

Arteriovenous Fistula and Pseudoaneurysm: Two Important But Rare Complications of Percutaneous Renal Biopsy and Safety of the 16 G Automated Biopsy Needle

Arteriovenöz Fistül ve Psodoanevrizma: Böbrek Biyopsinin Nadir Fakat Önemli İki Komplikasyonu ve 16 G Otomatik Biyopsi İğnesinin Güvenilirliği

ABSTRACT

OBJECTIVE: The aim of this study was to evaluate the safety of 16 G automated biopsy needles, and the incidence of AVF and pseudoaneurysm in patients undergoing renal biopsy.

MATERIAL and METHODS: Patients who underwent renal biopsy from January 2010 to December 2012 were prospectively evaluated. Color Doppler USG, hemoglobin and platelet counts, spot urine analysis were performed before and after the biopsy procedure, AVF and pseudoaneurysm that developed secondary to percutaneous renal biopsy were evaluated by Doppler USG at 12 h, and 24 h, and 6 and 12 months after biopsy.

RESULTS: Postbiopsy small perirenal, subcapsular, or parenchymal bleeding without clinical relevance were detected in 59 patients (89.2 %) 12 and 24 hours after procedure. RBC counts per high power field increased significantly after the procedure in all subjects ($p<0.05$). Significant retroperitoneal bleeding, macroscopic hematuria, arteriovenous malformation, and pseudoaneurysm were not detected in our cohort. Glomeruli counts were acceptable in all subjects.

CONCLUSION: To optimize safety, patient comfort, and diagnostic yield, a 16 G automated biopsy needle with real-time U/S guidance may be preferred as the standard approach.

KEY WORDS: Renal biopsy, Arteriovenous fistula, Pseudoaneurysm

ÖZ

AMAÇ: Bu çalışmanın amacı, nefrotik sendrom nedeni ile böbrek biyopsisi yapılan hastalarda, psödoanevrizma ve A-V fistül sıklığını, 16 G otomatik biyopsi iğnesinin güvenilirliğini değerlendirmektir.

GEREÇ ve YÖNTEMLER: Çalışmaya Ocak 2010 ile Aralık 2012 yılları arasında nefrotik sendrom tanısı nedeni ile böbrek biyopsisi yapılan hastalar alındı. Biyopsi işleminden sonra psödoanevrizma ve A-V fistül gelişip gelişmediğini değerlendirmek için işlem sonrası 12. saat, 24. saat, 6. ay ve 12. ayda hastalar renkli Doppler USG, hemogram, trombosit değerleri ve spot idrar tahlil sonuçları ile değerlendirildi.

BULGULAR: Biyopsi işlemi sonrasında 12. Saat ve 24. saatlerde 59 hastada (% 89.2) klinik önem taşımayan perirenal, subkapsüler ve parenkimal kanama saptandı. 12. ve 24. saatlerde gözlenen mikroskobik hematüri oranı 6. ay ve 12. aylarda görülen mikroskobik hematüri oranına göre istatistiksel olarak anlamlı oranda yüksek saptandı ($p<0.05$). Ancak klinik olarak anlamlı kanama, hemogramda anlamlı düşme, makroskobik hematüri saptanmadı. Hastaların işlem sonrası takibi sırasında psödoanevrizma ve de A-V fistül saptanmadı.

SONUÇ: Böbrek biyopsi işlemi sonrasında A-v fistül görülme oranı nadir olmamakla birlikte genellikle sessiz seyretmektedir. Klinisyenler yeterli doku elde etmek için ideal iğne kalınlığı ve görüntüleme yöntemi konusunda dikkatli olmalıdırlar. Güvenli işlem, hasta rahatlığı ve yeterli tanı materyali için USG eşliğinde 16-G otomatize böbrek biyopsi iğnesi kullanılmalıdır.

ANAHTAR SÖZCÜKLER: Böbrek biyopsisi, Arteriovenöz fistül, Psödoanevrizma

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INTRODUCTION

Renal biopsy is the most sensitive tool to evaluate causes of kidney diseases (1). Possible complications after renal biopsy are usually related to hemorrhage and include hematoma, pseudoaneurysm, hematuria, and formation of arteriovenous fistula (AVF) (2). Minor complications of renal biopsy such as microscopic hematuria and post-biopsy hematoma are common features and usually resolve within weeks after biopsy (3). However, an incidence of AVF that varies between 0.5 (4) and 16 % after renal biopsy (5) and complications developing up to 25 years later have been reported. The time period between the creation of the fistula and the clinical presentation can be very variable (6), ranging from 7 to 365 days post-biopsy (6). Some of the complications such as AVF and pseudoaneurysm may be due to the needle size (7). Using ultrasound-guided automated biopsy guns has lowered the complication rate in a significant way (8) so that the procedure is now carried out more frequently and renal biopsy can be considered a safe procedure (3). Color Doppler sonography (CDS) permits a safe, inexpensive, and noninvasive diagnosis and follow-up of postbiopsy AVF and pseudoaneurysm (7).

In the literature, only a few case reports have been presented with AVF in patients with nephrotic syndrome that underwent renal biopsy (9, 10, 11). The aim of this prospective study was to evaluate the safety of the 16 G automated biopsy needle, and to obtain the incidence of AVF and pseudoaneurysm in patients undergoing percutaneous renal biopsy.

PATIENTS and METHODS

The study was approved by our institutional review board. The investigation included only data of biopsy procedures performed for a clinical indication of the patients.

Patients who underwent renal biopsy from January 2010 to December 2012 were prospectively evaluated. After renal biopsy, the patients were placed under absolute bed-rest and monitored for at least 6 hours to reduce the risk of any bleeding. No patient died during the 12 months. Color Doppler USG, hemoglobin and platelet count, spot urine analysis were performed during the biopsy and after procedure. AVF and pseudoaneurysm that developed secondary to percutaneous renal biopsy were evaluated by Doppler USG at 12 h, and 24 h, and 6 and 12 months after biopsy.

The indications for renal biopsy were several renal diseases: clinically asymptomatic proteinuria with or without hematuria, to account for causes of glomerulonephritis or nephrotic syndrome.

Exclusion criteria included patients with bleeding diatheses such as those with an elevated International Normalized Ratio (INR), activated partial thromboplastin time (aPTT), significant thrombocytopenia, or elevated bleeding time or symptomatic cardiovascular disease including coronary artery disease, cerebral vascular disease, peripheral artery disease, and aortic

aneurysm, patients with rapidly progressive glomerulonephritis, acute nephritic syndrome, renal failure as well as hypertensive patients. Patient undergoing renal surgery or had a neoplasm and patients taking anticoagulants or antiaggregant were also excluded.

One radiologist, who had 10 years of experience in US-guided biopsy, performed the procedures. Biopsies were performed under ultrasound guidance using a 16G automated needle (C.R. Bard, Covington, UK). A needle guidance device in metal was attached to the transducer and the needle path was indicated on the screen by two parallel lines to facilitate correct needle insertion. The path was put along the cortex as close to the surface of the kidney as possible and major vessels were avoided by CDS evaluation. The skin entrance site was marked and the area washed with 5% chlorhexidine. Under local anesthesia with lidocaine, and with sterile dressing, the needle was inserted with the bevel pointing away from the kidney to avoid needle deviation into the central part of the kidney. The biopsy was preferably performed from the peripheral cortex either at the upper or lower pole of the kidney. Three biopsy specimens were removed. Procedural success was assessed according to Banff 97 criteria (12). An adequate specimen was defined as one that has 10 or more glomeruli and two or more arteries and a minimal specimen was defined as one that has at least seven glomeruli and at least one artery.

All of the Doppler US assessments were performed with a color Doppler US device (Aplio, Toshiba Tokyo/Japan) with the help of 3-6 MHz broadband convex probe (PLT 3.75 Toshiba Tokyo, Japan) prior to, during, and immediately after the procedure by radiologist. A comparison with the other kidney was attempted in all patients. Additional US examinations were performed only if clinically indicated, e.g., in cases of pain, fever, and a drop in serum hemoglobin, indicating hemorrhagic complications.

All data and findings were evaluated for prevalence of complications (bleeding and hematoma, AVF).

Demographical Data

Systolic and diastolic blood pressures (SBP, DBP) were obtained in all subjects. Arterial blood pressure measurements in "mmHg" were performed with the oscillometric system using the device in a seated position by taking the mean of two consecutive measurements performed within 5 minutes (OMRON M6 Comfort, Kyoto, Japan).

Laboratory Tests

A complete blood count was performed after an 8-hour overnight fasting period with blood obtained from the antecubital vein. Samples were drawn with a 20 gauge "vacutainer" needle into dry and EDTA containing tubes with amounts of 5 cc and 3 cc respectively. Hemoglobin (Hb) level, thrombocyte (PLT) count were assessed with the Sysmex XI2000 device (Sysmex Corporation of America, Long Grove, Illinois, USA) within 10

minutes after the blood samples were drawn. Serum creatinine, fasting plasma glucose (FPG), albumin, total cholesterol (TC), high-density lipoprotein-cholesterol (HDL-C), and triglyceride (TG), were evaluated (Olympus AU 640, Japan). Low-density lipoprotein cholesterol (LDL-C) level was assessed with the Friedewald formula which can be formulated as $LDL = TC - (HDL-C) - (TG/5)$ (13). Estimated glomerular filtration rate (eGFR) was evaluated with the “Modification of Diet in Renal Disease” MDRD formula which can be shown as $MDRD: GFR = 170 \times [Scr]^{-0.999} \times [age]^{-0.176} \times (0.762 \text{ if the subject is women}) \times (1.180 \text{ if the patient is black}) \times [BUN]^{-0.170}$ (14). APTT (reference interval, 23–36 seconds) was obtained by a using the HemoTech device (Medtronic, Minneapolis, Minnesota), INR (reference interval, 0.9–1.2) was measured by a BCS-XP device (Siemens-Germany), and the bleeding time (reference interval, 2-9 minutes) was also measured.

Spot urine analysis performed by using the dipstick test. Microscopic hematuria was considered in the case of two of three urine samples with 3 or more red blood cells per high powered field (RBCs/hpf). Visible hematuria was defined as a macroscopic or gross hematuria.

Proteinuria was evaluated by 24 h urinary protein excretion. Samples were obtained at two different times and assessed with the Olympus AU 640 device by immunoturbidimetric methods (SOR). The average of proteinuria values at two different times was calculated.

STATISTICAL ANALYSIS

MedCalc were used for statistical analysis. To test the normal distribution for permanent data, the Shapiro-Wilk test was applied. According to the results gathered from this test, parametric methods were used if necessary. The mean comparisons of binary groups were done with Student’s t test. For the mean comparisons of the groups where more than 2

groups involved, 1-way analysis of variance (ANOVA) was applied. Multiple comparisons were done with Tukey Honestly Significant Difference (HSD) test. For the assessment of the effects of interactions of 2 different variables on the mean values, the factorial ANOVA test was used. Linear association between 2 variables was evaluated with the Pearson correlation test. Type I error level was determined to be 0.05 in all of the comparisons.

RESULTS

A total of 65 patients (34 males, 31 females) with a mean age of 40.25 ± 14.2 years were included in the study. All biopsies were successful and yielded sufficient material for diagnostic histologic workup. The mean number of glomeruli per patient was found to be 8.9 ± 1.0 . The final diagnoses were various types of FSGS in 19 patients, minimal change disease in 12 patients, MPGN in 10 patients, membranous glomerulonephritis in 9 patients, and others in 15 patients.

All patients’ blood pressure was normal (mean systolic pressure was 117.6 ± 10.7 mmHg, mean diastolic pressure was 77.9 ± 5.1 mmHg) and none of patients used antihypertensive medication.

Postbiopsy small hematomas, mainly small perirenal, subcapsular, or parenchymal bleeding without clinical relevance were detected in 59 patients (89.2 %) in the first 12 and 24 hours after the biopsy procedure. Red blood cell counts per high power field increased significantly after the procedure in all subjects ($p < 0.05$). Significant bleeding with clinical findings, macrohematuria and significantly decreasing hemoglobin and platelet levels were not observed. Some biochemical laboratory findings during and following renal biopsy were shown in Table I. Neither AVF nor pseudoaneurysm was detected at the 12 and 24th hours and in the 6 and 12th months of after the procedure.

Table I: During and following renal biopsy, comparison of laboratory data’s and detect of both AVF and pseudoaneurysm in CDU

	Prebiopsy	12 hours AB	24 hours AB	6 months AB	12 months AB	p value
Hb, g/dL	14.25 ± 1.3	14.14 ± 1.2	14.21 ± 1.2	14.33 ± 1.3	14.28 ± 1.3	NS
PLT, $\times 10^3/\text{mL}$	275.85 ± 80.7	270.25 ± 79.6	302.54 ± 83.3	298.74 ± 73.2	301.23 ± 68.9	NS
RBCs in spot urine, hpf	0.82 ± 0.5	122.13 ± 8.3	113.24 ± 5.4	0.7 ± 0.3	0.6 ± 0.3	< 0.05
AVF	ND	ND	ND	ND	ND	NS
PSD	ND	ND	ND	ND	ND	NS
Creatinine, mg/dL	0.79 ± 0.2	0.78 ± 0.2	0.80 ± 0.3	0.76 ± 0.2	0.77 ± 0.2	NS
SBP, mm Hg	117.62 ± 10.7	116.53 ± 10.4	118.32 ± 11.1	120.63 ± 11.3	119.49 ± 11.2	NS
DBP, mm Hg	77.91 ± 5.1	76.56 ± 4.9	78.85 ± 5.3	79.12 ± 5.3	79.10 ± 5.6	NS

Abbreviations: **AB**, After biopsy; **ND**, not detected; **AVF**, arteriovenous fistula; **CDU**, color doppler ultrasonography; **Hb**, hemoglobin; **PLT**, platelet; **RBCs**, red blood cell; **PSD**, pseudoaneurysm

Table II: Demographic and laboratory data during and after renal biopsy.

	Prebiopsy	12 months after procedure	p value
Age, year	40 ± 14.2	41 ± 14.1	>0.05
FPG, mg/dL	97 ± 17.7	99 ± 18.1	>0.05
TC, mg/dL	260 ± 87.5	221 ± 54.7	<0.05
LDL-C, mg/dL	152 ± 76.3	122 ± 63.3	<0.05
HDL-C, mg/dL	53 ± 29.9	58 ± 33.2	<0.05
Triglyceride, mg/dL	267 ± 145.3	194 ± 99.5	<0.05
Albumin, g/dL	2 ± 0.6	3 ± 0.8	<0.05
24 hours proteinuria, mg/day	6071 ± 4780	1275 ± 654.3	<0.05
eGFR, mL/min	108 ± 12.7	113 ± 13.6	>0.05
aPTT, seconds	28 ± 2.8	29 ± 2.9	>0.05
INR	1 ± 0.1	1 ± 0.2	>0.05
Bleeding time, minutes	5 ± 2.2	5 ± 2.4	>0.05

Abbreviations: **SBP**, systolic blood pressure; **DBP** diastolic blood pressure; **FPG**, fasting plasma glucose; **TC**, total cholesterol; **LDL-C**, low-density lipoprotein cholesterol; **HDL-C**, high-density lipoprotein cholesterol; **eGFR**, estimated glomerular filtration rate; **APTT**, activated partial thromboplastin time; **INR**, International Normalized Ratio.

The statistical significance of demographic and laboratory data's prebiopsy and 12th month of after the procedure were shown in Table II. Gender, age, systolic blood pressure, diastolic blood pressure, creatinine levels, fasting plasma glucose levels, bleeding time levels, INR levels, aPTT levels, and eGFR prebiopsy were not found to be significantly different as compared to 12th month of after the renal biopsy ($p>0.05$). The total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, 24 hours proteinuria, and albumin values prebiopsy were significantly different from the values 12 months after biopsy procedure ($p<0.05$).

DISCUSSION

This study is a rare prospective observational study to investigate the reliability of 16 G sizes of automated biopsy needle, and risk of AVF and pseudoaneurysm in patients undergoing percutaneous renal biopsy. In upper and lower pole of kidney where removed biopsy specimen is safety procedure in patient with normotensive and with normal kidney function. If biopsy specimen was removed in these regions with 16 G needle, AVF and pseudoaneurysm were not occurring in short and long time duration. The most common iatrogenic biopsy-related vascular injuries in native kidneys as well as in renal allografts are AVF and pseudoaneurysm. Size of needle and location are important factors that determine presentation. It has been suggested that the complication rate is lower with the use of thin biopsy needles (15). However, the previous studies that compared needle sizes (14 and 18 G) had conflicting results due to the use of different types of needles (manual and

automated). Although the larger manual needles provided more glomeruli per field (16), they were related with an increased rate of complications (17). The only comparative study of the same gauge (14 G) removed more glomeruli with the automated needle without an alteration in complications (18). Recently, a prospective study using 14-G and 16-G automated needles showed no difference in the incidence of complications or in the number of glomeruli (19). In another prospective study (20) 16-G and 18-G automated needles were investigated. There was no difference in major complications, but patients had more pain in the 16-G group. The biopsy specimen was significantly better in the 16-G group, with more glomeruli and less artifact. Additionally, a prospective randomized controlled trial using automated needles of 3 different sizes (14, 16, and 18 G) in kidney allograft biopsies revealed no difference in complication rates between the 3 sizes, but a higher diagnostic adequacy and more pain in the group with the largest needle (21). The mean number of glomeruli per subject in our study was found as 8.09 ± 1.1 (range=0–86) and was significantly higher by use of automated 16 G needle. In our subjects, glomeruli count was comparable as reported in literature.

Although the ultrasonography-guided procedure is simple to perform, it carries the risk of vascular complications such as AVF and pseudoaneurysm (22). While the reported incidence of AVF has been between 5 and 10 % so far (23), the incidence of symptomatic post-biopsy AVF is between 0.3 and 4 % (24). Seventy percent of AVF are asymptomatic, and usually resolve spontaneously within weeks or months (25).

In five series totaling 1,042 native kidney biopsies, 31 AVF (3 %) were detected after the renal biopsy (26-30). It should be noted that their frequency was quite low in the more recent series; the higher incidence in the old series may have been due to cruder methods of localizing the biopsy site. As for renal allografts, 22 AVF complicated 309 biopsies (7 %) in two series (31, 32). AVF and pseudoaneurysm complications were not seen in the patients described here but have been recorded elsewhere. The incidence of these AVF and pseudoaneurysm has been reduced by the introduction of ultrasound guidance, and blind renal biopsy should always be avoided. However, Riccabona et al. reported that despite ultrasonography-guided renal biopsy, postbiopsy renal AVF and pseudoaneurysm are more common than expected (7). Unfortunately, they performed the biopsy in the prone position and with 14 G core biopsy Bio-Cut needle.

AVF is important complication of renal biopsy because it may causes to flank pain, gross hematuria, hypertension, arterial bruits, congestive heart failure, or even renal failure (11). If macrohematuria occurs after percutaneous renal biopsy it should be considered to diagnose as AVF. Although rates of macrohematuria as low as 3% or less have also been reported (33-35) significant macrohematuria leading to anemia rate was not seen our study suggesting that all needle sizes can be used with equal safety.

Biopsy-induced AVF and pseudoaneurysm are known to be correctly identified by CDU imaging, which can distinguish intrarenal blood flow abnormalities (36) and by selective arteriography, which can evaluate size and localization (37). Although angiography is known as a gold standard for the diagnosis of postbiopsy AVF and pseudoaneurysm, CDU has been used effectively to detect AVF and pseudoaneurysm after biopsy (26, 31, 32, 37-39). In a series of 208 biopsies of renal allografts, Renowden et al. detected 16 AVF and found none false positive or false-negative outcomes with CDU as compared with angiography (32).

AVF and pseudoaneurysm can present with many different symptoms such as continuous abdominal bruit, palpable thrill, high output cardiac failure, thromboembolic phenomenon, reduced renal function and severe hypertension (6). As in previous studies (40, 41), Omoloja et al. reported that in their case report that the patient's creatinine level increased from a baseline of 0.8 mg/dL to 1.3 mg/dL 6 weeks after biopsy with an elevated blood pressure (10). In a review of 30 postbiopsy AVF in the De Beukelaer et al. study (42) most was in hypertensive patients. All of our patients were normotensive and neither blood pressure nor creatinine level was increased after renal biopsy and these symptoms were not detected in our patients. Nonetheless, when AVF and pseudoaneurysm cause severe clinical signs such as persistent hematuria, high-flow shunts and deterioration of renal function, or when there is a high risk of rupture, e.g. in the presence of severe hypertension and progressive increase in size of pseudoaneurysm, it has been established that selective

arteriography is essential (4). There was none of these findings or significant bleeding post-biopsy in our patients so we did not consider an angiography procedure.

It is suggested that the particular route of the biopsy track, precise position of the real-time ultrasonography during biopsy (43), renal medullary disease, nephrocalcinosis, hypertension, renal insufficiency, and number of attempts and depth of the biopsy are more relevant to the incidence of complications than the size of the needle used (44). Any core-cutting biopsy needle introduced through a large renal artery or vein is likely to cause a serious complication irrespective of the needle size. There is a well-documented range of AVF and pseudoaneurysm after percutaneous core biopsies in both native and transplanted kidneys ranging from 0.9 to 15 % (45). Selim et al. (46) reported that parenchymal pseudoaneurysm of a renal allograft may appear after core needle biopsy. They suspected that the size of the core biopsy needle which was 14 G was a likely contributor as well as the biopsy region which was the corticomedullary junction. In contrast, our biopsy specimens were usually removed from the lower and upper pole with an ultrasonographic automated 16 G biopsy needle. While ultrasound guidance is helpful in avoiding major vascular injuries of this sort, it is more difficult to avoid penetrating the renal medulla even with the help of imaging. Bleeding would be expected to be more likely when the biopsy needle penetrates the renal medulla, as this is the site of the larger renal blood vessels.

CONCLUSION

AVF occurring after renal biopsies are not rare, but are mostly silent. Clinicians should be aware of the ideal needle size and method of imaging to obtain tissue. To optimize safety, patient comfort, and diagnostic yield, they can use to a 16-G automated needle with real-time U/S guidance as a standard approach. Future studies evaluating AVF as a complication of renal biopsy should focus methods and needle size to modify this risk for patients who require this procedure.

REFERENCES

1. Vogler C, Wang Y, Brink DS, Wood E, Belsha C, Walker PD: Renal pathology in the pediatric transplant patient. *Adv Anat Pathol* 2007; 14: 202-216
2. Furness PN, Philpott CM, Chorbadian MT, Nicholson ML, Bosmans JL, Corthouts BL, Bogers JJ, Schwarz A, Gwinner W, Haller H, Mengel M, Seron D, Moreso F, Cañas C: Protocol biopsy of the stable renal transplant: A multicenter study of methods and complication rates. *Transplantation* 2003;76: 969-973
3. Feneberg R, Schaefer F, Zieger B, Waldherr R, Mehls O, Schärer K: Percutaneous renal biopsy in children: A 27-year experience. *Nephron* 1998; 79: 438-446
4. Matsell DG, Jones DP, Boulden TF, Burton EM, Baum SL, Tonkin IL: Arteriovenous fistula after biopsy of renal transplant kidney: Diagnosis and treatment. *Pediatr Nephrol* 1992; 6: 562-564

5. Brandenburg VM, Frank RD, Riehl J: Color-coded duplex sonography study of arteriovenous fistulae and pseudoaneurysms complicating percutaneous renal allograft biopsy. *Clin Nephrol* 2002; 58: 398-404
6. Tarif N, Dunne PM, Parachuru PR, Bakır AA: Life-threatening hematuria from an arteriovenous fistula complicating an open renal biopsy. *Nephron* 1998; 80: 66-70
7. Riccabona M, Schwinger W, Ring E: Arteriovenous fistula after renal biopsy in children. *J Ultrasound Med* 1998; 17: 505-508
8. Riehl J, Maigatter S, Kierdorf H, Schmitt H, Maurin N, Sieberth HG: Percutaneous renal biopsy: Comparison of manual and automated puncture techniques with native and transplanted kidneys. *Nephrol Dial Transplant* 1994; 9: 1568-1574
9. Rütth EM, Dittrich K, Jüngert J, Uder M, Rascher W, Dötsch J: Successful interventional treatment of arteriovenous fistula after kidney biopsy in paediatric patients—a report of three cases. *Nephrol Dial Transplant* 2008; 23: 3215-3218
10. Omoloja AA, Racadio JM, McEnery PT: McEnery: Post-biopsy renal arteriovenous fistula. *Pediatr Transplantation* 2002; 6: 82-85
11. Alcázar R, de la Torre M, Peces R: Symptomatic intrarenal arteriovenous fistula detected 25 years after percutaneous renal biopsy. *Nephrol Dial Transplant* 1996; 11: 1346-1348
12. Racusen LC, Solez K, Colvin RB, Bonsib SM, Castro MC, Cavallo T, Croker BP, Demetris AJ, Drachenberg CB, Fogo AB, Furness P, Gaber LW, Gibson IW, Glotz D, Goldberg JC, Grande J, Halloran PF, Hansen HE, Hartley B, Hayry PJ, Hill CM, Hoffman EO, Hunsicker LG, Lindblad ES, Marcussen N, Mihatsch MJ, Nadasdy T, Nickerson P, Olsen TS, Papadimitriou JC, Randhawa PS, Rayner DC, Roberts I, Rose S, Rush D, Madrigal LS, Salomon DR, Sund S, Taskinen E, Trpkov K, Yamaguchi Y: The Banff 97 working classification of renal allograft pathology. *Kidney Int* 1999;55:713
13. Friedewald WT, Levy RI, Fredrickson DS: Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem* 1972; 18: 499-502
14. Levey AS, Coresh J, Greene T, Marsh J, Stevens LA, Kusek JW, Van Lente F; Chronic Kidney Disease Epidemiology Collaboration: Expressing the Modification of Diet in Renal Disease Study equation for estimating glomerular filtration rate with standardized serum creatinine values. *Clin Chem* 2007; 53: 766-772
15. Korbet SM: Percutaneous renal biopsy. *Semin Nephrol* 2002; 22: 254-267
16. Kim D, Kim H, Shin G, Ku S, Ma K, Shin S, Gi H, Lee E, Yim H: A randomized, prospective, comparative study of manual and automated renal biopsies. *Am J Kidney Dis* 1998; 32: 426-431
17. Nyman RS, Cappelen-Smith J, al Suhaibani H, Alfurayh O, Shakweer W, Akhtar M: Yield and complications in percutaneous renal biopsy. A comparison between ultrasound-guided gun-biopsy and manual techniques in native and transplant kidneys. *Acta Radiol* 1997; 38:431-436
18. Burstein DM, Korbet SM, Schwartz MM: The use of the automatic core biopsy system in percutaneous renal biopsies: A comparative study. *Am J Kidney Dis* 1993; 22: 545-552
19. Manno C, Strippoli GF, Arnesano L, Bonifati C, Campobasso N, Gesualdo L, Schena FP: Predictors of bleeding complications in percutaneous ultrasound-guided renal biopsy. *Kidney Int* 2004; 66:1570-1577
20. Arora K, Punia RS, D'Cruz S: Comparison of diagnostic quality of kidney biopsy obtained using 16g and 18g needles in patients with diffuse renal disease. *Saudi J Kidney Dis Transpl* 2012;23:88-92
21. Nicholson ML, Wheatley TJ, Doughman TM, White SA, Morgan JD, Veitch PS, Furness PN: A prospective randomized trial of three different sizes of core-cutting needle for renal transplant biopsy. *Kidney Int* 2000; 58: 390-395
22. Orons PD, Zajako AB: Angiography and interventional aspects of renal transplantation. *Radiol Clin North Am* 1995; 33: 461-471
23. Boschiero LB, Saggin P, Galante O, Prati GF, Dean P, Longo M, Ancona G: Renal needle biopsy of the transplant kidney: Vascular and urologic complications. *Urol Int* 1992; 48(2): 130-133
24. Bilge I, Rozanes I, Acunas B, Minareci O, Nayir A, Oktem F, Tonguç E, Kozok Y, Emre S, Ander H, Sirin A, Poyanli A: Endovascular treatment of arteriovenous fistulas complicating percutaneous renal biopsy in three paediatric cases. *Nephrol Dial Transplant* 1999; 14: 2726-2730
25. Beaujeux R, Boudjema K, Ellero B, Rimmelin A, Roy C, Dietemann JL, Wolf P, Cinqualbre J, Bourjat P: Endovascular treatment of renal allograft post-biopsy arteriovenous fistula with platinum microcoils. *Transplantation* 1994; 57: 311-314
26. Rollino C, Garofalo G, Rocchetto D, Sorrentino T, Sandrone M, Basolo B, Quattrocchio G, Massara C, Ferro M, Picciotto G, Rendine C, Piccoli G: Color coded Doppler sonography in monitoring native kidney biopsies. *Nephrol Dial Transplant* 1994; 9: 1260-1263
27. Tung KT, Downes MO, O'Donnell PJ: Renal biopsy in diffuse renal disease: Experience with a 14-gauge automatic biopsy gun. *Clin Radiol* 1992; 46:111-113
28. Altebarmakian VK, Guthinger WP, Yakub YN, Guitierrez OH, Linke CA: Percutaneous kidney biopsies: Complications and their management. *Urology* 1981; 18:118-122
29. Ekelund L, Lindholm T: Arteriovenous fistulae following percutaneous renal biopsy. *Acta Radiol Diagn (Stockh)* 1971; 11(1): 38-48
30. Bennett AR, Wiener SN: Intrarenal arteriovenous fistula and aneurysm: A complication of percutaneous renal biopsy. *Am J Roentgenol Radium Ther Nucl Med* 1965; 95:372-382
31. Hubsch PJS, Mostbeck G, Barton P, Gritzmann N, Fruehwald FXJ, Schurawitzki H, Kovarik J: Evaluation of arteriovenous fistulae and pseudo aneurysm in renal allograft following percutaneous needle biopsy. *J Ultrasound* 1990; 9: 95-100
32. Renowden SA, Blethyn J, Cochlin DL: Duplex and color flow sonography in diagnosis of post biopsy arteriovenous fistulae in the transplant kidney. *Clin Radiol* 1992; 45:233-237
33. Pillay VK, Kurtzman NA: Percutaneous biopsy of the transplanted kidney. *JAMA* 1973; 226:1561-1562

34. Buselmeier TJ, Schauer RM, Mauer SM, Goetz FC, Simmons RL, Najarian JS, Kjellstrand CM, Najarian JS, Kjellstrand CM: A simplified method of percutaneous allograft biopsy. *Nephron* 1976; 16:318-321
35. Nagar D, Wathen RL: An improved method for renal allograft biopsy. *Kidney Int* 1979; 16: 519-521
36. Bach AM, Merton DA, Burke JF Jr, Halpern EJ: Sonographic diagnosis of arteriovenous fistula and pseudoaneurysm after biopsy of a transplanted kidney. *J Ultrasound Med* 1993; 12: 545-547
37. Hubsch P, Schurawitzki H, Traindl O, Karmel F: Renal allograft arteriovenous fistula due to needle biopsy with late onset of symptoms – diagnosis and treatment. *Nephron* 1991; 59: 482-485
38. Harrison KL, Nghiem HV, Coldwell DM, Davis CL: Renal dysfunction due to an arteriovenous fistula in a transplant patient. *J Am Soc Nephrol* 1994; 5: 1300-1306
39. Pall AA, Reid AW, Allison ME: Renal artery aneurysm six years after percutaneous renal biopsy: Successful treatment by embolization. *Nephrol Dial Transplant* 1992; 7: 883
40. al Rasheed SA, al Mugeiren MM, Abdurrahman MB, Elidrissy AT: The outcome of percutaneous renal biopsy in children: An analysis of 120 consecutive cases. *Pediatr Nephrol* 1990; 4: 600-603
41. Escolar G, Dí'az-Ricart M, Cases A: Uremic platelet dysfunction: Past and present. *Curr Hematol Rep* 2005; 4: 359-367
42. De Beukelaer MM, Schreiber MH, Dodge WF, Travis LB: Intrarenal arteriovenous fistulas following needle biopsy of the kidney. *J Pediatr* 1971; 78: 266
43. Jiang WX, Wang HF, Ma J, Han HJ.: Arteriovenous fistula and pseudoaneurysm as complications of renal biopsy treated with percutaneous intervention. *Chin Med J* 2010; 123 (19):2736-2738
44. Wickre CG, Golper TA: Complications of percutaneous needle biopsy of the kidney. *Am J Nephrol* 1982; 2: 173-178
45. Orons PD, Zajko AB: Angiography and interventional aspects of renal transplantation. *Radiol Clin North Am* 1995; 33:461
46. Selim M, Goldstein MJ: Goldstein Case report: Parenchymal pseudoaneurysm of a renal allograft after core needle biopsy: A rare cause of allograft injury. *Transplantation Proceedings* 2011; 43: 2781-2783