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TECHNICAL NOTE

An improved technique for ultrasound guided percutaneous renal biopsy

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Percutaneous renal biopsy has become one of the fundamental diagnostic techniques in nephrology since its introduction in 1951 [1]. Biopsy device and guidance methods have been refined progressively during the past two decades [2] with the use of surface anatomic landmarks for guidance superseded by radiographic, computed tomographic, or ultrasonic imaging methods [3–8]. We report the application of an orthogonal ultrasonic guidance technique for renal biopsy in which the needle is visualized continuously throughout its placement. This method was initially developed for intrauterine fetal transfusion [9], and its use has been reported for transuterine fetal procedures [10, 11] and amniocentesis [12].

Methods. The patient is placed in a prone position (with the optional interposition of a bolster). Both kidneys are surveyed ultrasonically from the back and sides with a sector scanning device during varying inspiratory efforts. Unless clinical conditions specifically dictate selection of one of the kidneys, we choose that kidney for which *(1)* the lower pole descends below the last rib, and, *(2)* the lower pole is visualized satisfactorily with the ultrasonic probe positioned laterally along posterior or mid-axillary line. The probe is returned to the back and centered over the lower pole, then rotated from sagittal to transverse viewing planes and repositioned as needed, until the central ray of the image passes through the proposed biopsy site. This is usually a location lateral to the collecting system below the last or between the two lower most pyramids (Fig. 1). The operator attempts to select a path which is aligned perpendicular to the floor when kidney descent is adequate. The location of the center of the probe surface is marked on the skin with a 2-mm weal made with a ballpoint pen, tip retracted.

The skin surface is prepared, draped, and locally anesthetized. A small incision is made through the weal to facilitate passage of the biopsy needle, (Tru-Cut, disposable biopsy needle, 15.2-cm cannula, 20-mm specimen notch, Travenol Laboratories, Deerfield, Illinois, USA). The needle is aligned visually along the path selected during the viewing phase. Needle passage is monitored by continuous ultrasound imaging from the lateral viewing portal with the scan plane aligned parallel to the needle (Fig. 2). The needle tip position is defined by a small side lobe flare and reconfirmed as the most distal reflector as the scan plane is swept through the biopsy region. In this position the kidney is seen in transverse section and the needle barrel and tip are seen entering the image field from the 10 o'clock position (Fig. 3). The needle is advanced to the renal capsule during suspended inspiration and then further advanced slightly to pierce the capsule. The needle can be redirected if alignment with the kidney is not satisfactory in the ultrasound image, namely, deflection toward or away from the image apex within the scan plane or cephalad or caudad after changing scan plane attitude (Fig. 2). After the needle is positioned perpendicular to the renal margin and seated in the capsule, the biopsy specimen is obtained in the conventional way. Needle entry into the renal parenchyma is visualized. Freeze-frame images obtained prior to advancing the cutting sheath can show the exact position of the gap between blades (Fig. 4). Continued imaging during the biopsy will indicate if the entire needle is displaced when the cutting sheath is advanced.

Results. The biopsy method detailed herein was attempted in 31 consecutive biopsies. Serum creatinine in patients ranged from 0.7 to 5.0 mg/dl, with 11 patients having a serum creatinine greater than 2.0 mg/dl. In each patient the kidneys were visualized ultrasonically and lateral viewing portals for biopsy guidance were found. In general, the entire procedure could be performed within 15 to 20 min. Diagnostically satisfactory material was obtained from 29 patients. In one patient the biopsy needle could not be visualized and renal tissue was obtained utilizing ultrasound localization of the kidney and blind biopsy. No renal tissue was obtained from one patient despite satisfactory visualization because of extreme mobility of the kidney which was displaced rather than entered by the biopsy needle. There was a single patient who had significant perinephric bleeding which required blood transfusion and one patient who had a unilateral ureteral obstruction secondary to a blood clot.

There were an additional 12 patients with renal allografts having 21 separate biopsy procedures. The technique was similar but an attempt was made to retrieve a long sample of cortex, specifically, by selecting a needle entry path along or oblique, rather than perpendicular to, the long axis of the kidney. This approach is possible because of the anterior, subcutaneous position of the transplant kidney. Material satisfactory for pathologic diagnosis was obtained from each of

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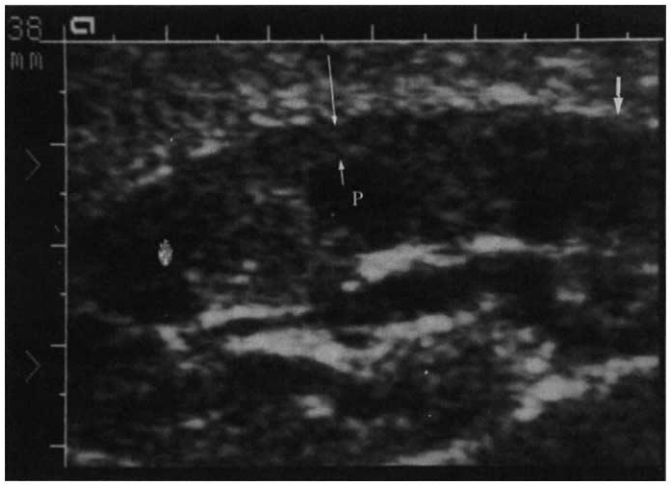

Fig. 1. *Magnification pre-biopsy ultrasound image of renal parenchyma. Arrows* demarcate a 4.8 mm cortical thickness above the central pyramid (**P**). The biopsy site is marked by a *large arrow*. Large divisions on the scale are 10 mm.

these patients. There was one instance of transient hematuria and one patient had significant hematuria which was managed conservatively with spontaneous lysis of clot in the collecting system and bladder. Most of these patients were studied because of a clinical suspicion of acute rejection.

Discussion. The guidance method described is a general one applicable for many portions of the body. It has particular advantages for renal biopsy. As with other ultrasound techniques kidney visualization is anatomic and does not depend on renal function. There is no need for parenteral contrast agents, and both patient and staff are spared radiation exposure. The particular advantages of this method are that the guidance device is removed from the biopsy field, decreasing the chance for infection and avoiding impediments for the operator. It also provides extended options for needle redirection after skin entry, with three degrees of freedom, which compensates for variations in respiratory effort or incorrect initial needle placement. Needle visualization is continuous, therefore eliminating the standard approach of introducing a smaller bore, sharp needle to the anticipated depth of the kidney and determining capsular depth by needle deflection during deep breathing. The speed of the procedure is increased and we believe the possibility of capsular laceration is reduced by lessening pre-biopsy manipulation.

The original and technically simplest form of ultrasonic guidance for renal biopsy is external demarcation of the kidney position and blind biopsy along a predetermined path during held respiration [5–7]. This was improved with continuous two-dimensional renal imaging with slotted transducers or mechanical guides attached to the transducer housing [13]. The disadvantages of this approach include difficulty in achieving optimal renal scanning and needle tip visualization simultaneously and the restriction to respiratory effort alone for repositioning. Only a portion of the needle is seen with that method, and the transducer must either be sterilized or wrapped with a sterile plastic and bonded to the skin of the biopsy field with a lubricant.

The guidance technique described herein is an extension of

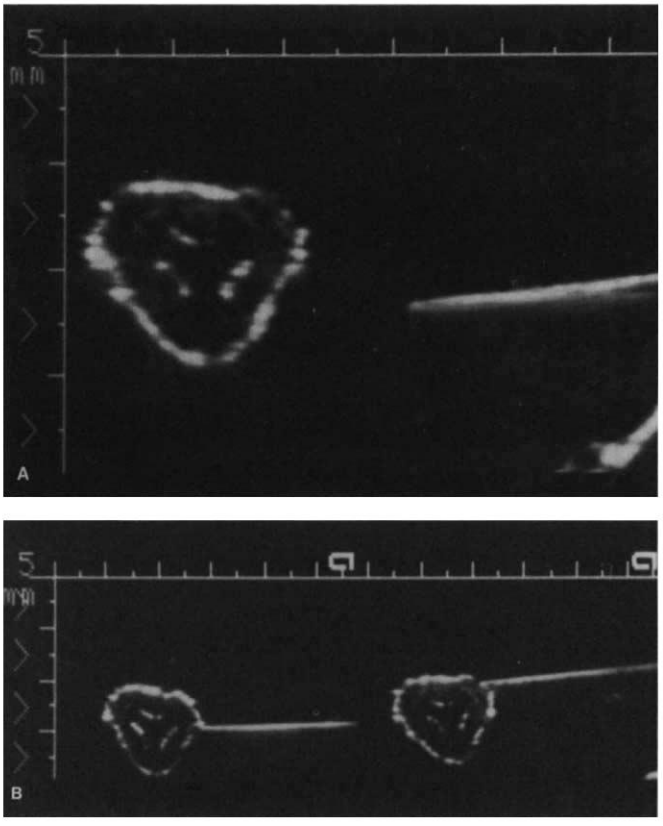

Fig. 2. *Orthogonal viewing of the phantom target (sweet gherkin, 16 mm diameter, in water) and the biopsy needle (#22 spinal) entering from 3 o'clock position.* **B** *Split screen magnification views of repositioning of the needle at the pickle surface.*

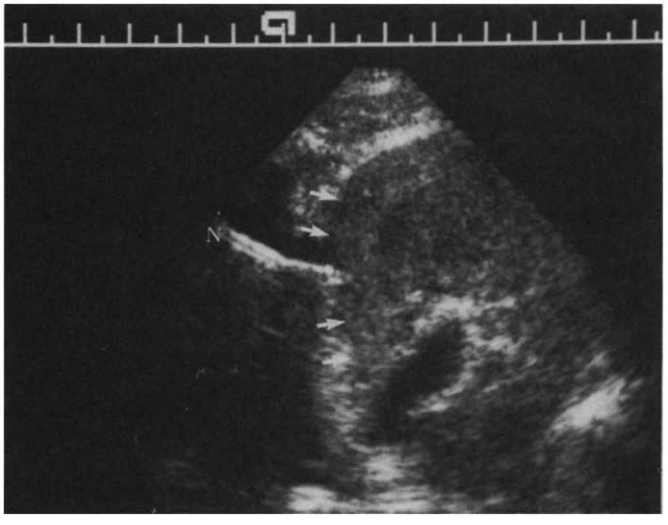

Fig. 3. *The biopsy needle* (**N**) *enters from the 10 o'clock position and contacts the renal capsule at right angles.* The needle position is slightly more medial and can be readjusted before tissue sampling. The border of kidney is indicated by *arrows*. Large divisions on the scale are 10 mm.

mechanical guide methods which permits the operator maximal freedom for needle redirection without compromising visualization of needle or target. An additional feature is that with

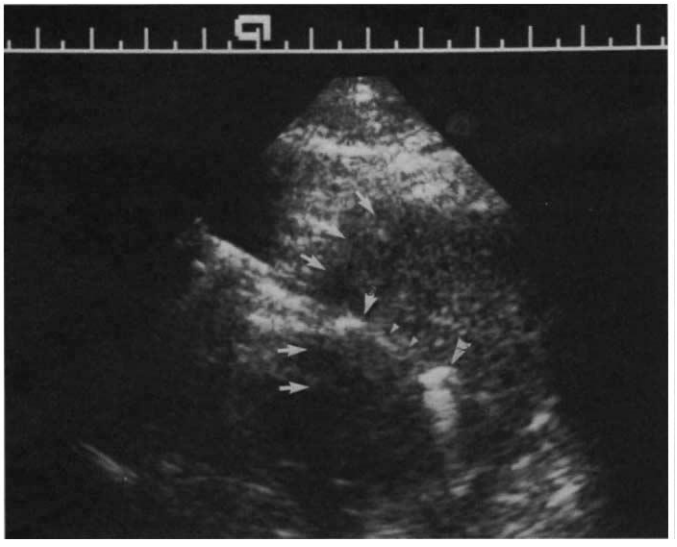

Fig. 4. *One thirtieth second stop-action view during tissue sampling of the thin biopsy portion of the needle* (small arrow) *between the more reflective thicker end and barrel portions* (large arrows). The border of the kidney is indicated by *arrows*. Large divisions on the scale are 10 mm.

sonification angles greater than 50° and appropriate instrumentation there is no apparent limit to the caliber of a metallic needle which can be visualized in a soft tissue field. We have not experienced difficulties in imaging 22-gauge needles during aspiration of renal cysts or percutaneous biopsy of suspected renal neoplasm and have visualized 25-gauge needles in "phantom" target practice.

Although our examinations were performed within the Radiology Department, newer ultrasound equipment is mobile and does not require room shielding or have unusual electrical current requirements, so that biopsy guidance can potentially be performed at the bedside. The use of sector scanning is emphasized because of the large field of view obtained from a small skin contact point. Our preference is for electronic sector scanning equipment, although prior to these patients we have used more widely available mechanical sector scanning instruments with comparable results.

We have found the technique to work well under a variety of clinical conditions (that is, renal size, patient size, underlying disease). In most circumstances if primary ultrasonic visualization is not possible, it is usually with a very small fibrotic kidney for which other percutaneous localization procedures are also not likely to be successful. Although the number of patients we report is small, our complication rate and success rate in obtaining adequate renal tissue for diagnosis are at least comparable to that reported with other techniques [5–7, 14–16], and we anticipate further improvement as ultrasonic image quality continues to improve. However, the method does require training in ultrasonic imaging and three dimensional biopsy localization and is applied most expeditiously as a collaboration between a nephrologist and an ultrasonologist.

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