Factors Associated with Complications and Adequacy of Percutaneous Kidney Biopsy

Kraiwiporn Kiattisunthorn, M.D., Suchai Sritippayawan, M.D., Ratana Chawanasuntorapoj, M.D., Nalinee Premasathian, M.D., Kriengsak Vareesangthip, M.D., Ph.D., Leena Ong-Aj-yooth, M.D.

Department of Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.

ABSTRACT

Objective: Percutaneous kidney biopsy (PKB) is an essential procedure in practical nephrology. However, it may cause serious complications, especially in high-risk patients. This study is to determine the factors associated with the complications and the adequacy of PKB under ultrasonic guidance.

Methods: Patients were stratified according to serum creatinine (SCr) and randomized for needle types (spring-loaded automatic gun and Tru-cut needle), diameters (16G vs 18G) and the effect of compression at biopsy site. The patients were observed for major (bleeding requiring a blood transfusion or intervention) and minor (not requiring intervention) complications.

Results: The patients with serum creatinine (SCr) < 4.0 mg/dl (n=133) had significantly lower complications than those with SCr ≥ 4.0 mg/dl (n=35), both major (2 [1.5%] vs. 5 [14.3%]) and minor (6 [4.5%] vs. 3 [8.5%]). All complications occurred within 48 hours (93.8% within 24 hours). In group A, no significant difference in complications was found in needle types, axes, diameters and compression at the biopsy site, including numbers of puncture (< 6 times), length of tissue, kidney size and echogenicity. All samples except two were adequate for diagnosis, with an average of 13 glomeruli. There was no significant difference in tissue adequacy (≥ 10 glomeruli) in needle types and diameters, but the failure rate and number of puncture were higher with the Tru-cut needle ($p < 0.01$).

Conclusion: The needle type and size or compression at the puncture site do not affect the complication after PKB under ultrasonic guidance, whereas a SCr ≥ 4.0 mg/dl is an important factor of the complications but there is no effect on the adequacy of the renal tissues.

Keywords: Percutaneous kidney biopsy; Complication; Factor; Adequacy; Creatinine

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Percutaneous kidney biopsy (PKB) has become an essential tool in the diagnosis and treatment of patients with glomerular disease, but it may result in bleeding and other complications. Technical advancement in renal ultrasonography and biopsy needles has improved the success rate of PKB. The real-time ultrasonography has been applied to locate the kidney during the procedure. There are several studies that compared the safety and adequacy of the kidney biopsy using Tru-cut needle and spring-loaded automatic biopsy needle. It has been claimed that the complications from the use of Tru-cut needles were higher than those from the latter. Even though the number of glomeruli obtained from a Tru-cut needle were higher than a spring-loaded one, the information for diagnosing renal biopsy tissues was similar between the two methods.[1-8] However, the diameter of Tru-cut needles is larger. We, therefore, cannot conclude whether the size or type of the biopsy needle is the major factor predisposing to the complications after PKB.

Correspondence to: Kraiwiporn Kiattisunthorn
E-mail: kraiwiporn@mahidol.ac.th

The standard of care after a kidney biopsy has included bed rest with compression at the punctured site for 24 hours. The native kidneys are retroperitoneal organs and they move along with respiration. The pressure applied to the back may not reach the puncture site; rather, it may be painful and uncomfortable.

Our study was designed to compare the success, defined as minimal complications and tissue adequacy, of the percutaneous kidney biopsy under real-time ultrasonography with the use of both types (spring-loaded automatic gun and Tru-cut) of needles and diameters (16 guage (16G) and 18 guage (18G)). Additionally, we wanted to evaluate the effects of compression at the puncture site for prevention of complications.

MATERIALS AND METHODS

From April 2003 to February 2004, 168 percutaneous kidney biopsies were performed using real-time ultrasound guidance in the Renal Division, Siriraj Hospital. All patients who were more than 15 years old and underwent kidney biopsies under medical indication were recruited. Exclusion criteria were an inability to cooperate, uncorrectable prolonged coagulogram or thrombocytopenia, severe hypertension, defined as systolic blood pressure

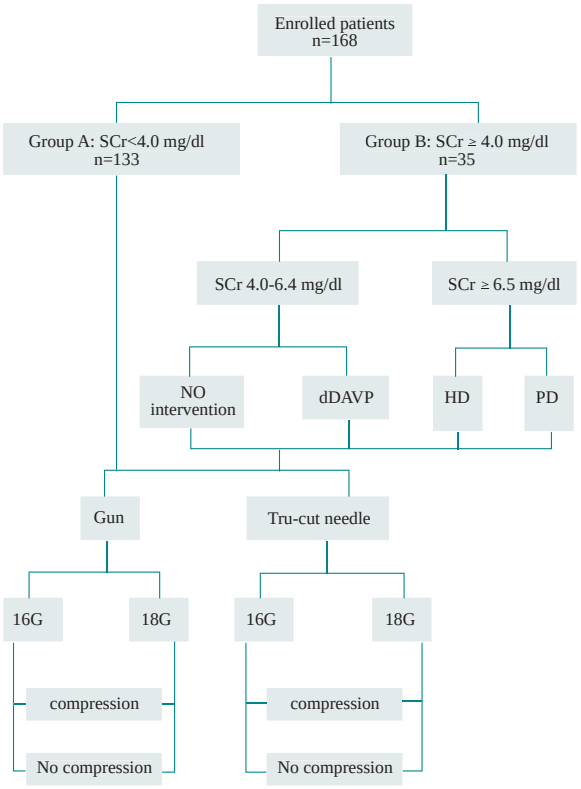

Fig 1. The process of randomization

dDAVP = Deamino-8-D-arginine vasopressin, HD = hemodialysis, PD = peritoneal dialysis

(SBP) ≥ 180 or diastolic blood pressure (DBP) ≥ 100 mmHg, and solitary kidney. All patients had a normal platelet count and coagulogram at the time of the biopsy. Drugs that affected coagulogram or platelet count, for example, aspirin, NSAIDs, heparin, and warfarin, were stopped until their effect disappeared. The patients were stratified according to their serum creatinine (SCr): group A, SCr < 4.0 mg/dl, and group B, SCr ≥ 4.0 mg/dl. In group B, the patients received intervention to prevent bleeding complications due to platelet dysfunction. The patients with SCr 4.0-6.4 mg/dl were randomized to receive either no specific treatment or dDAVP 0.3 μg/kg intravenously one hour before biopsy. Those with SCr ≥ 6.5 mg/dl received either hemodialysis or 50 exchanges of acute peritoneal dialysis prior to the procedure (Fig 1). All of them were randomized for the percutaneous kidney biopsy, using a 16G or 18G spring-loaded automatic biopsy needle or a 16G or 18G Tru-cut needle. After the biopsy, the patients were randomized, either to receive puncture site compression using a sandbag for eight hours or to continue absolute bed rest without compression. All of them were placed in supine position for 24 hours.

All biopsies were done either by attending nephrologists (27.4 %) or second-year nephrology trainees (72.6%). The patients were in prone position with a pillow support under their abdomen. The lower pole of the kidney was localized by the Puncture Electronic Linear Probe UST-5039P-3.5 (3.5-MHz). The biopsy was performed under a sterile technique and local anesthesia. A small cut with a No.11 scalpel blade was made on the skin and the biopsy needle was inserted until it reached the kidney capsule. The patients were asked to hold their breath for a few seconds while the needle was fired. The biopsy was repeated until an adequate amount of tissue was obtained. If the kidney tissue could not be obtained within two attempts with the randomized needle, we performed a biopsy with another type of needle of the same diameter.

After the biopsies, the patients were closely observed for symptoms and signs of any complications, for example, gross hematuria, subcapsular hematoma and hypotension (BP < 90/60, decrease of SBP or DBP ≥ 30, 15 mmHg, respectively). The complications were divided into two categories, namely: major complication, which requires further intervention such as blood transfusion, Deamino-8-D-arginie vasopressin dDAVP or transamine administration, embolization, nephrectomy, infection caused by the procedure or death; and minor complication which requires only supportive treatment.

The tissue adequacy and tissue diagnosis were interpreted by a pathologist. The tissue adequacy was defined as obtaining more than 10 glomeruli[9,10] and tissue diagnosis was defined as the ability to make a diagnosis from the biopsied tissue. The frequency of failure to obtain glomeruli, defined as the inability to obtain adequate renal tissue within two attempts, was also recorded.

The patients without complications were discharged 72 hours after the biopsy and were followed up at the out-patient clinic approximately one week after discharge.

The data were analyzed using SPSS v.12.0 for Windows. The chi-square and the independent-samples t-test were used to compare the differences between the study groups. Results were expressed as mean ± standard deviation. A p value of less than 0.05 was considered statistically significant.

TABLE 1. The baseline characteristics

Characters	Needle type		Needle diameter		Compression after biopsy	
	Gun (n=87)	Tru-cut (n=81)	16G (n=91)	18G (n=77)	Yes (n=94)	No (n=74)
Age (yr)	38 ± 14	38 ± 16	36.5 ± 14.2	39.3 ± 15.3	28.2 ± 15.4	37.6 ± 14.5
Hematocrit (%)	32.3 ± 7.2	33.9 ± 7.1	33.2 ± 6.9	32.8 ± 7.3	32.7 ± 6.9	33.2 ± 7.2
Platelets (x109/L)	271.3 ± 134	269.6 ± 78.1	283.1 ± 115.8	260.3 ± 90.4	265.6 ± 120.8	276.2 ± 92.1
PT (s)	11.1 ± 1.1	10.6 ± 1.1	10.6 ± 1.1	11.0 ± 1.4	10.8 ± 1.1	10.9 ± 1.3
PTT (s)	25.1 ± 3.9	25.3 ± 2.9	25.4 ± 3.9	25.1 ± 3.4	25.1 ± 3.7	25.3 ± 3.6
SCr (mg/dl)	3.2 ± 3.6	2.4 ± 2.6	2.6 ± 2.5	2.9 ± 3.5	2.6 ± 1.7	2.9 ± 3.3
SBP (mmHg)	133.1 ± 20	130.9 ± 17.6	130.8 ± 19.7	133.1 ± 16.3	130.5 ± 17.4	132.7 ± 18.6
DBP (mmHg)	78.9 ±11.9	79.1 ± 11.3	78.5 ± 11.8	80.4 ± 10.9	78.7 ± 11.3	79.9 ± 11.5
BMI (kg/m2)	23.7 ± 3.7	23.1 ± 4.4	23.1 ± 3.9	23.8 ± 4.4	23.9 ± 4.5	22.9 ± 3.7
Kidney size (cm)	9.6 ± 0.9	9.7 ± 0.7	9.65 ± 0.75	9.55 ± 0.83	9.62 ± 0.82	9.6 ± 0.8
Echogenicity no:increase	67:20	72:9	108:25	28:7	106:27	29:6
Direction 1:2:3	39:27:21	29:26:26	66:36:31	19:9:7	64:38:31	19:9:7

TABLE 2. The baseline characteristics between the patients in group A (SCr < 4.0 mg/dl) and group B (SCr ≥ 4.0 mg/dl)

Characters	Group A n=133	Group B n=35	p value
Age (yr)	37.8 ± 14.7	37.9 ± 15.6	0.94
Hematocrit (%)	34.1 ± 7.2	28.8 ± 4.7	0.001
Platelets x109/L	279.2 ± 105.2	242.6 ± 98.6	0.35
PT (s)	10.7 ± 1.2	11.3 ± 1.3	0.27
PTT (s)	24.9 ± 3.5	26.2 ± 4.2	0.12
SCr (mg/dl)	1.5 ± 0.9	7.6 ± 3.8	0.001
SBP (mmHg)	129.7 ± 18.3	140.7 ± 14.5	0.04
DBP (mmHg)	78.49 ± 11.5	83.24 ± 10.4	0.009
BMI (kg/m2)	23.7 ± 4.2	22.5 ± 3.9	0.11
Kidney size (cm)	9.65 ± 0.76	9.41 ± 0.92	0.07
Length of tissue (cm)	0.86 ± 0.3	0.88 ± 0.3	0.82
Echogenicity no:increase	117:16	19:16	0.03
Direction 1:2:3	68:36:29	19:9:7	0.89
Gun:Tru-cut	67:66	20:15	0.52
Diameter 16G:18G	70:63	21:14	0.44
Compression yes:no	70:63	11:24	0.47

TABLE 3. The complications and serum creatinine

	Group A, SCr < 4.0 mg/dl, n=133 (%)	Group B, SCr ≥ 4.0 mg/dl, n=35 (%)	p value
Major complications	2 (1.5)	5 (14.3)	0.005
Minor complications	6 (4.5)	3 (8.5)	0.40
total	8 (6.0)	8 (22.9)	0.006

TABLE 4. The complications and the randomized parameter

Parameters	Group A, SCr < 4.0 mg/dl, n=133 (%)	Group B, SCr ≥ 4.0 mg/dl, n=35 (%)	Total cases n=168 (%)
Needle type			
Gun	5 (3.8)	4 (11.4)[a]	9 (5.4)
Tru-cut	3 (2.3)	4 (11.4)[a]	7 (4.2)
Needle diameter			
16G	5 (3.8)	4 (11.4)[a]	9 (5.4)
18G	3 (2.3)	4 (11.4)[a]	7 (4.2)
Compression after biopsy			
Yes	5 (3.8)	2 (5.7)	7 (4.2)
No	3 (2.3)	6 (17.1)[a]	9 (5.4)

a. p < 0.05 versus group A

TABLE 5. Pretreatment and complications

SCr (mg/dl)	Pretreatment n (%)	Complication n (%)	*p* value
4.0-6.4	None (7)	3 (42.9)	0.59
	dDAVP (10)	2 (20.0)	
≥ 6.5	HD (12)	3 (25.0)	0.51
	PD (6)	0 (0)	

dDAVP = Deamino-8-D-arginine vasopressin, HD = hemodialysis, PD = peritoneal dialysis

TABLE 6. Adequacy

	Needle type		Needle diameter	
	Gun n=87 (%)	Tru-cut n=81 (%)	16G n=91 (%)	18G n=77 (%)
≥ 10 glomeruli	56 (64.4)	55 (67.9)	68 (74.7)	43 (55.8)[a]
For diagnosis	82 (94.3)	80 (98.8)	89 (97.8)	73 (94.8)
≥ 3 attempts	19 (28.4)	40 (60.6)[b]	28 (40)	31 (49.2)

a. p < 0.05 compare between type of needle
b. p < 0.001 compare between needle diameter

RESULTS

One hundred and sixty-eight native percutaneous kidney biopsies were analysed. There were 133 (79.2%) and 35 (20.8%) biopsies in group A (SCr < 4.0 mg/dl) and group B (SCr ≥ 4.0 mg/dl), respectively. The baseline characteristics between the randomized groups, the needle type and diameter and whether the puncture site compression was applied were not significantly different.

Overall complications occurred in 16 biopsies (9.5%). There were 7 (4.2%) major and 9 (5.3%) minor complications. No patient needed nephrectomy or died. The most frequent event was gross hematuria (11 cases, 6.5%). The patients in group B had a higher rate of complications compared to those in group A (22.9% vs. 6.0%, RR = 3.80; 95%CI 1.53-9.41; p = 0.006), especially major complications (14.3% vs. 1.5%, RR = 9.50, 95%CI 1.92-46.91; p = 0.005).

In both groups A and B, compression at the biopsy site, both needle types and diameter size did not result in a statistically different rate of complication. We also found no effect of these factors on the complications: kidney size (< 9.0 cm), increased renal echogenicity, biopsy side, the presence of ascites, the number of biopsies attempted or the operator. (p NS)

In the group with SCr ≥ 4.0 mg/dl, we found no statistical difference between those who received the pretreatment with dDAVP or received no specific treatment. In terms of dialysis mode before the biopsy, there were no complications in the patients who had acute peritoneal dialysis, compared with a 25% complication rate in those who received hemodialysis treatment, but there was no statistical significance.

The overall adequacy of the diagnoses was 96.4% (162 from 168 biopsies). The mean number of glomeruli obtained was 13.1 ± 7.8 (0-56 glomeruli per biopsy).

There was no statistically difference in adequacy of tissue (≥ 10 glomeruli) or adequacy in making a diagnosis between both types of needles; however, the number of patients who were punctured more than twice to obtain adequate tissue was higher in the Tru-cut needle group. (60.6% vs. 28.4%; RR = 2.26, 95%CI 1.44-3.56; p = 0.0003) (Table 6). In addition, there was a higher failure rate to obtain kidney tissue in the Tru-cut (0% vs. 24.7%; p < 0.0001) and reused needle groups (3.7% vs. 20.98%; RR =5.67, 95%CI 1.05-55.2; p = 0.026). From multivariate analysis we found that the type and number of needles reused were statistically significant variables that had a predictive value in requiring more than two attempts to obtain adequate tissue in the Tru-cut needle group. Whereas there was no failure rate in either new or reused spring-loaded gun.

Using different needle sizes did not result in a statistical difference in diagnostic adequacy and number of passes required. However, the group using a larger needle diameter (16G) had more specimens containing more than 10 glomeruli. A multivariate analysis was performed. The only statistically significant factor was the needle diameter size.

DISCUSSION

In our study, the overall complications of percutaneous kidney biopsy are 9.5% which is similar to previous studies. However, it is difficult to compare the rate of complications from each report because of the variability of the baseline characteristics of the biopsied population

and the different complication criteria.[1-11] Percutaneous kidney biopsy under real time ultrasonic guidance increased the chance of obtaining adequate tissue compared with intravenous pyelography or free-hand ultrasound guidance technique.[4,10,11] There was no correlation between needle type, needle diameter or puncture site compression and rate of complications. Although the mean glomeruli obtained were not different, in order to obtain adequate tissue, the Tru-cut needle and smaller needle diameter (18G) group required more attempts.

In the Tru-cut and small needle diameter (18G) group, more patients needed more than three attempts and specimens contained less than 10 glomeruli. Specimen with fewer glomeruli may have been enough to diagnose certain diffuse renal parenchyma diseases. But a focal disease such as FSGS could not be excluded in tissue containing less than 25 normal glomeruli.[12] Although we did not find any association between the number of passes and bleeding events, the more passes through the renal capsule, the more chance of expected complications. The limitation of this study will be discussed later.

Christensen and colleagues described factors predisposed to percutaneous kidney biopsy complications, including renal insufficiency (SCr > 1.2 mg/dl), poorly controlled hypertension (diastolic BP > 90 mmHg) and prolonged bleeding time.[5] The definition of renal insufficiency in the previous studies was a SCr range from > 1.3 to > 1.5 mg/dl.3,5 In this study we used SCr of 4.0 mg/dl as the cut-off for the opportunity of bleeding tendency. This hypothesis was based on a study of Gordge and colleagues[13] who studied platelet functions by using platelet aggregometry and found platelet dysfunction in moderate to severe renal failure patients (SCr ≥ 3.9 mg/dl). Winkelmayer and colleagues reported a five-fold increase in the risk of severe postoperative bleeding in patients with advanced renal insufficiency (estimated GFR < 40 ml/min).[14] Whittier and colleagues found a 2-3 fold increase in the complication rate in patients with SCr ≥ 5.0 mg/dl who undergone percutaneous kidney biopsies using the free-hand technique.[15] Our study included as many as 20.8% of patients with SCr ≥ 4.0 mg/dl. As a result, the complication rate was significantly higher than those of other studies. However, total and major complications, which merely required 1-2 units of blood transfusion for patients with mild renal failure, were only 6.0 and 1.5%, respectively.

The significant different baseline characteristics between the groups stratified according to serum creatinine were hematocrit, serum creatinine, increase renal parenchyma echogenicity from renal ultrasound, and systolic and diastolic blood pressure. We did not find any association with these factors, except for the serum creatinine level and complications. Nevertheless, factors associated with an increased opportunity of bleeding events such as severe hypertension and Hct < 27% were not found in our study.

We could not demonstrate the different outcomes in the groups with serum creatinine ≥ 4.0 mg/dl which received different interventions, no treatment or dDAVP and hemodialysis or peritoneal dialysis. The fact that no patient with serum Cr > 6.5 mg/dl who had pre-biopsy peritoneal dialysis had complication may be because the sample size was too small to show the difference.

From 16 cases with complication, only one patient (6.2%) was presented 24 hours after biopsy. This patient, who had severe renal failure (SCr 10.4 mg/dl) and had one hemodialysis session prior to the biopsy, presented with hematuria and a significant (7.7%) decrease in hematocrit 36 hours after the biopsy. The treatment was bed rest and one unit of packed red blood cell transfusion. The data may be used to determine the appropriate time required to observe patients with low risk for complications which may reduce the length of their hospital stay and cost. Nevertheless, Whittier and colleagues reported complications 120 hours after a biopsy.[15] In the study, they performed 750 percutaneous renal biopsies and reported 11% complication rate, 9% of which presented with major complications. All required re-admission as well as blood transfusion or bed rest. None of them lost their kidney or died. The authors, however, did not describe their renal function or other characteristics that might be associated with bleeding complications.

There were a number of limitations in our study. Firstly, the exact number of complications was underestimated, because we only did renal ultrasonography in symptomatic patients. As a result, asymptomatic subcapsular hematoma was not identified. Previous studies reported over 90% incidence of perinephric hematoma from plain computerized scanning 24 to 72 hours after biopsy.[16] The majority of hematomas were small to moderate in size which resolved spontaneously. Clinically significant hematomas occurred in less than 2% of the biopsy procedures.[17] Timing of the evaluation and the imaging method used in our study may explain the difference in the incidence of perinephric hematoma detected. Secondly, there were a small number of patients in the group with moderate to severe renal failure, and the number of patients with complication was so low that we could not demonstrate factors associated with complications or the effect of intervention on complications. Thirdly, performing the biopsy using a Tru-cut needle may require more skill, resulted in a greater failure rate and more attempts were required to obtain adequate amount of tissue. Fourthly, the difficult cases were biopsied by experienced staff, which explained the similar complication rate despite more risk factors. Finally, 92% of cases had four or less needle passes. The high risk patients had a fewer number of punctures so the result did not show a statistically significant difference in the complication rate compared with lower risk patients who had more needle passes.

CONCLUSION

Percutaneous kidney biopsy under ultrasonic guidance is safe and effective, especially in patients with normal renal function and mild renal impairment. The risk of complication is not associated with needle type, needle's diameter or effect of post biopsy puncture site compression. However, we recommend that a biopsy on the moderate to severe renal failure patients should be done by experienced nephrologists who are familiar with the technique in order to reduce the number of needle passes and complications. Further investigations should be needed to determine the efficacy of intervention given prior to the biopsy and factors predisposed to the complications in patients with significant renal impairment.

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บทคัดย่อ

ปัจจัยที่มีผลต่อภาวะแทรกซ้อนและความพอเพียงของชิ้นเนื้อที่ได้จากการตัดชิ้นเนื้อไต โดยใช้เครื่องอัลตราซาวน์ดูตำแหน่งไต

ไกรวิพร เกียรติสุนทร พ.บ., สุชาย ศรีทิพยวรรณ พ.บ., รัตนา ชวนะสุนทรพจน์ พ.บ., นลินี เปรมัษเฐียร พ.บ., เกรียงศักดิ์ วารีแสงทิพย์ พ.บ. ปร.ด., ลีนา องอาจยุทธ พ.บ.

ภาควิชาอายุรศาสตร์, คณะแพทยศาสตร์ศิริราชพยาบาล, มหาวิทยาลัยมหิดล, กทม 10700, ประเทศไทย

วัตถุประสงค์: การตรวจพยาธิสภาพชิ้นเนื้อไตเป็นหัตถการที่สำคัญและจำเป็นอย่างหนึ่งในการวินิจฉัยและรักษาโรคไต แต่อาจจะก่อให้เกิดภาวะแทรกซ้อนที่รุนแรงโดยเฉพาะผู้ป่วยที่มีปัจจัยเสี่ยงสูง เพื่อประเมินปัจจัยที่มีผลต่อการเกิดภาวะแทรกซ้อนและความพอเพียงของชิ้นเนื้อที่ได้จากการตัดชิ้นเนื้อไตโดยใช้เครื่องอัลตราซาวน์ดูตำแหน่งของไต

วิธีการ: ศึกษาในผู้ป่วย 168 ราย แบ่งผู้ป่วยเป็น 2 กลุ่มตามระดับ serum creatinine (SCr) กลุ่มที่ 1 SCr น้อยกว่า 4.0 มก./ดล. (133 ราย) และกลุ่มที่ 2 SCr มากกว่าหรือเท่ากับ 4.0 มก./ดล. (35 ราย) สุ่มเลือกชนิด (spring-loaded automatic gun/Tru-cut needle) ขนาดของเข็ม (16G/18G) ที่จะใช้ในการตัดชิ้นเนื้อไต และการกดทับบริเวณที่ตัดชิ้นเนื้อไต (กดทับ/ไม่กดทับ) การประเมินผลของการศึกษาดูจาก 1. การเกิดภาวะแทรกซ้อนชนิดรุนแรงและไม่รุนแรง 2. ความพอเพียงของชิ้นเนื้อที่ได้ในการวินิจฉัย

ผลการศึกษา: ผู้ป่วยในกลุ่มที่ 2 มีอัตราการเกิดภาวะแทรกซ้อนชนิดรุนแรงมากกว่ากลุ่มที่ 1 อย่างมีนัยสำคัญทางสถิติ (14.3% vs 1.5%) ภาวะแทรกซ้อนทั้งหมดเกิดภายใน 48 ชั่วโมง (93.8% ภายใน 24 ชั่วโมง) โดยไม่พบความสัมพันธ์ระหว่างภาวะแทรกซ้อนและชนิดหรือขนาดของเข็ม รวมทั้งการกดทับบริเวณที่ตัดชิ้นเนื้อไต ผู้ป่วย 162 ราย (96.4%) ได้รับการวินิจฉัยจากพยาธิสภาพเนื้อไต จำนวน glomeruli เฉลี่ยเท่ากับ 13 glomeruli โดยไม่พบความสัมพันธ์ระหว่างความพอเพียงของเนื้อไตที่ได้ (มากกว่า 10 glomeruli) และชนิดของเข็ม แต่สัมพันธ์กับขนาดของเข็ม จำนวนผู้ป่วยที่ต้องได้รับการเจาะมากกว่าเท่ากับ 3 ครั้งในกลุ่มที่ใช้ Tru-cut needle มากกว่า gun อย่างมีนัยสำคัญทางสถิติ (40 [60.6%] vs 19 [28.4%], $p < 0.01$)

สรุป: การใช้เครื่องมือที่ต่างชนิดกันหรือการกดทับบริเวณที่เจาะหลังการเจาะตัดชิ้นเนื้อไตส่งตรวจไม่มีผลแตกต่างในการเกิดภาวะแทรกซ้อนหลังการเจาะไต ในขณะที่ serum creatinine ที่เกิน 4.0 mg/dl เป็นปัจจัยเสี่ยงที่สำคัญในการเกิดภาวะแทรกซ้อน โดยไม่มีผลต่อจำนวน glomeruli ที่ใช้ในการกำหนดความพอเพียงของชิ้นเนื้อที่ส่งตรวจ