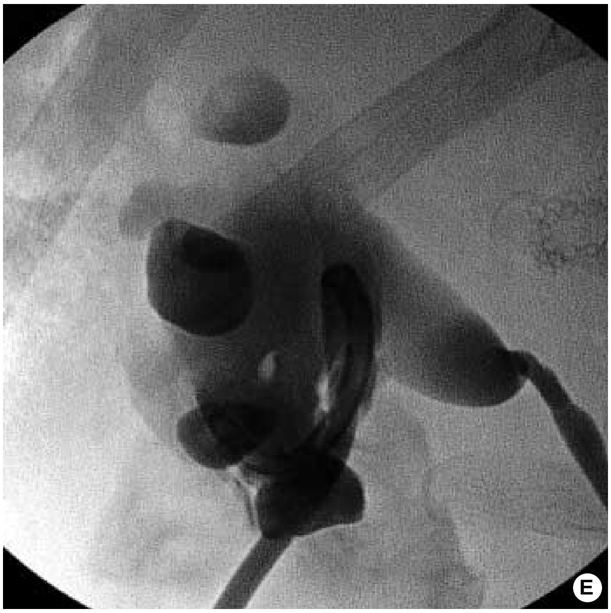


Fig. 1. *(Continued from the previous page)* (E) A 10 F pigtail catheter is placed in the renal pelvis. After retrieval of the guidewire, the nephrogram is obtained.

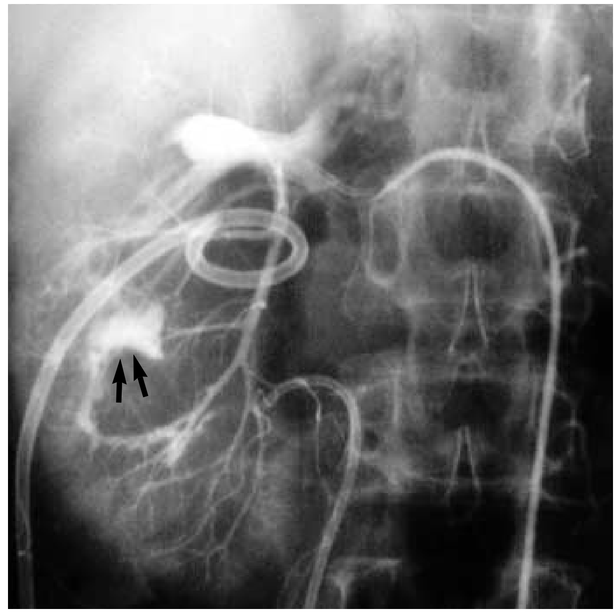


Fig. 2. Pseudoaneurysm developed after percutaneous nephrostomy (PCN). A large amount of hematuria poorly controlled by conservative management was drained through the catheter of PCN. On right renal arteriography, a large pseudoaneurysm (arrows) is seen near the entry site of the tube inserted into the kidney and needs embolization.

stones (3-5).

The puncture technique of PNL is nearly identical to that of PCN, but the entry site is different according to the shape and location of stone (Fig. 3). The process of PNL usually consists of four steps; 1) creation of a percutaneous tract (the most critical step), 2) tract dilatation up to 30-34 F for a nephroscope, 3) fragmentation and extraction of stone with ultrasonic lithotripsy, forceps, and baskets, and 4) placement of a nephrostomy tube (3, 4). The whole procedure can be performed in a single session at operating room using a C-arm fluoroscopy, but the authors prefer two sessions, that is, the access tract is created in the radiology department and the remaining procedures are done in the operating room on the next day.

Complications occur in about 20% of patients and include hemorrhage, pseudoaneurysm, arteriorvenous fistula, trauma of the urinary tract, injury to the adjacent organs, and sepsis (3-5).

PERCUTANEOUS DILATATION OF THE URINARY TRACT

Percutaneous dilatation of the urinary tract is most commonly performed in the ureter although it can be done through the entire urinary tract from the calyces to the urethra. Approach can be made either through percutaneous antegrade route or transurethral retrograde route, either under fluoroscopic guidance or using endourologic procedures (7).

Ureteral strictures result from various benign or malignant diseases. Benign strictures of ureter are as follows: obstruction of ureteropelvic junction, infections such as tuberculosis, anastomotic strictures following surgery, iatrogenic causes, and periureteral causes such as retroperitoneal fibrosis or endometriosis. Malignant ureteral strictures may develop in primary ureteral tumors or secondary to direct invasion or metastasis (8-12).

The average success rate is about 50% although the outcome of the percutaneous dilatation for benign ureteral strictures has been variably reported (8-14). Factors affecting the outcome include underlying causes, location, length, duration of strictures, and associated vascular compromise. The shorter the length and duration of structures, the better results of percutaneous dilatation are. Old, fibrotic strictures related with ischemia appear less responsive to dilatation: after radical hysterectomy and radiation therapy, strictures at ureteroenteric anastomosis, and transplantation ureteral strictures. Also, strictures in ureteral tuberculosis may be poorly responsive to balloon dilatation. However, our results of ureteral strictures to percutaneous dilatation and ureteral stenting are promising (7).

Like other procedures, percutaneous ureteral dilatation should begin with formation of PCN (9-14). Although the lower-polar calyx is usually favorable for external drainage, the interpolar calyx is more suitable for ureteral dilatation. A tip-curved catheter is advanced just above the stenotic area and then contrast material is injected for clear demonstration of the stenosis (Fig. 4). In patients with ureter anastomosed to an ileal or colonic conduit, ureter can be catheterized via

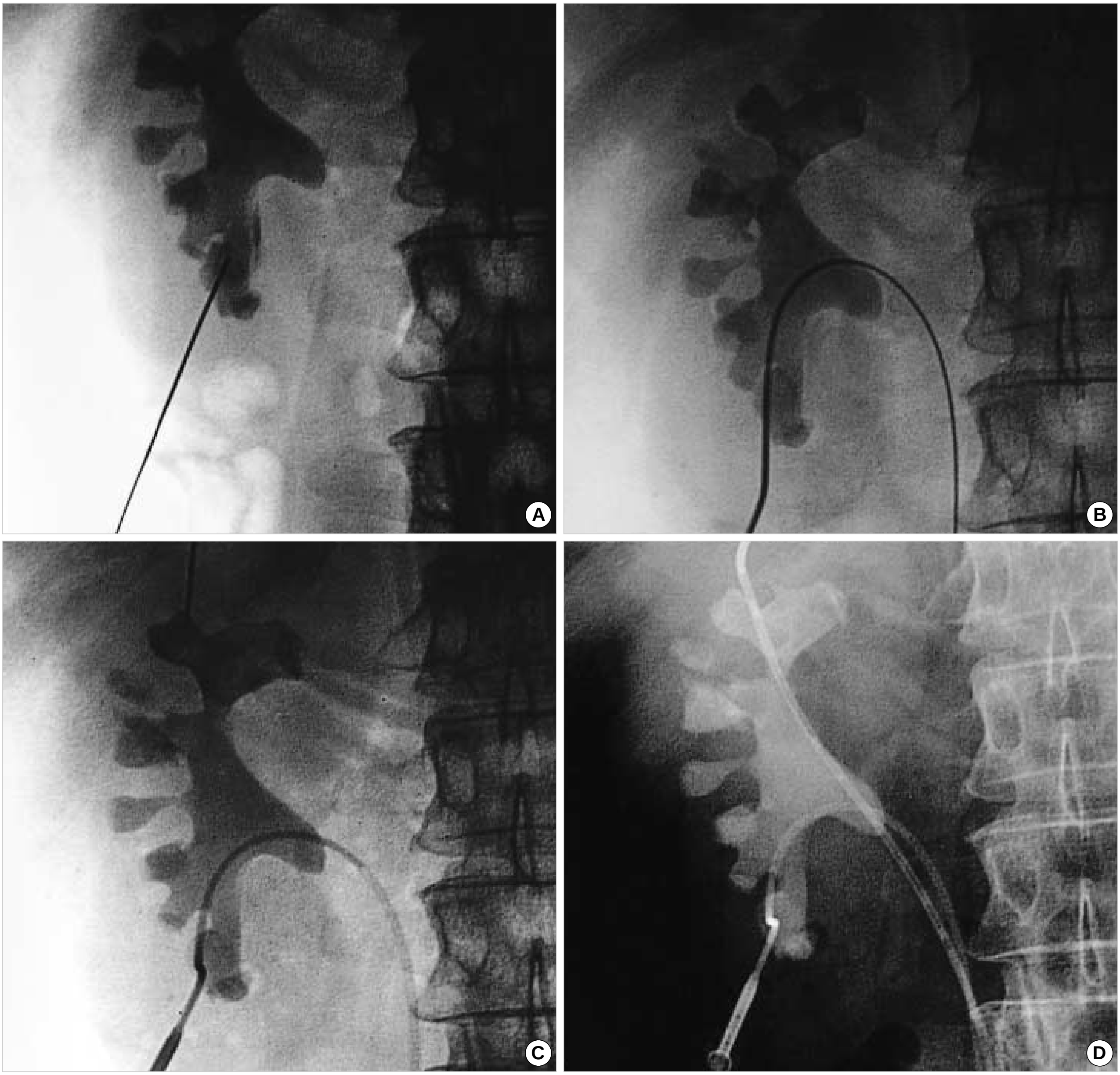


Fig. 3. The procedures of creation of a tract for percutaneous nephrostolithotomy in a 50-yr-old man with stag-horn stone. (A) The posterior calyx of the lower pole containing the stone is punctured with an 18-gauge needle. (B) A guidewire is introduced through the needle into the ureter and a sheath is inserted over the guidewire. (C) Another posterior calyx of the upper pole containing the stone is punctured with an 18-gauge needle. (D) Another sheath is placed over the guidewire. The procedures from A to D were performed at the radiology department. On the following day, the tracts were progressively dilated up to 30 F at operation room to accommodate nephroscope and ultrasonic lithotriptor.

retrograde approach to the conduit under fluoroscopic guidance (15). The stenotic lesion is negotiated with a proper set of a catheter and a guidewire carefully manipulated. Then the stenotic lesion is progressively dilated by advancing the catheter, uereteral dilator, or by inflating balloons of appropriate diameter and length. Balloon catheters with a diameter of 4-10 mm and a length of 3-4 cm are ususally used. After dilatation, a ureteral stent, either internal or internal-external, is placed for 3-8 weeks to prevent restenosis (16). Common problems of the placement of internal ureteral stent include poorly angled percutaneous tract, tortuously dilated ureters, tight obstructions, wedged stent, and improperly positioned proximal pigtail. They may be worked out with technical modifications such as interpolar calyceal access, urinary decompression prior to stenting, and the use of a peel-away sheath (17).

Follow-up imaging is necessary to evaluate the outcome of ureteral strictures by percutaneous dilatation. Although radio-

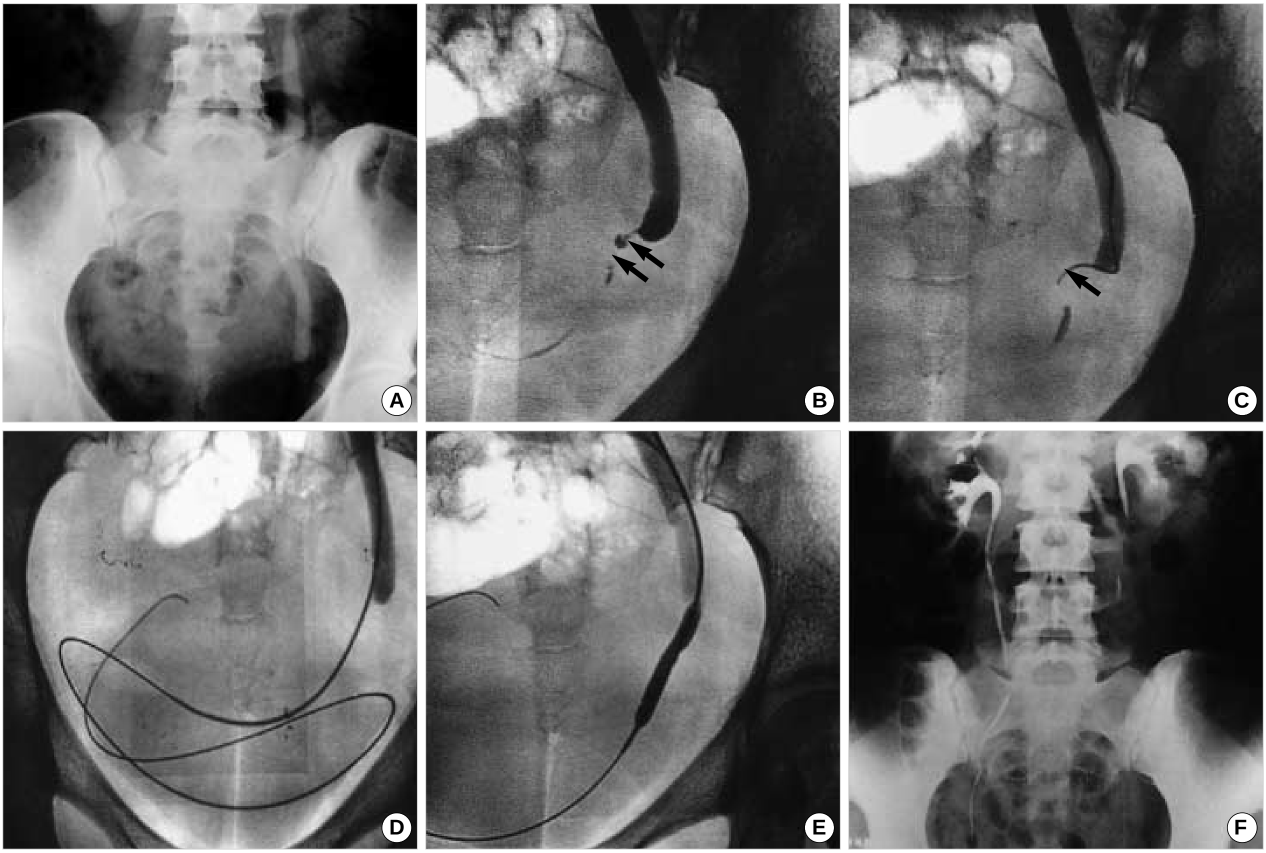


Fig. 4. A 31-yr-old woman with a history of ureteral injury during Caesarian section. (A) Left pelvocalyces and ureter are dilated above the level of stricture at the distal ureter on initial IVU. (B) Nephrostogram obtained following percutaneous nephrostomy reveals a short-segment stricture in left distal ureter (arrows). (C, D) A guidewire (arrow) was negotiated through the stricture and was passed to the urinary bladder. (E) Balloon dilatation was successfully performed on the short-segment stricture of the left distal ureter. (F) On follow-up IVU, left pelvocalyx and ureter appear normal.

nuclide scanning is considered to be the best imaging modality, intravenous urography (IVU) and ultrasound (US) are also excellent to detect the restenosis. The interval between follow-ups should be individually decided (7).

SCLEROTHERAPY FOR RENAL CYSTS

Benign renal cysts, which are mostly composed of cortical cysts, and parapelvic cysts in adults are so common that they are found in approximately 50% of all autopsy cases older than 50 yr. Renal cysts vary in size and frequently occur in multiple (18). They usually grow slowly on follow up. Tubular obstruction with ischemia has been postulated as the cause of a renal cyst (19).

Renal cysts are usually silent, but huge, infected or hemorrhagic cysts can be symptomatic. They can cause obstruction of the pelvocalyceal system, pressure atrophy of the adjacent parenchyma, and stone formation in obstructed calyces. Renin-dependent hypertension and erythropoietin-related polycythemia vera rarely occur in renal cysts (18, 19).

A symptomatic benign renal cyst is managed with a combination of percutaneous drainage and sclerotherapy (18). Simple aspiration increases their recurrences with rates of 30% to 80% probably due to rapid fluid turnover in the cyst (18, 19). Various sclerosing agents have been tried to reduce the recurrence following drainage by inducing sclerosis of epithelial lining of the cyst. Those sclerosing agents include hypertonic dextrose solution, hypertonic water-soluble contrast material, iophendylate (Pantopaque), quinacrine, bismuth phosphate, absolute alcohol, tetracycline, minocycline hydrochloride, and morrhuate sodium (18, 19). Recently, absolute alcohol is most commonly used due to its rapid and strong sclerosing activity (21).

The technique and the protocol for sclerotherapy of the renal cyst are variable but usually composed of three major steps (18, 19, 21): 1) puncture of the cyst under ultransonographic guidance, 2) insertion of a small pigtail catheter in the cyst, 3) repeated injection of sclerosing agents until there is no significant amount of fluid draining from the cyst (Fig. 5). Following aspiration of fluid through a 6-8F catheter, contrast material is injected to demonstrate the internal appearance of the cyst and to ensure no communication between the cyst cavity

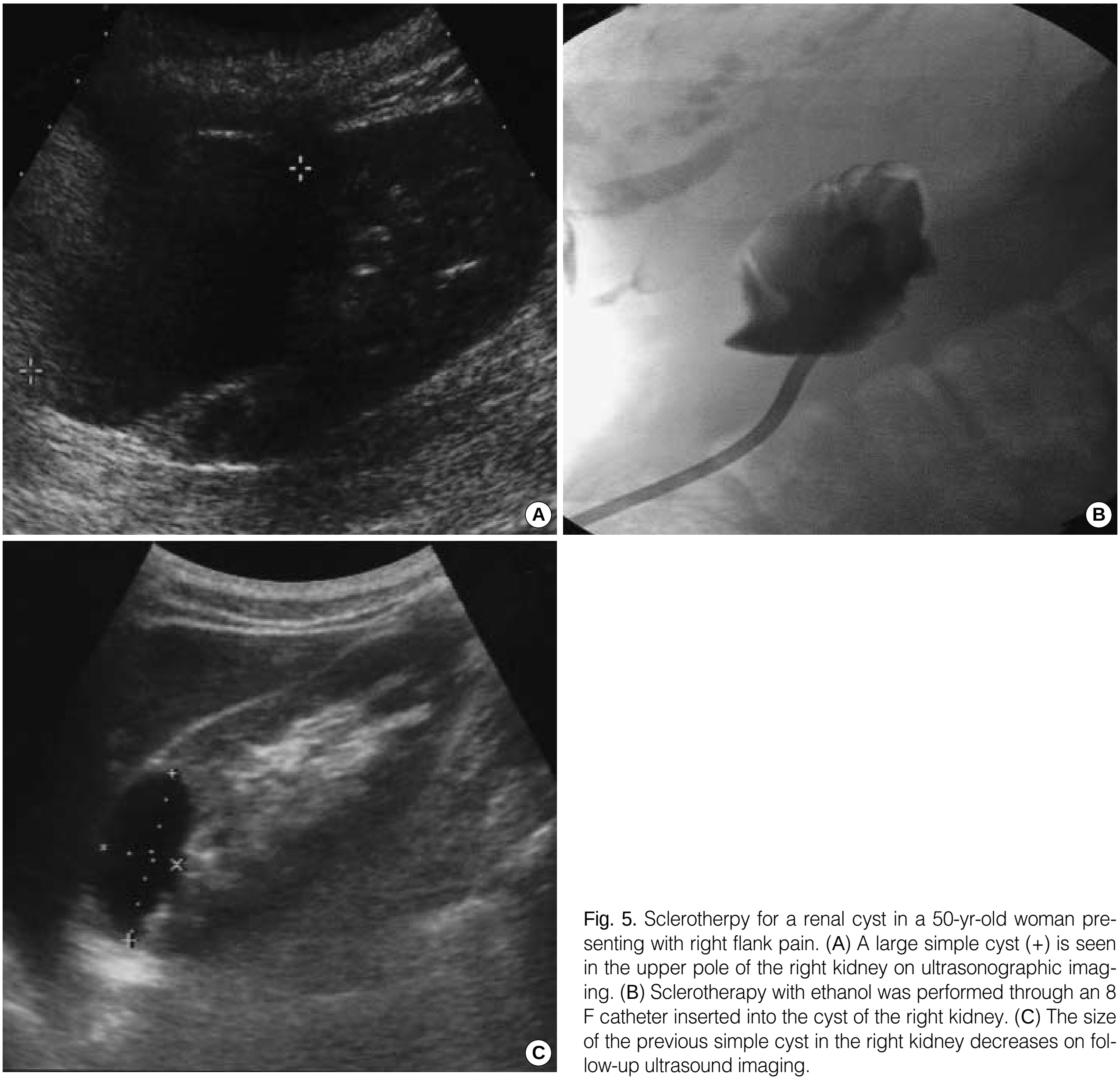
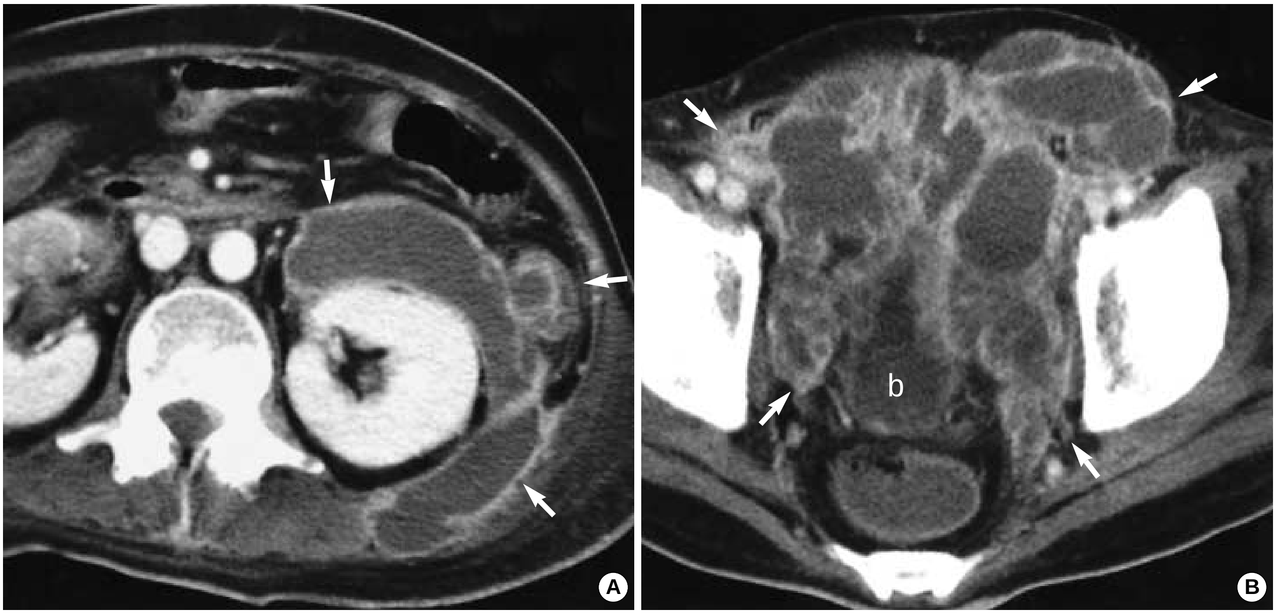


Fig. 5. Sclerotherpy for a renal cyst in a 50-yr-old woman presenting with right flank pain. (A) A large simple cyst (+) is seen in the upper pole of the right kidney on ultrasonographic imaging. (B) Sclerotherapy with ethanol was performed through an 8 F catheter inserted into the cyst of the right kidney. (C) The size of the previous simple cyst in the right kidney decreases on follow-up ultrasound imaging.

and the pelvocalyceal systems. Then the contrast material is removed as much as possible and 25-50% of the cyst volume is slowly replaced with absolute alcohol for 15 to 30 min. Postural change of the patient every five minutes promotes the sclerosis between surface of the inner wall and sclerosing agent. Overdistension of the cyst should be avoided since the sclerosing agent may spill and injure the surrounding tissue. The procedure should be repeated once or twice a day according to the amount of the fluid drained. When the amount of the fluid drains less than 5 mL, the catheter is removed. The cyst should be followed up with US or other imaging modalities. Two or more cysts can be treated simultaneously with above procedures.

If a cystic lesion communicates with the renal collecting system (e.g., calyceal diverticulum or hydrocalycosis), sclerosing agent should not be injected, since it may cause stricture of the collecting system (18, 19, 21). An infected cyst needs only percutaneous catheter drainage with antibiotic therapy, but without sclerotic therapy because infection has a very strong sclerosing effect. When the cyst content is hemorrhagic, sclerotherapy should not be conducted until hemorrhagic fluid becomes clear and malignant cells are not detected on cytologic examination.

The outcomes of sclerotherapy in renal cysts are generally excellent and have been reported with success rates of 75-100% following cyst drainage and sclerotherapy (18, 19, 21). Cysts that are not responsive to sclerotherapy can be marsupialized into the renal collecting system before surgical resection is



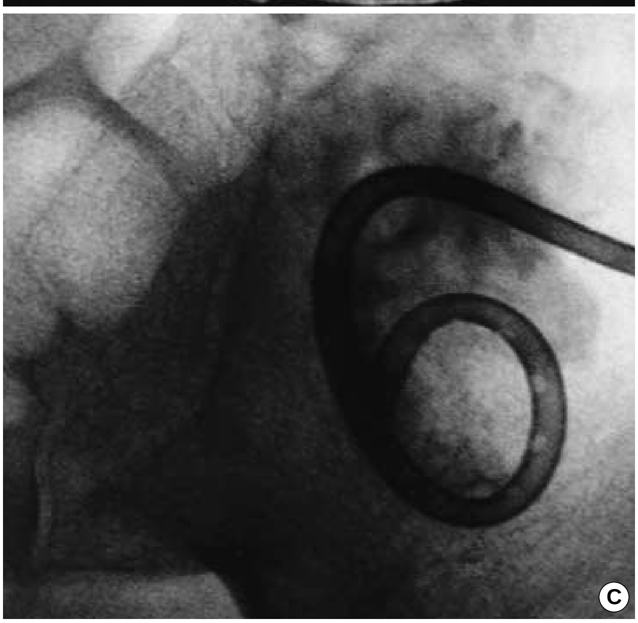


Fig. 6. Percutaneous catheter drainage for retroperitoneal abscess after surgery of colon cancer in a 32-yr-old man. (A, B) Note a large amount of fluid collection (arrows) in the anterior and posterior pararenal space of the left kidney and around the urinary bladder (b) with well-enhanced thick walls, suggestive of abscess. (C) The pig-tailed catheter is inserted into the perivesical space to drain the infected fluid. The techniques of percutaneous catheter drainage are composed of 3 steps: puncture of abscess, insertion of guidewire, and introduction of catheter.

considered.

Complications associated with the procedure include bleeding either intracystic or perirenal, arteriovenous fistula, pseudoaneurysm, and infection (18, 19, 21). The adverse effects of the sclerosing agents are systemic drug reaction and inflammation, fat necrosis, and retroperitoneal fibrosis caused by leakage of the sclerosing agents. However, most of these complications do not occur if the catheter tip is appropriately located and the cyst is not overdistended.

PERCUTANEOUS CATHETER DRAINAGE

Percutaneous catheter drainage (PCD) is an excellent radiourologic intervention to drain abdominal and pelvic fluid collections such as abscesses, hematomas, lymphoceles, and peritoneal pseudocysts (22, 23). Infected tumors also can be managed by PCD (24). Some pelvic fluid collections are approached via transvaginal, transrectal, transperineal, or transgluteal routes (25, 26). In cases of lymphocele and peritoneal pseudocysts, sclerotherapy is added to prevent recurrence (20). Absolute alcohol is most commonly used sclerotic agent but the povidone-iodine solution is also an effective one in lymphocele.

Basic techniques are similar to those of PCN and consist of puncture, guidewire insertion, tract dilation, and catheter placement (22-24) (Fig. 6). Puncture for transvaginal or transrectal PCD is guided by endoluminal US. Tract dilation via

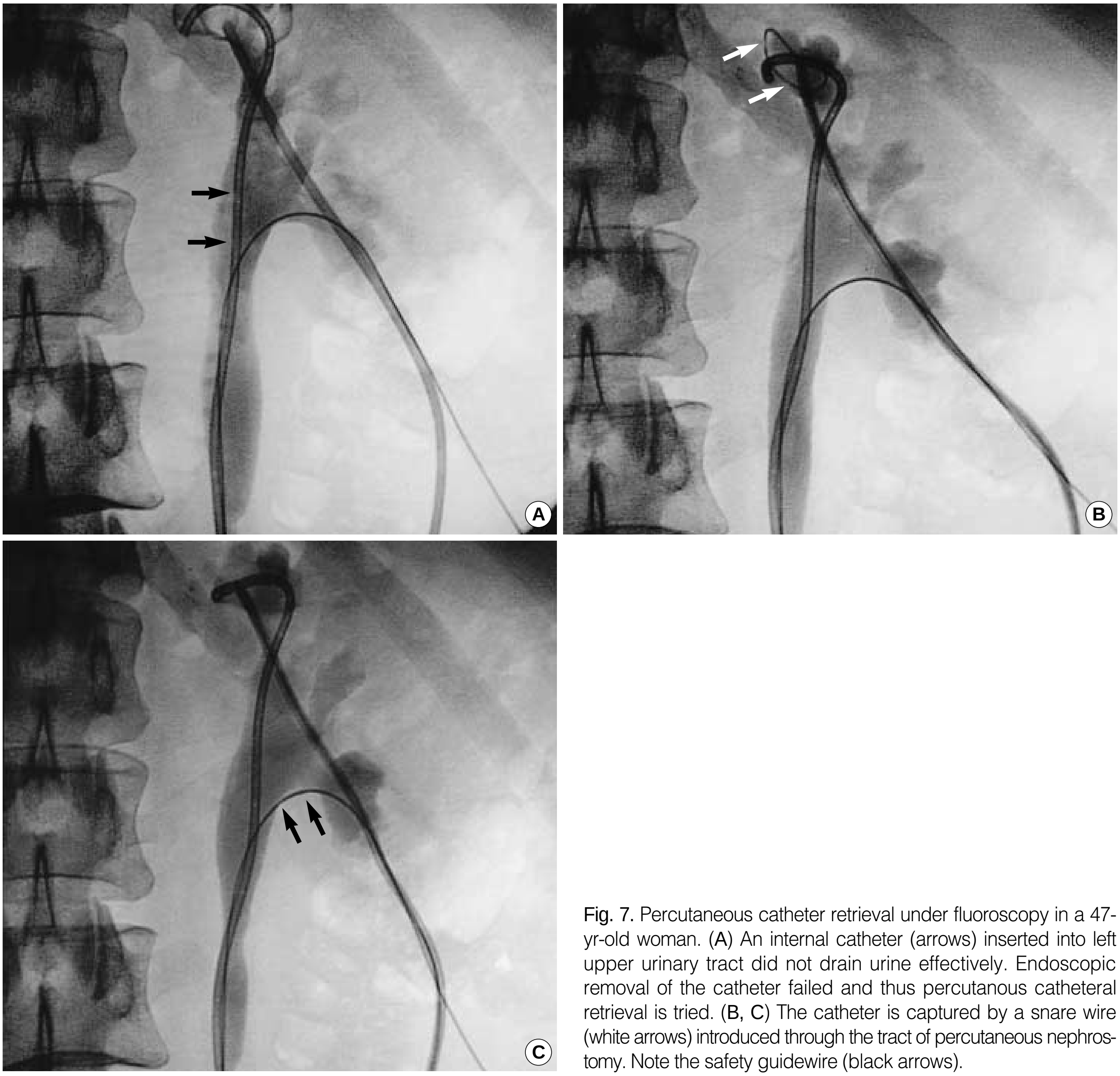


Fig. 7. Percutaneous catheter retrieval under fluoroscopy in a 47-yr-old woman. (A) An internal catheter (arrows) inserted into left upper urinary tract did not drain urine effectively. Endoscopic removal of the catheter failed and thus percutanous catheteral retrieval is tried. (B, C) The catheter is captured by a snare wire (white arrows) introduced through the tract of percutaneous nephrostomy. Note the safety guidewire (black arrows).

a transvaginal or transrectal route is sometimes difficult but can be accomplished with use of a stiff guidewire, rigid dilators, or the endoluminal US-guiding system. The size and type of the drainage catheter should be chosen appropriately according to the nature of the fluid to be drained.

PERCUTANEOUS FOREIGN BODY RETRIEVAL

Percutaneous retrieval of various foreign bodies in the urinary tract is possible under the fluoroscopic guidance without an aid of nephroscope. Malpositioned or fractured ureteral stent is the most common foreign body encountered in the urinary tract (Fig. 7). Stones and fungus ball can also retrieved percutaneously. Various devices and techniques such as loop snares, baskets, and forceps have been developed for the retrieval of foreign bodies of the urinary tract (27-32).

BIOPSIES

Percutanous biopsies of genitourinary tumors can be performed under fluoroscopic or ultrasonographic guidance. Various kinds of needles and guns have been developed for the biopsy. Core biopsy with a gun is more common than fine needle aspiration in the genitourinary tract. A gun with a needle of 16-18 gauge is used for renal biopsy to make diagnosis of renal parenchymal disease (Fig. 8). In case of renal biopsy, atten-

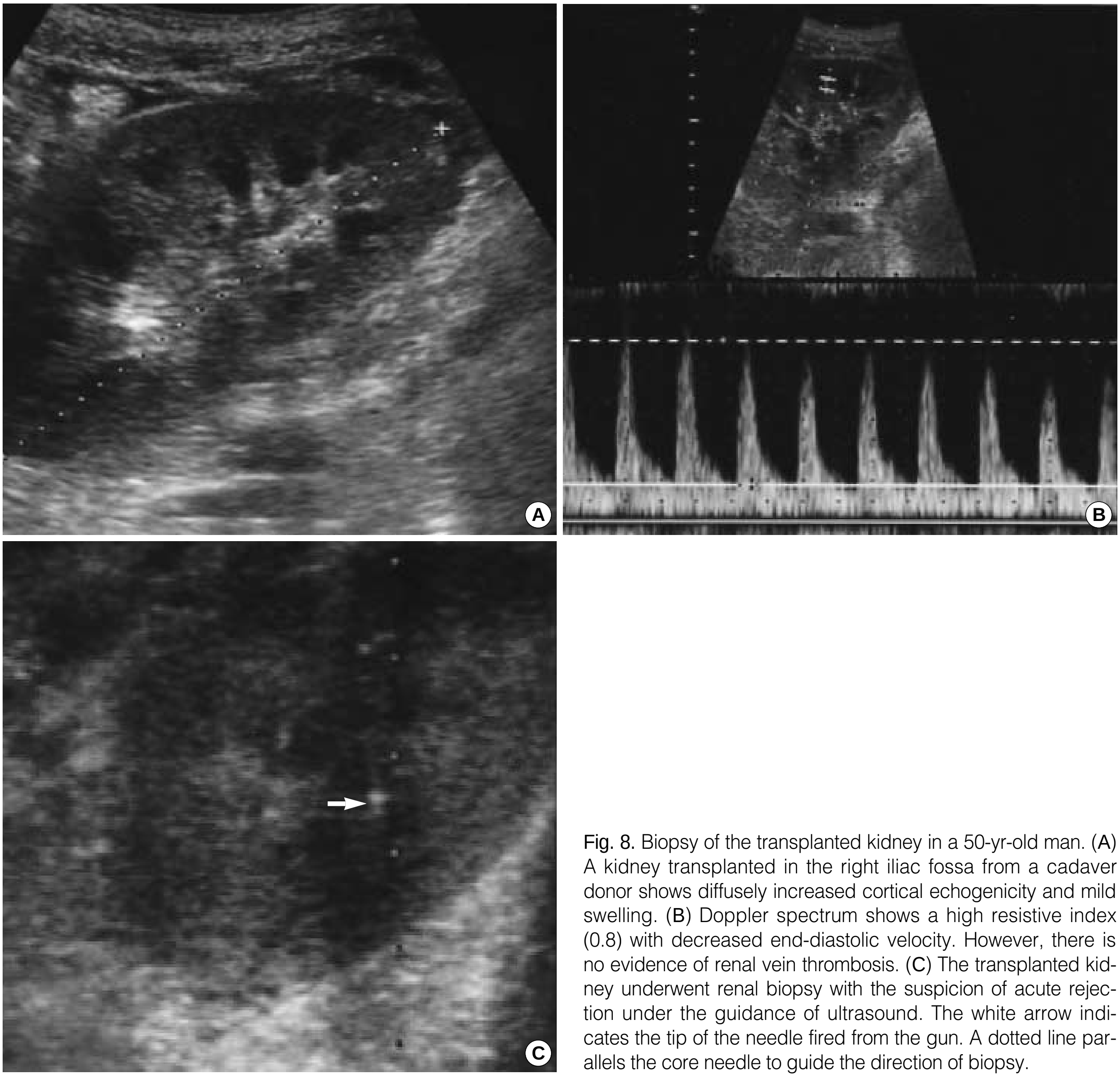


Fig. 8. Biopsy of the transplanted kidney in a 50-yr-old man. (A) A kidney transplanted in the right iliac fossa from a cadaver donor shows diffusely increased cortical echogenicity and mild swelling. (B) Doppler spectrum shows a high resistive index (0.8) with decreased end-diastolic velocity. However, there is no evidence of renal vein thrombosis. (C) The transplanted kidney underwent renal biopsy with the suspicion of acute rejection under the guidance of ultrasound. The white arrow indicates the tip of the needle fired from the gun. A dotted line parallels the core needle to guide the direction of biopsy.

tion should be paid to prevent the fired needle from traversing the central renal area since the risk of injury to large vessels increases.

Transabdominal or endoluminal US can guide the biopsy of pelvic lesions such as prostate, seminal tract, and gynecologic lesions. Fluoroscopy-guided retrograde brush biopsy was designed for patients suspected of transitional cell carcinoma in the upper urinary tract but is not widely used since ureteroscopic biopsy with improved devices is more popular (33).

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