Ultrasound Monitoring After Kidney Biopsy as Predictor of Bleeding Complications

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Abstract

Introduction: Percutaneous Renal Biopsy (PRB) remains the most important tool in the diagnosis and treatment of patients with kidney disease. The introduction of ultrasound (US) guidance with automated spring-load device has been a focal point in the management of renal biopsies, making the procedure quicker and easier. However, the best period of observation of bed rest and observation in hospital is not yet known. Kidney biopsies are usually devoid of significant complications and when they appear, are the result of bleeding around (hematoma) or in the collecting system (macrohematuria) of the kidney. The most frequent complication, related to biopsies is perinephric hematoma usually clinically silent and resolve spontaneously. The aim of this study is to define the role of the changes of hematoma volume, detected by the US, as significant determinant of outcomes in patients (pts) undergone PRB. We compared the hematomas at 30 minutes (T0) and after 8 hrs (T8) and 24 hrs (T24), after kidney biopsy.

Methods: In 72 consecutive patients, ultrasound guided percutaneous renal biopsies were performed with an automated biopsy device. Clinical and biochemical features of each patient at the time of the biopsy were reported. On ultrasound images, the volume of hematomas were calculated with ellipsoidal formula. We measured the widest diameters of the hematoma on sagittal and transverse sections. The size of the hematoma was recorded on a 1-4 arbitrary scale: Type 1 (> 0 ≤ 6ml), Type 2 (> 6 ≤ 12ml), Type 3 (> 12 ≤ 24ml), type 4 (> 24ml). The presence or absence of the hematoma and its volume changes were evaluated at T0, T8 and T24. The pts were stratified into two groups: with or without hematoma. We compared patients with a hematoma volume greater than 6 ml with that with a volume of less than 6 ml.

Results: In the group of pts with hematoma we recorded a progressive decline in the volume of the hematoma at 8 and 24 hrs after biopsy (percentage of decline at 8 hrs 31.03% and 54.65% at 24 hours). A linear correlation between the decrease in the volume of the hematoma was found at 8 and 24 hrs post-biopsy, suggesting that the first was a predictor of the latter. The same result was also obtained when we studied only pts with larger hematomas.

Conclusions: Our data suggest that hematoma is usually formed immediately after renal biopsy. Ultrasonography shows a progressive decline of hematoma after 8 and 24 hours. We noted a linear correlation of post-biopsy reduction of hematoma between the 8th and 24th hour. If larger studies confirmed this observation, it may help nephrologist to better understand when is the best time to discharge the patient who has undergone kidney biopsy.

ABBREVIATIONS

PRB: Percutaneous Renal Biopsy; US: Ultrasound; CT: Computed Tomography; T0: Time 0; T8: Time 8; T24: Time 24; Δ: Delta

INTRODUCTION

Percutaneous Renal Biopsy (PRB) is a key tool in Nephrology which is essential for the diagnosis, management and prognosis of kidney diseases.

During the execution of the biopsy, the real-time ultrasonosound (US) enables us to monitor the progress of the needle to the renal capsule and, compared to the blind technique, allows a considerable reduction of the post-biopsy complications (2-6% vs 10%) together with a better quality of core specimen for histopathological analysis [1,2]. The associated use of the automated devices with spring-loaded needle entails an added benefit compared with traditional Tru-Cut or Vim-Silverman because the needle transit in the parenchyma is very rapid with a lower risk of kidney laceration [3,4]. Despite these technical advances which have improved the safety of the biopsy, it remains an invasive procedure and not risk-free, which can
cause complications such as bleeding arterovenous fistula (AVF) development and, more rarely, sepsis [5-7]. The most common complication after Renal Biopsy is bleeding or perinephric and/or subcapsular hematoma, which in most cases resolve spontaneously, without any further intervention or need for blood transfusions. Macrohematuria is easily detected visually, but the perirenal bleeding is more difficult to diagnose without US or computed tomography (CT) scanning. The advent of CT revealed that the post-biopsy hematomas are common in up to 85% of the patients [8,9].

Because the bleeding remains the most serious complication of PRB and hematomas are the most frequent complication, we carried out a study on consecutive US-guided kidney biopsies performed with the use of an automated device, with the scope of assessing the changing volume of hematoma detected by ultrasound and recorded in three different times during the first 24 hrs after PRB.

Our hypothesis, which this study should confirm, is that post-biopsy hematoma is formed immediately after the biopsy, reaches the biggest volume within 30 mins and subsequently tends to spontaneously decrease in the next 24 hrs after biopsy maneuver.

If the study proves that after the first 30 mins of a renal biopsy, no further bleeding is present and therefore the volume of hematoma is not increased or even decreased, then we can propose a safe and early discharge of our patients from hospital. The literature provides controversial information about the right period of bed rest and hospital recovery time after the kidney biopsy and it is debated whether PRB can be performed in outpatients. As a result of the low rate of post-biopsy complications, some authors have reported that selected patients can be discharged on the same day of the biopsy with no increased risk of complications [10,11]. Instead, others argue that an early discharge could result in a remarkable number of missed complications and they recommend monitoring of patients for a prolonged period up to 24 hrs, because an observation time less than 8 hrs is likely to miss more than 33% of complications [12].

Another study found that a stable post-PRB hematocrit at the 6th hour, predicts a low risk of bleeding complications at 24 hrs after biopsy. This observation could support the safety in performing PRB in outpatients [13].

But all these reports do not include systematic post-BRP US controls to detect complications such as hematomas. In fact, US or CT were performed only in cases of significant clinical signs such as flank pain, hypotension or remarkable decrease of hemoglobin levels.

**MATERIALS AND METHODS**

We studied prospectively 72 PRB (31 men, 41 women). All biopsies were performed under real-time US guidance using automated device with spring-loaded needle of 18 Gauge with a cannula length of 15 cm and specimen notch of 2.0 cm. A 3.5 MHz convex transducer, supplied by biopsy adapter with needle guide, has been used.

Vessels in the lower pole of the kidney were imaged before the kidney biopsy with color and power Doppler to avoid the larger vessels during biopsy manoeuvre and to monitor the bleeding after the PRB. Informed consent was obtained from all patients before performing the PRB. All patients were admitted at the renal unit of “S.G. Moscati” hospital and were observed for 24 hours after they had undergone PRB.

All biopsies were performed by a single nephrologist (S.I.) experienced in US-guided renal biopsies for more than ten years and another nephrologist skilled in renal and abdomen US-imaging (R.M.).

The indications for kidney biopsy were urinary abnormalities such as hematuria and / or proteinuria (n. 27), nephrotic range proteinuria (n. 28), acute renal failure (n. 10), abnormal serum creatinine level of uncertain etiology (n. 7).

Contraindications to kidney biopsy were an uncorrectable bleeding condition, severe hypertension that cannot be controlled with medication, renal parenchymal thickness of the lower pole of the kidney lower than 11 mm, multiple bilateral renal cysts. In patients with high risk of bleeding such as those with moderate or severe renal impairment, we followed the protocol with desmopressin 0.3 mcg / kg. A complete blood count, bleeding time, prothrombin time (PT) and activated partial thromboplastin time (APTT) were regularly obtained before performing the biopsy. A post-biopsy hemoglobin level was recorded only at 24 hours.

All patients were kept in bed laying flat on their back for 8 hrs and then they remained in bed for 18 successive hrs.

After 8 hrs, the pts were allowed to carry out mild or moderate activity if the US showed mild or no hematoma. The pts were monitored after the biopsy for signs and symptoms of complications.

We performed continuous US monitoring of all biopsied kidneys for the first 30 mins and recorded images at 30 mins (time 0 =T0); subsequently we repeated the renal US after 8 hrs (time 8 =T8) and 24 hrs (time 24 = T24). On the US images of the hematoma at T0 T8 T24, recorded with the patient in the prone position, we measured its widest diameters obtained on sagittal and cross sections. We calculated the volume of the hematoma with the ellipsoidal formula: longitudinal diameter x width x thickness x 0.5 as shown in Figure (1,2).

Depending on the size of the hematoma volume we have established an arbitrary scale of 1-4 presented in Table (1).

We divided the patients into two groups: with and without hematoma. With the aim to find out if the two groups had similar or different characteristics during the biopsy, we evaluated the parameters that are summarized in Table (2): age, creatinine, bleeding time, blood pressure, pre-biopsy Hgb, post-biopsy Hgb at 24 hours, Δ Hgb, platelets count.

In the Group of patients with hematoma, we measured and compared the average volume of the hematoma at 30 mins post-biopsy (T0), at 8 hrs (T8) and after 24 hrs (T24) to determine if their size increased, decreased or remained the same during US monitoring (Table 3).

Subsequently, we further divided patients with hematoma in two groups: the group with Major hematoma (Major H.) (greater
than 6 ml) and the group with Minor hematoma (Minor H.) (less than 6 ml). The clinical characteristics of these patients at biopsy are reported in Table (4).

We compared the average volume of hematoma in the two latter groups, to see if larger hematomas could get worse in this regard than smaller ones (Table 5).

**Statistical analysis**

Statistical analysis was done using the unpaired and paired Student's test for continuous data. Data are reported as mean ± SD. The comparison between the volume of hematomas at 8 hrs versus 24 hrs was done using standard linear regression analysis. Differences were considered significant for *p*-value < 0.01.

**RESULTS AND DISCUSSION**

**Results**

Renal biopsy related complications occurred in 57 of 72 biopsies (79.16%). Perirenal hematoma was the only ascertained

### Table 3: Progressive Hematoma volume reduction over time from T0 to T24.

<table>
<thead>
<tr>
<th>Time</th>
<th>T0</th>
<th>T8</th>
<th>T24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average H. volume (ml)</td>
<td>11.26</td>
<td>7.76</td>
<td>5.14</td>
</tr>
<tr>
<td>% of H. volume reduction</td>
<td>31.3% (<em>p</em> &lt; 0.0001)</td>
<td>54.65% (<em>p</em> &lt; 0.0001)</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations:** H: Hematoma T0: 30 mins after biopsy; T8: after 8 hrs; T24: after 24 hrs

### Table 4: Patient characteristics at biopsy between Major H.(>6 ml) and Minor H. (<6 ml).

<table>
<thead>
<tr>
<th>Major H.</th>
<th>Minor H.</th>
<th><em>p</em>-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>31 (54.38%)</td>
<td>26 (45.61%)</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>37.9±15.96</td>
<td>50.69±19.32</td>
</tr>
<tr>
<td>Creatinine (mg/dl)</td>
<td>1.69±2.20</td>
<td>2.45±2.35</td>
</tr>
<tr>
<td>Bleeding time(min)</td>
<td>3.88±1.71</td>
<td>3.77±1.66</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>121.67±4.21</td>
<td>120.0±3.87</td>
</tr>
<tr>
<td>Diastolic blood pressure (mm Hg)</td>
<td>77.5±5.21</td>
<td>77.27±6.46</td>
</tr>
<tr>
<td>Pre-Hgb(g/dl)</td>
<td>13.21±1.63</td>
<td>12.9±2.09</td>
</tr>
<tr>
<td>24/hPost-Hgb(g/dl)</td>
<td>12.50±1.55</td>
<td>12.55±1.95</td>
</tr>
<tr>
<td>Delta-Hgb(g/dl)</td>
<td>0.71±0.80</td>
<td>0.35±0.50</td>
</tr>
<tr>
<td>PLT (X1000)</td>
<td>260±70.51</td>
<td>253±74.22</td>
</tr>
</tbody>
</table>

**Abbreviations:** H: Hematomas

### Table 5: Hematoma reduction over time from T0 to T24 between Major H. and Minor H.

<table>
<thead>
<tr>
<th>Time</th>
<th>Major H.</th>
<th>Minor H.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average H. volume (ml)</td>
<td>18.09</td>
<td>8.32</td>
</tr>
<tr>
<td>% of H. volume reduction</td>
<td>59%</td>
<td>59.38%</td>
</tr>
</tbody>
</table>

**Abbreviations:** H: Hematoma T0: 30 mins after biopsy; T24: 24 hrs after biopsy
complication. There was no significant difference in age, coagulation parameters, blood pressure, pre and post-biopsy, 24 hrs hemoglobin concentration, PLT count, between 57 pts with hematoma and 15 pts hematoma-free (20.83%).

The only statistical difference was in Δ Hgb (p <0.0001) (Table 2). Only one patient (1.38%) required post-biopsy blood transfusion (two units); he had lower pre-biopsy hemoglobin levels (9.5 grams), higher creatinine concentration (12 mg/dl) and Type 3 (18 ml) post-biopsy hematoma.

All hematomas were highlighted during the post-biopsy US examination at T0. No hematoma subsequently developed afterwards in patients that were hematoma-free at T0.

The average volume of the hematoma was at T0: 11.26 ml (median 6.49; SD 12.56), T8: 7.76 ml (median 4.99; SD 10.35); T24: 5.10 ml (median 1.68;SD 8.13). The volume of the hematoma has gradually reduced during exams T0 - T8 - T24 with an average reduction of 31.3% after 8 h and 54.65% at 24 h (Table 3).

Comparing the characteristics of the patients in groups with Major and Minor H., we haven’t found significant differences except that the former were younger in age and with a higher Δ Hgb (Table 4).

The Major H. showed an average volume at T0 of 18.09 ml (SD 13.61) and at T24 of 8.32 ml (SD 9.85) with 54% reduction. The Minor H. showed an average volume at T0 of 3.11 ml (SD 2.06) and at T24 of 1.26 ml (SD 1.91) with 59.38% reduction (Table 5).

Finally, comparing the volumes of all hematomas, a linear correlation was found between the decline of the volumes surveyed at the 8th hour and those surveyed at the 24th hour (correlation coefficient r = 0.9265; p = <0.0001) (Figure 3). This linear correlation has been maintained even in patients having Major H. (r = 0.9203 p = <0.0001) (Figure 4).

One week away from the discharge of patients, US examination showed the disappearance of hematomas or further volume reduction.

Discussion

The most common post-PRB complication is the bleeding, which collects in the perinephric space and / or beneath the renal capsule, or outside of the kidney in the collecting system causing macro/microhematuria. Usually, complications resolve spontaneously and require no special interventions (minor complications) but, in 7.4% of cases, they require action, mainly through blood transfusion or, rarely, invasive procedures such as therapeutic embolization (0.7%) or nephrectomy (0.3 %) (major complications) [14,15].

In most of the patients who had undergone renal biopsy, the clinically silent perirenal hematomas are shown by US after a few minutes after biopsy. They appear at the lower pole of the kidney, usually without altering the convex shape of the boundary, in the form of crescent-shaped iperechoic strip, because free fresh blood is moderately echogenic (Figure 1-2); the echogenicity decreases over time [16,17]. Our experience has shown that renal biopsy is a safe technique with minimal risk of complications. Over the course of two years (April 2010-March 2012) we performed 72 biopsies and none of them needed an invasive procedure, no patients required emergency surgery or nephrectomy. The only patient who required blood transfusions had the lowest pre-biopsy hemoglobin level and the highest serum creatinine value. It’s know that post-biopsy complications are more frequent in pts with lower hemoglobin level (11 - 1 vs 12 +2g / dl), advanced kidney failure, prolonged bleeding time [11,18].

In our series, the incidence of post-biopsy perinephric hematomas was 80%. On the US images we measured the widest diameters of haematomas in sagittal and in cross section (Figure 1, 2) and calculated the volume of the hematoma with the ellipsoid formula [19]. This allowed us to determine the volume of the post-biopsy hematoma creating a dimensional scale size with a score from 1 to 4 (Table 1) and to compare the volumes in three different times of US observation: 30 mins after the biopsy (T0), after 8 hrs (T8) and after 24 hrs (T24). We observed that the hematomas with a larger volume are those recorded at Time 0, then the volume decreases at 8 hrs, and decreases further at 24 hrs (Table 3).

So in this way we have documented that the heavier bleeding occurs within the first 30 mins after the biopsy as a result of the needle traumatic act on larger caliber vessels [20]. We have shown a very significant decrease of the hematoma volumes in the post-biopsy times and, most important, the reduction percentage was more than 50% after 24 hrs (Table 3).

We also found a strong positive correlation between the reduction of the post-biopsy hematoma volume from 8 to 24 h and this linear correlation is also present in pts with hematoma that is greater than 6 ml (between 6 ml and> 24 ml or Major hematomas of Type 2,3 and 4) (Figure 3,4). The fact that even these larger hematomas have a significant decline at 24 hrs with an average volume reduction from 18 ml to 8 ml (54%) compared to T0 (Table 5), reassures us about their development. This indicates that even the largest hematomas are not subject to any further bleeding after the initial post-biopsy period.

To confirm this observation, previous studies indicated that the hemoglobin drop was observed in immediate post-biopsy period in patients with major complications [2]. As shown in the correlation diagrams (Figure 3,4), the reduction of hematoma at 8 hrs can predict its decrease at 24 hrs after biopsy, therefore patients in which the hematoma does not increase at the 8th hour, they can be discharged.

Generally, the patient who undergoes a PRB is monitored through clinical parameters with the scope of detect appearance of macromoematuria, lumbar pain, high blood pressure and changes in hemoglobin levels, which are usually measured after several hours of PRB and at 24 hrs. The literature data show that both the clinical signs and the changes in pre- and post-PRB hemoglobin level may be misleading. For example, Paivansalo et al., in his follow-up study by sonography, highlighted the presence of hematoma in only a few patients exhibiting post-biopsy disorders (5 out of 12 pts with severe back pain, and 4 out of 21 pts with hematuria) [22].

On the other hand, a mild decrease of post-PRB hemoglobin level of approximately one gram is common in half of the patients and does not necessarily suggests an unfavorable course. The
cause of this non hemorrhagic change of hemoglobin is still not very clear. It is believed to be a result of hemodilution related to systematic saline infusion after PRB or to the redistribution of fluids in the supine position in edematous patients [11].

None of the numerous clinical risk indicators reported by literature (renal failure, uncontrolled blood pressure, prolonged bleeding time, increased PTT at baseline, post-biopsy reduction of hemoglobin, etc.) allows us to accurately predict which biopsies will have an unfavorable course [23].

In a prospective study [24], only the female gender, age (35 + 14.5 years vs 40.3 + 15.4 years), and PTT at baseline showed a significant predictive value. In our study we did not demonstrate any difference in the parameters at biopsy in the group with hematoma compared to the group without hemotoma excluding the change in pre- and post-biopsy hemoglobin (Δ Hgb in pts with hematoma: 0, 54 + -0 , 70, Δ Hgb in pts without hematoma: 0, 22 + -0, 49; p <0.001) (table 2).

The lack of reliable clinical indicators of renal bleeding reinforces the role of the US monitoring during the post-biopsy observation. There is debate in the Nephrology community about the use of post-biopsy hemotoma as a predictor of biopsy outcome. Waldo et al., [25] performed US examination of biopsied kidneys 1hr after the PRB in 162 adults and documented the appearance and timing of complications in the next 23 hrs. The authors showed that post-PRB hematomas were present only in 20% of cases in patients without complications and they were small (<3 cm); in cases with significant complications, they were more frequent (77%) and most of these greater than 3 cm. The presence of hemotoma at one hour had a positive predictive value of 23% and a negative predictive value of 98% in determining the biopsies that would be associated with more complications: it is therefore the absence of post-biopsy hemotoma that strongly indicates the favorable course.

While the lack of perirenal hemotoma after 1 hour should reassure clinicians about the uncomplicated course of the biopsy, this study can not an answer the interesting question of whether the execution of ultrasoungraphy subsequent to the 1st hour can increase the predictive value of the procedure.

Our systematic post-PRB US monitoring of patients with hemotoma demonstrates that if there isn’t an increase in hemotoma volume after 8hrs of biopsy, it will not even occur after 24 hours; this indicates a favorable outcome of the PRB.

CONCLUSION

We believe that today the ultrasound should be used not only to locate the lower pole of the kidney, but also to have a more rigorous post-biopic monitoring of bleeding. It is our belief, based on ultrasound practice, that the post-PRB hemotoma is formed simultaneously with the biopsy needle penetration into the renal parenchyma, it reaches the largest volume within the first thirty minutes and tends to decrease over 24 hrs; it can be easily revealed, quantified and monitored by the ultrasound, providing the clinician a useful resource during post-PRB observation.

Hemotoma reduction within 24 hrs suggests a favorable course of the biopsy and can prove to be more useful than other risk indicators such as hemoglobin changes post-PRB. If more and larger studies could confirm the linear correlation regarding the hemotoma volume declining observed between the 8th and the 24th hour post-PRB, this can help nephrologists to better understand when is the best time to discharge patients who underwent a kidney biopsy.

REFERENCES


