Using the Automated Biopsy Gun with Real-Time Ultrasound for Native Renal Biopsy

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Abstract

Background: The use of an automated biopsy system for renal biopsy has recently gained popularity, but its safety in single functioning kidneys is unclear.

Objective: To report our experience with the automated system for closed renal biopsy during a 5 year period.

Methods: Eighty-five patients underwent percutaneous native renal biopsy with the automated biopsy gun (16G needle) under real-time ultrasound. They were chronologically divided into two groups: 41 patients (group A), using an older ultrasound machine; and 44 patients (group B), using a newer ultrasound machine. Nine patients biopsied with a manual 14G Tru-cut needle served as the control (group C).

Results: The number of "attempted" passes at the kidney was 4.0 $\pm$ 0.1 in group B, 4.7 $\pm$ 0.3 in group A ($P < 0.05$ vs. group B), and 5.8 $\pm$ 0.5 in group C ($P < 0.01$ vs. group B). The number of successful passes did not differ (3.3 $\pm$ 0.1, 3.3 $\pm$ 0.1, 3.1 $\pm$ 0.2). The ratio of "attempted/successful" was 1.28 $\pm$ 0.07 in group B, 1.95 $\pm$ 0.38 in A, and 1.90 $\pm$ 0.21 in C ($P < 0.01$ vs. B). The number of glomeruli obtained was similar in the three groups. Adequate tissue was obtained in 95%, 98%, and 100%, respectively. Hemoglobin decreased by 4.3 $\pm$ 1.1% in group B, 6.9 $\pm$ 1.3% in group A, and 11.3 $\pm$ 1.8% in group C ($P < 0.05$ vs. B). Perinephric/subcapsular hematoma occurred in 5 patients (11.4%) in group A (2 taking aspirin), in 2 patients (4.9%) in group B, and in none in group C. The necessity for blood transfusion post-biopsy was similar in all groups. Four of five patients with single functioning kidneys (one in group A and four in group B) had uneventful biopsies, and adequate tissue was obtained in three.

Conclusions: The use of the automated biopsy gun is effective, safe and has a low rate of major complications. It may be used safely in single functioning kidneys.

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In recent years the use of the ultrasound-guided automated biopsy gun for percutaneous renal biopsy has largely replaced the traditional manually operated true-cut needle. This allows the use of smaller gauge needles (16–18G) with multiple passes, as compared to the traditional 14G needle [1–6]. It has been used in single functioning kidneys, but reports on this issue are limited [7].

We began to use the automated biopsy gun under ultrasound guidance in 1995. The present report summarizes our experience with this procedure. This method can be safely used in single functioning kidneys.

Patients and Methods

The study group included all patients who underwent percutaneous native kidney biopsy following the introduction of the automated biopsy gun to our center in 1995. All biopsies were performed by a team that included the same radiologist and one of three nephrologists, of whom one performed 70% of the procedures. The instruments used were a Pro-mag 2.2 biopsy system (automated biopsy gun, Manan Medical Products, Northbrook, IL, USA), with a 2.2 cm stroke, loaded with a 20 cm long/16G automatic cutting needle (either Manan or MDTECH, Gainseville, FL, USA). The ultrasound machine used in the first 44 procedures was an Elscint-1000. Since April 1998 an ATL-9 ultrasound machine was used. The patients were taken off all anticoagulants and antiplatelet aggregation agents for one week (none of the patients received clopidogrel, which may have a longer effect). Routine tests including prothrombin time, partial thromboplastin time and fibrinogen were performed during the 24 hours prior to biopsy. Bleeding time was not used on a routine basis, unless considered necessary (e.g., severe renal failure, systemic lupus erythematosus). The biopsy was usually performed in the early morning after an overnight fast, with the patient in a prone position and with a pillow pressing on the abdomen. The use of sedation (1–3 mg intravenous midazolam) was optional. The lower lobe of the left kidney was biopsied, unless decided otherwise (based on the appearance of the kidneys). The puncture area was prepared under sterile conditions, and a local anesthetic was introduced under real-time ultrasonography to both the skin and the deep tissues all the way to the kidney. A small skin incision was then made to facilitate introduction of the biopsy needle. The automated biopsy gun, loaded with the biopsy needle, was introduced using an adapter attached to the ultrasound probe and advanced under real-time ultrasonographic vision to the lower pole, where the pre-loaded automated biopsy gun was discharged for the true cut. The final approach and "firing" was done, the patient having been instructed to hold his/her breath. Each puncture takes about 15 seconds ("skin to skin") with the actual penetration of the needle into kidney parenchyma lasting less than 1 second. Since the 16G cylinder-shaped tissue is too thin for longitudinal cut, second and third samples were taken. A pathology laboratory technician was available on site for immediate handling of the tissue for light microscopy, immunofluorescence and electron microscopy. Following the biopsy the puncture area was cleaned and sprayed with a moisture vapor permeable spray dressing. The patient was rolled over to a supine position and was instructed to remain in bed for 6–

8 hours. The first urine voiding following the biopsy was monitored for macrohematuria; blood pressure was measured intensively for the first 2 hours, and follow-up hemoglobin was taken both 10 and 24 hours post-biopsy. A repeat ultrasound was indicated for severe back or abdominal pain, a dramatic change of blood pressure or heart rate, a major drop in hemoglobin, or persistent macrohematuria. Transient microhematuria, a transient self-resolving subcapsular or perinephric hematoma were considered as minor complications. Major complications included: the need for blood transfusion (based both on a clinical assessment and hemoglobin levels of the patient pre-biopsy and post-biopsy), acute urinary obstruction due to clot retention, intrarenal arteriovenous fistula, the need for an invasive procedure to stop or drain bleeding (embolization or nephrectomy), perinephric abscess, sepsis, or death.

The patients were divided into two groups: with the biopsy done using an older ultrasound machine (group A – 44 patients, March 1995 through February 1998), and using a newer ultrasound machine (group B – 41 patients, April 1998 through March 2000). A third group of nine patients served as the control (group C). These patients underwent biopsy by a single senior nephrologist who preferred to use the manual true-cut 14G needle, also under ultrasound guidance. Briefly, this biopsy is done after detaching the ultrasound probe from the biopsy needle, and the final location of the needle inside the kidney is verified by the needle's movement during respiration. Seven of the nine patients in group C underwent biopsy prior to 1998 with the older ultrasound machine, and in two patients the newer machine was used. Since these two did not seem to differ in any of the relevant parameters, they were included in one group (C).

The data collected for each patient included demographic and relevant laboratory parameters (age, gender, serum creatinine, serum albumin), final biopsy-based renal diagnosis, and biopsy-related data: number of glomeruli obtained, and complications, with special attention to any change in serum hemoglobin levels. As a quantifiable measurement of success or failure we recorded the ratio of "attempted" to "successful" passes at the kidney (A/S ratio), where 1 is the optimum and any number above 1 is less than optimal.

Data are presented as mean ± SEM except for age (mean ± SD). Comparison between means was done using analysis of variance (ANOVA) with Bonferrroni's correction. $P < 0.05$ was considered significant.

Results

During the study period, the automated biopsy gun was used to perform 89 renal biopsies and the manually operated Tru-cut needle was used for 9 biopsies. Data on four patients were missing, leaving 94 patients for analysis. The indications for the renal biopsies included proteinuria in 46 patients, chronic renal failure in 14, acute renal failure in 10, vasculitis in 8, SLE in 7, multiple myeloma in 6, and hematuria in 3 patients. The automated biopsy gun was used with the older ultrasound machine in 44 biopsies (group A) and with the newer ultrasound machine in 41 (group B). All biopsies with the gun were performed with a 16G needle. Group C (control) included nine patients, biopsied with a 14G needle under ultrasound guidance but without the gun (see Methods). As shown in Table 1, the patients in group B tended to be older than the patients in group C. There was no difference between the groups in serum creatinine and serum albumin levels.

Table 2 presents the results of the renal biopsies in the three groups. There were significantly fewer attempted passes at the kidney in group B compared with both group A or C. There was no difference in the number of tissue cores (successful passes) between groups. The ratio of attempted/successful passes was lower in group B than in groups A and C, but a statistical significance was shown only between groups B and C ($P < 0.01$) probably due to the large variation in group A. This suggested that by using the automated biopsy gun together with a good quality sonographic picture, a lower number of passes at the kidney was needed. The number of glomeruli obtained was not different among the three groups (Tables 2 and 3). Adequate tissue for diagnosis was obtained in 98% in group A, 95% in group B, and 100% in group C.

Table 4 lists the complications arising from the renal biopsies in

Table 1. Patients' characteristics at the time of renal biopsy

	Group C (Control) (n=9)	Group A (n=44)	Group B (n=41)
Age (yr)*	40.0±19.2	52.0±16.1	53.9±18.5**
(range)	(16–70)	(18–75)	(17–80)
Male/female	5/4	25/19	20/21
Serum creatinine (mg/dl)	2.2±0.3	2.3±0.2	2.3±0.3
Serum albumin (g/dl)	3.2±0.3	3.5±0.1	3.2±0.1

* Mean ± SD ** $P = 0.09$ vs. group C.

Table 2. Results and characteristics of renal biopsies

	Group C (Control) (n=9)	Group A (n=44)	Group B (n=41)
(A) "attempted" passes	5.8±0.5	4.7±0.3	4.0±0.1*, **
(S) "successful" passes	3.1±0.2	3.3±0.1	3.3±0.1
A/S	1.90±0.21	1.95±0.38	1.28±0.07**
No. of glomeruli	19.9±3.6	21.6±2.2	18.3±1.8
Adequate tissue	9/9 (100%)	43/44 (98%)	39/41 (95%)
Single functioning kidney	0	1	4

* $P < 0.05$ vs. group A ** $P < 0.01$ vs. group C;

Table 3. Distribution of the number of glomeruli obtained in the three groups

No. of glomeruli	Group C (Control) (n=9)	Group A (n=44)	Group B (n=41)
1–5	0	1	3
6–10	1	10	7
11–15	4	8	8
16–20	0	8	9
>20	4	17	14

SLE = systemic lupus erythematosus

Table 4. Complications of renal biopsies

	Group C (Control) (n=9)	Group A (n=44)	Group B (n=41)
Δ Hgb (g/dl)	−0.78±0.40	−0.86±0.16	−0.47±0.10*
Δ Hgb (%)	−11.3±1.8	−6.9±1.3	−4.3±1.1**
Macrohematuria	0	1	0
Hematoma (%)	0	5 (11.4)[b]	2 (4.9)[a]
Transfusion (%)	1 (11.1)	2 (4.5)	2 (4.9)
Inadequate tissue	0	1	2

* $P < 0.05$ vs. group C ** $P = 0.09$ vs. group C [a] Perinephric in two patients [b] Perinephric in two patients, subcapsular in one, retroperitoneal in two.

the three groups. Serum hemoglobin levels decreased less in groups B and A than in group C, but these decreases did not reach significance. However, the percent decrease in serum hemoglobin was significantly lower in group B than in group C. Macroscopic hematuria occurred in only one patient. Significant perinephric hematoma was observed in two patients from group B (4.9%). Both patients were asymptomatic, and a repeat ultrasound was performed because of the decrease in hemoglobin due to the clinical and technical data described above. In group A, 5 patients (11.4%) developed significant hematomas: 1 patient had an asymptomatic subcapsular hematoma, 2 had perinephric hematoma (1 was symptomatic with flank pain and macroscopic hematuria), and 2 patients developed subcapsular hematoma that spread to the retroperitoneum. The two latter patients had inadvertently continued to take low dose aspirin before the biopsy. Thus, if they were to be excluded from the data analysis, the incidence of significant hematomas decreased to 3 patients in group A (6.8%). None of the above complications required an invasive procedure.

Three patients in group A needed blood transfusion. One had Wegener's granulomatosis with acute necrotizing glomerulonephritis and a creatinine clearance of 15 ml/min. Her pre-biopsy hemoglobin level was 7.7 g/dl, which decreased to 7.5 g/dl on the evening following the biopsy. There was no overt bleeding. Thus the transfusion was required due to the patient's illness and not necessarily due to bleeding from the biopsy site. A second patient had multiple myeloma with perinephric hematoma. The third patient had a retroperitoneal hematoma.

In group B, two patients needed blood transfusion. One had severe renal failure (creatinine clearance of 14 ml/min), with serum hemoglobin of 8.3 g/dl before the biopsy, and was diagnosed with radiation nephritis. The second patient had multiple myeloma, with a hemoglobin level of 9.1 g/dl before the biopsy. In group C, one patient needed transfusion. She had acute interstitial nephritis, with a creatinine clearance of 23 ml/min and a serum hemoglobin level of 7.6 g/dl before the biopsy. No significant hematoma was detected on ultrasound.

Inadequate tissue was obtained in one patient from group A. In group B, two biopsies failed to obtain adequate tissue. Both patients were young males with renal failure, most probably chronic, with unilateral atrophic kidney and a second kidney with atrophic cortex. Neither patient had signs of blood loss or any other complication following the biopsy.

Five patients (one in group A and four in group B) had a single functioning kidney. One of the five had undergone donor nephrectomy in the past, one had single crossed ectopic kidney, and three patients had a unilateral atrophic kidney. No patient in group C had a single functioning kidney, reflecting the nephrologist's hesitancy to perform the biopsy with this technique. The five patients with a single functioning kidney in this subgroup were aged between 20 and 70; they underwent an average of four attempted passes (range 3–5) to yield an average of 2.9 cores (range 1.5–4) and an average of 10 glomeruli (range 1–22). Hemoglobin level fell by an average of 1.1 g/dl (range 0–1.8). One patient required blood transfusion (as described in the previous paragraph). In two patients with relatively atrophic kidneys, the tissue collected consisted of renal medulla only and was inadequate for histologic diagnosis.

Three of the seven patients with SLE had coagulopathy, two with elevated antiphospholipid antibodies and one with platelet dysfunction. The patient with platelet dysfunction was treated with prednisone for 4 weeks prior to biopsy. No patient received prophylactic treatment with fresh frozen plasma or platelet transfusion prior to biopsy. These patients with SLE did not experience more bleeding than did the general cohort.

Discussion

Renal biopsy has been performed since 1951 [8], initially by aspiration needle and later by the Franklin-Vim-Silverman needle [9] and then the Tru-cut needle [9]. The development of ultrasound facilitated kidney localization for biopsy and subsequently replaced the use of intravenous pyelography [10]. Still, using the Tru-cut needle for biopsy necessitates good operating skills, with the final step usually being done while the ultrasound probe is detached from the needle, thus leaving some doubt as to the final location of the needle and rendering the patient at risk for post-biopsy complications.

In the last decade the spring-loaded automated biopsy gun combined with real-time ultrasound guidance was introduced [1,2] and quickly gained popularity among nephrologists as the best method for biopsying both native kidneys and renal allografts [3,4,6,11–16]. One prospective randomized study [6] and several retrospective non-randomized studies [3–5,17–19] compared use of the automated biopsy gun with the manually operated Tru-cut. Although different sized needles were used in those studies, results showed that the combination of real-time ultrasound guidance with automated gun, loaded with either a 14G or 18G needle, while yielding adequate tissue for diagnosis was accompanied by fewer major bleeding complications, ranging from 1 to 14% [3,5,6,17–20]. This success rate, coupled with fewer complications of renal biopsy, seems to depend on a few factors. Real-time ultrasonography allows accurate localization and continuous visualization of the kidney during the biopsy procedure. This can be achieved with the automated biopsy gun but not with the manually operated needle. In this respect, it is noteworthy that in the current study the use of the gun with a newer ultrasound machine was associated with a higher success rate, as reflected by the low ratio of attempted/successful passes at the kidney, and fewer complications. The size of

the biopsy needle may affect the number of glomeruli obtained and possibly the rate of complications [3,5]. The automated biopsy gun enables the use of a smaller gauge needle. Indeed, most of the recent publications used 18G needles with satisfactory results [6,11]. In the current study a 16G needle was used. The advantage of a small gauge needle may be offset by an insufficient number of glomeruli, but this can be overcome by using a microscope on site to allow verification of adequate tissue harvesting. Thus, the combination of real-time ultrasound guidance with the automated biopsy gun, loaded with either a 16G or 18G needle, appears to be relatively easy, rapid, convenient for both the patient and the operator, and safe with regard to major complications.

Patient selection and preparation may affect the outcome of renal biopsy. A very low incidence of complications was achieved in a cohort of 1,090 biopsies obtained using the gun with a 18G needle, by a strict control of blood pressure, detailed coagulation tests, and avoiding biopsy if the renal cortex measured less than 10 mm [11].

This study has shown that the use of the automated biopsy gun in patients with single functioning kidneys is both efficient and safe. The use of percutaneous renal biopsy in patients with single functioning kidneys is not well documented (7,21). In 1992 Schow et al. [21] claimed that the risk of significant hemorrhage after closed biopsy in this subset of patients is low, and that the automated biopsy gun under real-time ultrasound is feasible in patients with single functioning kidneys. In 1995 Mendelssohn and Dole [7] performed renal biopsies in nine patients with single functioning kidneys. Patients included only those with well-controlled blood pressure, normal size of the single functioning kidney, and a contraindication for general anesthesia. Biopsy was successful in eight of the nine patients. No immediate post-biopsy complications were noted in any patient [7]. When considering the risk of significant hemorrhage after closed kidney biopsy versus the risks of an open biopsy, percutaneous renal biopsy in single functioning kidneys using the automated biopsy gun under real-time ultrasonography appears to be a sound option [21]. As shown in the current study, the increasing experience acquired with the procedure, along with the use of a newer ultrasound machine, is reflected in the number of patients with single functioning kidney in each group who underwent this procedure (none in group C, one in group A, and four in group B).

This procedure also seems to be safe in high risk patients, e.g., those with lupus nephritis and coagulation disorders, as shown in three of our patients. After we concluded the data analysis in the current study, a 27 year old woman with severe type IV lupus nephritis and platelet dysfunction underwent an uneventful biopsy using the gun with a 16G needle. Six years previously she had undergone an open biopsy for the same problem.

The method is also safe for patients with less than optimal cooperation regarding breath-holding during the penetration and firing steps. This applies to 9 of the 84 patients in the current study.

In summary, use of the automated biopsy gun with a 16G needle under real-time ultrasound guidance is a safe, relatively quick procedure, with fewer complications than the manually operated Tru-cut 14G needle, and it may be used with safety in carefully selected patients with single functioning kidneys.

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