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# Free-Hand Ultrasound-Guided Renal Biopsy: Report of 650 Consecutive Cases

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**Key Words**
Renal biopsy
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**Abstract**
In the past 4 years we have carried out 650 percutaneous renal biopsies (PRB), 54 on transplanted and 596 on native kidneys. PRB was performed with a 14-gauge one-piece disposable needle that was introduced free-handedly into the lumbar wall without any form of fixed guidance or support. Ultrasound was used to locate the kidney pole and to follow the progression of the needle tip in the renal parenchyma. The time needed for the whole procedure was about 5 min. The tissue specimen was adequate for histological evaluation in 98.8% of the cases. The prevalence of post-biospy complications (haematuria, pain, anaemia) was 2.5%. Haematuria was not a common complication (1.6%) in our series, whereas clinically silent perirenal haematoma was common. Mild perirenal bleeding (volume $<5$ ml) was found in 40 of a series of 150 patients (26.6%) who underwent ultrasound scan 24 h after the PRB. Haematoma exceeding 100 ml was revealed with US in only 0.6% of the patients. We conclude that free-hand ultrasound-guided PRB makes this technique easier, highly successful, time-saving and almost free of severe side effects.

## Introduction

In the sixties and seventies, percutaneous renal biopsy (PRB) was performed using the Franklin-modified Vim-Silverman needle. The lower pole of the left kidney was located with thin exploring needles, or by means of intravenous pyelography or fluoroscopy [1, 2]. This method was time-consuming, often unsuccessful and badly tolerated.

In the eighties, the disposable needles progressively replaced the previous ones, and the sonographic guidance replaced radiological guidance systems [3]. Sonography has been used in different ways in renal biopsy procedures.

Most commonly it was (and is) used to locate the kidney pole and to mark on the skin the point where the needle would be introduced, while the biopsy itself was carried out blindly [4–8]. Sonography was (and is) currently used, (a) to guide the needle into the kidney pole [9–12]; (b) for biopsy with fixed guides and (c) for biopsy with semiautomatic needles [13].

In our Institute, the ultrasound-guided PRB has been performed since 1987. The technique adopted was developed from that of fine-needle biopsy [14, 15]. In this method, the biopsy needle is introduced free-handedly and its progression is shown by continuous ultrasound guidance with posterior transversal and sagittal viewing planes. This paper describes the technique adopted and the clinical complications experienced in 650 cases. 150 of these underwent sonography 24 h after biopsy to reveal the possible presence of haematoma.

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## Patients and Methods

*Patients*

In the past 4 years, 650 ultrasound-guided PRB, have been carried out in our unit, 54 on transplanted kidneys. The biopsy was performed either by an ultrasound-skilled nephrologist or by a nephrologist together with an ultrasound-skilled physician. 14-Gauge × 115/150 mm disposable needles were used, namely the TRU-CUT (Travenol Laboratories, Deerfield, Ill., USA) or URO-CUT (TSK Laboratory, Japan) type. The biopsy was preferentially made on the lower pole of the left kidney. In 27 patients we had to operate on the lower pole of the right kidney because of abnormalities in the left kidney (ectopy, cysts or reduced volume).

The patients, 372 females and 278 males, ranged in age from 11 to 88 years. Serum creatinine ranged from 0.8 to 11.3 mg/dl, and it was higher than 2.0 mg/dl in 356 out of the 650 patients (table 1). Bleeding time, prothrombin time, platelet count were within the normal range in all the patients.

Every patient underwent abdominal ultrasonography before the biopsy procedure. Absolute contraindications to perform the kidney biopsy included: single kidney, staghorn calculi, polycystic kidney disease, multicystic kidney, malignancy, obstructive uropathy, severe vascular damage of the kidney, severe aortic atheromasia or aneurysm, reduction of the kidney size (l.d. < 90 mm) or parenchymal thickness (< 12 mm). As relative contraindications we considered: malformations (double pelvis, renal vein abnormalities), ptosis, splenomegaly.

*Method*

PRB is carried out on native kidney with the patient in the prone position. A hard pillow is placed under the abdomen to reduce both the respiratory movements of the kidney and the lumbar lordosis and to put the kidney in a horizontal position. The ultrasound probe used during the biopsy procedure (a 3.75-MHz convex probe or a 3.5-MHz linear probe) is put into a cellophane bag sterilized with ethylene oxide. Full contact between the probe and the skin is obtained using gel or sterile vaseline oil.

The nearest and most perpendicular entrance point of the needle to the kidney pole is determined by sagittal and transversal lumbar ultrasound scanning (fig. 1a, b). The mark is placed on the skin simply with a ball-point pen. We try to avoid inserting the biopsy needle into the paravertebral muscles, particularly in young or muscular patients. Muscle thickness is an obstacle both to the correct positioning of the needle during its progression and to its proper sliding.

The point of least resistance in the lumbar region is the insertion of the obliqui and transversus muscles. The lack of a muscular layer allows the needle to be introduced through the lumbar wall without diversion or resistance (fig. 2). Once the entry point is located, the skin is disinfected thoroughly and then anaesthesia of cutaneous and muscular layers is carried out with an injection of 10 ml of mepivacaine HCl (2%). A few minutes later, the cutaneous layer is cut with a scalpel and the needle is gradually introduced into the lumbar wall. Continuous ultrasound guidance with sagittal and transversal viewing planes is used to follow the needle tip on its progression, according to the fine-needle biopsy technique (fig. 3, 4).

When the needle tip reaches the kidney capsule, the patient is invited to breathe out and to stop breathing. In this phase, the biopsy needle is advanced into the cortex of the lateral-posterior region of the kidney pole in order to avoid damage to the smaller calices of the lower group whose lesion is the cause of haematuria (fig. 4). If the needle-tip is not easily visible, the patient is invited to inhale and exhale once or

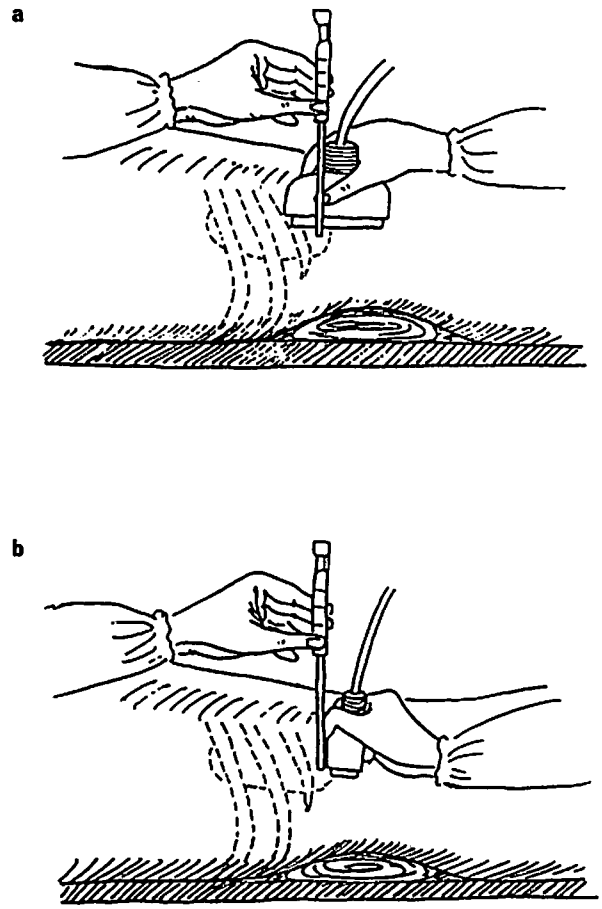



**Fig. 1. a, b.** Scheme of ultrasound guided PRB on native kidney. The needle was introduced free-handedly into lumbar wall. Transversal and longitudinal ultrasound scans were used to locate and follow the needle-tip towards the lower kidney pole.

**Table 1.** Percutaneous renal biopsy on native kidney: indications in the 596 patients

| Diagnosis | Patients | |
|---|---|---|
| | n | % |
| Acute renal failure | 18 | 3.0 |
| Nephrotic syndrome | 183 | 30.7 |
| Proteinuria <3 g/day | 105 | 17.6 |
| Hematuria with or without proteinuria | 137 | 22.9 |
| Systemic diseases | 86 | 14.4 |
| Acute glomerulonephritis | 34 | 5.7 |
| Chronic glomerulonephritis | 19 | 3.2 |
| Others | 14 | 2.3 |

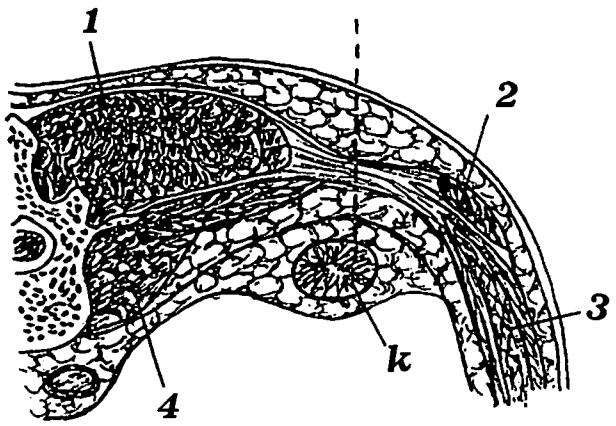
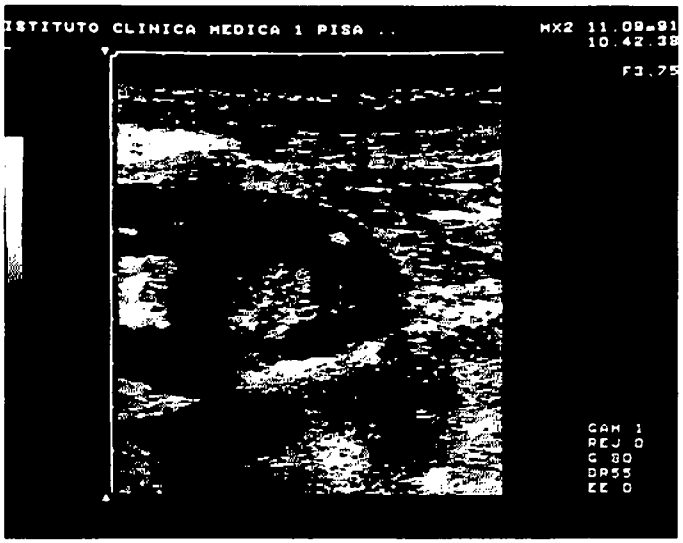
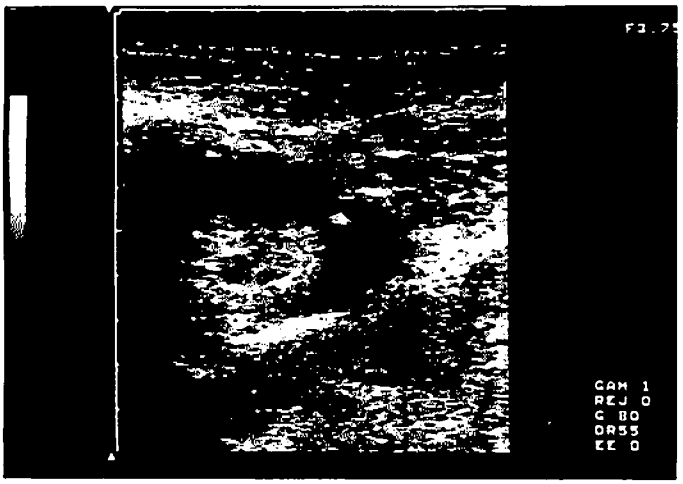



**Fig. 2.** Schematic section of the posterior wall of the lumbar compartment. 1 = m. sacrospinalis; 2 = m. latissimus dorsi; 3 = m. obliquus; m. transversus; 4 = m. psoas major; k = lower pole of left kidney; dotted line = needle's path.

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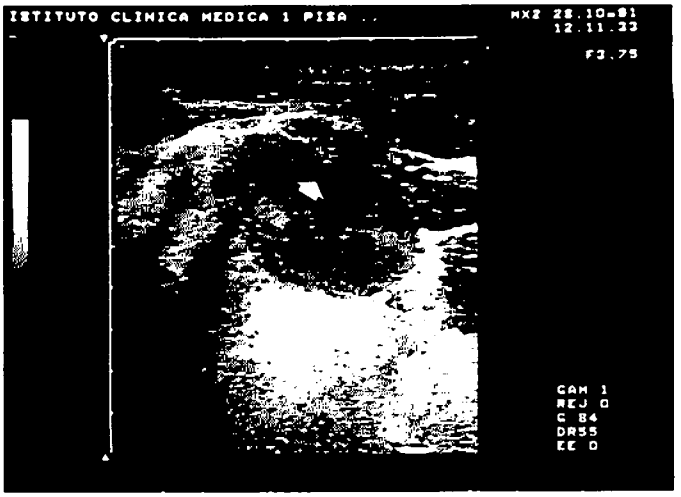



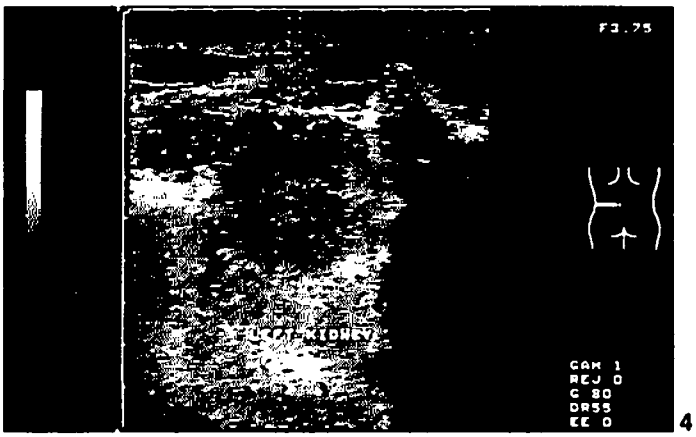


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**Fig. 4.** Posterior transversal scan. Lower pole of left kidney. The dotted lines indicate the needle's path; the arrows indicate the 'spot' of the tru-cut needle tip in the renal cortex. The muscles of the paravertebral compartment and those of posterolateral wall are clearly visible.

**Fig. 3.** Posterior longitudinal ultrasound scan. Needle-tip progression (echogenic spot: arrows) towards the posterior lumbar wall.

**Table 2.** Number of passes and samples in 596 percutaneous renal biopsies on native kidneys

| | Passes | Samples | n | % |
|---|---|---|---|---|
| No adequacy of sample (< 3 glomeruli) | 4 | 0 – 1 | 7 | 1.2 |
| Adequacy of sample (> 5 glomeruli) | 2* | 1 | 14 | 2.3 |
| | 1 | 1 | 446 | 74.8 |
| | 2 | 2 | 80 | 13.4 |
| | 2 | 1 | 34 | 5.7 |
| | 3–4 | 1–2 | 15 | 2.6 |

* PRB was repeated because of the presence of medullar tissue in the first sample.

**Table 3.** Post-biopsy clinical complication in the 596 patients who underwent Percutaneous Renal Biopsy of the native kidney

| | Number | % |
|---|---|---|
| Gross haematuria lasting <24 h | 6 | 1.0 |
| Gross haematuria lasting 15 days | 1 | 0.1 |
| Renal colic pain | 3 | 0.5 |
| Para perirenal haematoma associated with haematocrit fall | 3 | 0.5 |
| Anaemia without haematoma | 1 | 0.1 |
| Transient reduction of renal function | 1 | 0.1 |

**Table 4.** Perirenal post-bioptic bleeding: results from ultrasound scanning performed 24 h after biopsy in 150 patients

| | Number | % |
|---|---|---|
| Unquantifiable effusion | 21 | 14.0 |
| Blood spilling (<5 ml) | 19 | 12.6 |
| Haematoma (>100 ml) | 1 | 0.6 |
| Total | 41 | 27.3 |

The volume was determined by the means of the elipsoid formula: $^4/_3\pi \times {}^1/_2A \times {}^1/_2B \times {}^1/_2C$.

twice: the simultaneous movement of the needle during breathing indicates its right position in the kidney pole. Then a kidney biopsy is obtained by rapidly and firmly sliding the cannula over the stylet. Occasionally, for example in obese patients or in patients with floating kidney, PRB is carried out after the patient has been invited to breathe in deeply and hold his breath.

The biopsy procedure on a transplanted kidney is easier. It is performed on the upper pole [16], with the patient in the supine position that makes it easier to reach the part with the biopsy needle and makes it less likely to damage the iliac vessels and the vascular anastomosis.

All biopsied patients undergo a sonography scan 5 min after the end of the procedure. Then bed rest in the supine position is recommended for 24 h. Kidney tissue samples are regarded as useful if the number of glomeruli is higher than 5 in the specimen. The number of attempted biopsies is usually recorded.

Out of the 650 patients, a series of 150 consecutive patients underwent sonography 24 h after the biopsy, in order to evaluate the prevalence of subclinical perirenal haematoma. The volume of the haematoma was calculated using the ellipsoid formula: $^4/_3\pi \times {}^1/_2A \times {}^1/_2B \times {}^1/_2C$).

## Results

The biopsy procedure on *native kidney* was successful (more than 5 glomeruli per biospy specimen) in 98.8% cases: the average number of glomeruli per specimen was 14.6. The procedure was unsuccessful in 7 cases, in spite of 4 attempts per patient (absence of glomeruli in 3 cases and presence of 3 glomeruli in 4 cases). The tissue specimen was obtained at the first attempt in 489 patients (82%), at the second attempt in 66 patients (11.1%) and at the third or fourth attempt in 34 patients (5.7%) (table 2).

Biopsy on *transplanted kidney* was adequate for histological evaluation in 51 out of 54 patients (94.5%) In the other 3 cases, the procedure was unsuccessful because of the extreme hardness of the kidney and of the surrounding tissues, which prevented the operator from inserting the needle into the kidney. This inflammatory pattern was found in patients receiving cyclosporine A therapy and with poorly functioning transplants. Successful biopsies were obtained with only one attempt in 50 patients, whereas two attempts were made in the other 4 patients. In the latter group, 2 cases of gross haematuria occurred, lasting 36–48 h, without formation of perirenal haematoma.

The occurrence of major clinical complications (often concomitant) was very low (2.5%). Gross haematuria only occurred in 6 patients (0.8%), lasting less than 24 h and with no fall of red blood cell count. In 1 case, haematuria lasted a fortnight (requiring blood transfusion). Haematuria occurred in those patients with poor compliance during the procedure, or because of defective sliding of the biopsy needle. We recorded 3 cases of renal colic with transient haematuria (0.5%), 3 cases (0.5%) of perirenal haematoma with a decrease of haematocrit of more than 4%; 1 case, a patient affected with lupus nephritis, showed a 4% fall in haematocrit without any evidence of perirenal or pararenal blood collections. In 1 case, surgery was required to drain the blood collection (table 3).

Ultrasound scanning performed 5 min after the biopsy procedure did not reveal the formation of haematoma. 40

**Table 5.** Prevalence of post-biopsy perirenal haemorrhage described in the literature

| Author | Year | Guidance | Detection method | Patients | Prevalence % |
|---|---|---|---|---|---|
| Diaz-Buxo and Donadio [17] | 1975 | blind Rx | clinical | 1,000 | 1.4 |
| Rosenbaum et al. [20] | 1978 | Rx | CT | 20 | 85 |
| Alter et al. [21] | 1980 | Rx | CT | 21 | 57 |
| Ginsburg et al. [22] | 1980 | Rx | CT | 25 | 60 |
| Our series | 1993 | US | US | 150 | 27.2 |

US = Ultrasonography; Rx = radiological; CT = computerized tomography.

(26.6%) out of 150 patients who underwent ultrasound scanning 24 h after the renal biopsy showed small perirenal and/or pararenal blood spilling. A large haematoma was found in only 1 patient. This caused a fall in the red blood cell count and required blood transfusion. The haematoma was detected with ultrasound 4 days after biopsy, when the patient complained of loin pain (table 4).

The prevalence of perirenal bleeding was higher in the patients in whom more than one biopsy attempt was carried out. The histological patterns associated with the occurrence of perirenal haematoma were, in order of frequency: lupus nephritis, membranous glomerulonephritis, vasculitis and acute tubular necrosis. The prevalence of complications did not correlate with renal function, degree of proteinuria or hypertension.

## Discussion

There is no doubt that in the PRB procedure, sonography has several advantages, as an imaging guidance system, in comparison with radiological guidance techniques [3]. It is relatively fast, inexpensive, and can provide guidance in multiple axial, longitudinal and oblique planes of section. In the technique described in the present report, sonography is used to provide continuous real-time needle-tip localization during its progression toward the kidney pole. This technical possibility is very useful, particularly in obese patients or in those with small or floating kidney. However, these conditions do not facilitate renal biopsy – in the first case because of difficulty in needle-tip visualization due to sound attenuation is soft tissues, and in the other cases because the moving kidney makes penetration and sliding of the biopsy needle more difficult.

In addition, sonography can easily identify some of the major contraindications of renal biopsy.

The original ultrasound guidance technique was used only to locate the lower kidney pole and to mark the spot on the skin while the needle was inserted into the kidney blindly [4–7]. Co-axial probes are now availabe, as well as mechanical guiding devices which are applied to the ultrasound probe. These also permit the use of suction needles and of semiautomatic needles which allow the biopsy to be performed by a single operator [14].

It was found that these devices do not offer advantages compared to the free-hand procedure using fine needles [13] or, preferably in our opinion, sliding needles. They are also more expensive and time-consuming. In addition, the use of attachable so-called stretcher guides does not allow any readjustment, nor does it allow easy visualization of the needle tip because retroperitoneal fat and the fatty capsule of the kidney are hyperechoic. Under this condition, the visibility of the needle is very poor because of its inability to detect the echogenic needle within this echogenic background [14].

The biopsy procedure described here is similar to the traditional blind procedure. It can be performed by inexperienced operators after a short period of training, but requires considerable experience with real-time scanning beforehand. Sonographic experience eases the scanning technique that is essential to perform successful biopsies.

This procedure is also time-saving, requiring an average of 5 min to be carried out. It does not require any radiological structures and can be performed anywhere due to the manageability of the ultrasound scanner.

With the use of ultrasound guidance, fewer attempts are necessary to obtain an adequate specimen (1 attempt in 82% of cases) and there are fewer complications. In our experience, gross haematuria occurs in 1.6% of patients and it is not the most common complication of PRB, as reported in previous reports where hematuria occurs in 5–9% [17–19]. Peri/para-renal bleeding is the most frequent complication

(27.3%) in our series. However, it consisted of a mostly unquantifiable blood effusion (14%). In other cases, it consisted of a bleeding of $<5$ ml though it was clinically silent (12.6%); whereas a large haematoma, with a fall of hematocrit and loin pain was fortunately a rare complication (0.6%). The prevalence of haematoma was significantly lower in our experience than that reported in studies carried out on smaller series. Post-biopsy evaluations using computerized tomography [20–22] or ultrasonography, reported a prevalence ranging between 57 and 85% (table 5). The haematoma occurred more frequently when more attempts were necessary, and in patients with bad compliance during the procedure. Bleeding was frequently caused by damage to the kidney capsule. In all the cases, the diagnosis of haematoma was made by ultrasound scanning. The cases of large haematoma with a fall of the haematocrit of 4%, occurred 2–6 days after the biopsy – in 2 patients with severe hypertension and in 1 who underwent severe physical stress immediately after discharged. So, in spite of the simplicity of the procedure, it is advisable for patients to have a 24-hour bed rest and to keep blood pressure under control.

Our conclusions are that the ultrasound-guided free-hand PRB simplifies the biopsy procedure. It is not, however, without risk for the patient, and should be performed in nephrology departments. This technique seems to be safe, thorought and time-saving, provided it is carried out with ultrasonographic skill.


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## References


1 Ginsburg IW, Dinant JR, Mendez L: Percutaneous renal biopsy under direct radiology control. JAMA 1962;181:211–213.
2 Almkuist RD, Buckalew VM JR: Techniques of renal biopsy. Urol Clin North Am 1979;6: 503–517.
3 Madaio MP: Nephrology forum. Renal biopsy. Kidney Int 1990;38:529–543.
4 Berlyne GM: Ultrasonics in renal biopsy: an aid to determination of the kidney position. Lancet 1961;ii:750–751.
5 Bolton WK, Tully RJ, Lewis EJ, Ranninger K: Localization of the kidney for percutaneous biopsy: A comparative study of methods. Ann Intern Med 1974;81:159–164.
6 Goldberg BB, Pollack HM, Kelerman E: Ultrasonic Localization for renal biopsy. Radiology 1975;115:167–170.
7 Mailloux LU, Mossey RT, McVicar MM, Bluestone PA, Goldberg HM: Ultrasonic guidance for renal biopsy (abstract). Arch Intern Med 1978;138:438.
8 Worth DP, Khanna SK, Ubhi CS, Irving HC: The biopsy cut procedure for renal biopsies (abstract). Br Med J 1988;296:1603.
9 Birnholz JC, Kasinath BS, Corwin HL: An improved technique for ultrasound guided percutaneous renal biopsy. Kidney Int 1985;27: 80–82.
10 Yashimoto M, Fusjisawa S, Sudo M: Percutaneous renal biopsy well-visualized by orthogonal ultrasound application using linear scanning. Clin Nephrol 1988;30:106–110.
11 Burstein DM, Schwartz MM, Kobert S.M.: Percutaneous renal biopsy with the use of real-time ultrasound. Am J Nephrol 1991;11:195–200.
12 Sewell RF, Hamilton DV, Heaton A: Randomised comparison of two techniques for guiding renal biopsy. J. Nephrol 1993;6:44–47.
13 Wiseman DA, Hawkins R, Numerow LM, Taub KJ: Percutaneous renal biopsy utilizing real time, ultrasonic guidance and a semiautomated biopsy device. Kidney Int 1990;38:347–349.
14 Charbonnau JW, Reading CC, Welch TJ: CT and sonographically guided needle biopsy: Current techniques and new innovations. AJR 1990; 154:1–10.
15 Otto R, Deyhle P: Guided puncture under real-time sonographic control. Radiology 1980; 134:784–785.
16 Sameer H, Goldberg H, Katz, Cardella CJ, deVeber GA, Cook GT, Uldall PR: Percutaneous needle biopsy of transplanted kidney: Technique and complications. Am J Kidney Dis 1989;14:13–17.
17 Diaz-Buxo JD, Donadio JV: Complications of percutaneous renal biopsy: An analysis of 1,000 consecutive biopsies. Clin Nephrol 1975;4: 223–427.
18 Wickre CG, Golper TA: Complication of percutaneous needle biopsy of the kidney. Am J Nephrol 1982;2:173–178.
19 Gault MH, Muercke RC: Renal biopsy: Current views and controversies. Nephron 1983;34: 1–34.
20 Rosenbaum R, Hoffsten PE, Stanley RJ, Klahr S: Use of computerized tomography to diagnose complications of percutaneous renal biopsy. Kidney Int 1978;14:87–92.
21 Alter AJ, Zimmermann S, Kirachaiwanich C: Computerized tomographic assessment of retroperiteonal hemorrhage after percutaneous renal biopsy. Arch Intern Med 1980;140:1323–1326.
22 Ginsburg JC, Fransman SL, Singer M, Cohanim M, Morrin PAF: Use of computerized tomography (CT) to evaluate bleeding after renal biopsy. Nephron 1980;26:240–243.