The aim of this study is to correlate the degree of hematuria, grade in CT classification, treatment and outcome in patients with blunt renal trauma. Ninety patients (72 men and 18 women) with blunt renal trauma presenting flank pain and hematuria received contrast-enhanced CT study within 12 hours after trauma. According to the CT appearance, blunt renal trauma was further classified into four grades. Results were compared to the surgical findings and clinical follow-up.

There were 63 cases with grade I renal lesions, nine grade II, 15 grade III and three grade IV. Seventy-eight of 90 cases (86.7%) required conservative treatment only, three (3.3%) received renorrhaphy and six (6.7%) underwent nephrectomy. One (1.1%) with perirenal hematoma complicated by perirenal abscess required percutaneous drainage. One (1.1%) with a grade I renal lesion expired due to hypovolemic shock after multiple fractures of the pelvis and the femur. Another one (1.1%) with a grade III lesion expired due to active renal arterial hemorrhage. The mortality rate in patients with blunt renal trauma was 2.2% (2/90). Two cases of major vascular pedicle injury presented microscopic hematuria only.

Although the presence of microscopic hematuria may suggest mild blunt renal trauma in most cases, patients with vascular pedicle injury may present with microscopic hematuria only. Contrast-enhanced CT is capable of demonstrating the severity of blunt renal trauma. The CT findings associated with clinical evaluation on patient’s hemodynamic status may provide important information for surgical treatment planning. In our study, the overall prognosis of blunt renal trauma is generally good.

Key words: Blunt renal trauma; Computed tomography (CT); Hematuria

Organ-preserved management has become the treatment of choice for most patients with blunt renal trauma clinically in the recent decade [1-3]. However, patients with main vascular pedicle injury, which may cause fatal arterial hemorrhage or renal infarction, might present as microscopic hematuria and easily be missed clinically [4]. Although ultrasonography has been used for the initial evaluation of blunt renal trauma, the actual severity of a renal trauma may be missed or underestimated by sonography alone [5-6]. The aim of this article is to correlate the grade of CT imaging classification of blunt renal trauma with the degree of hematuria, treatment of choice and outcome of patients.

MATERIALS AND METHODS

From January 1995 to December 1999, ninety consecutive patients, who received contrast-enhanced CT study within 12 hours following a blunt renal trauma, were enrolled into this study. There were 72 men and 18 women with a male-to-female ratio of 4:1.
The age ranged from 1 to 83 years, averaging 29.6 years.

CT study was performed using Somatom Plus 4 (Siemens, Forchheim, Germany) and Somatom HiQ S (Siemens, Erlangen, Germany): the former was a spiral mode and the latter was conventional. Each scan started from the level of the diaphragm to the pubis with a slice thickness of 10 mm and a table feed of 15 mm on the spiral CT. On the conventional CT, a slice thickness of 10 mm was selected. Each patient received 100 ml of intravenous contrast medium at a rate of 2 ml per second. There was a 70-second delay after the start of contrast infusion before the scanning was initiated. Repeating scans of the kidneys 5 minutes after the completion of the initial scans were performed. Reconstruction was done with an increment of 10 mm on the spiral CT. All CT images were reviewed by two radiologists.

Patients were further classified into four groups based on the CT grading of renal trauma based on Federle’s classification [7]. Grade I renal trauma specified superficial cortical laceration and/or perirenal hematoma. Grade II renal trauma represented deep corticomedullary laceration without involving the collecting system. Grade III renal trauma included shattered kidney and/or main vascular pedicle injury, while grade IV renal trauma stood for injury of the renal pelvis or the ureteropelvic junction. The imaging results were compared to the degree of hematuria, type of treatment and outcome.

**RESULTS**

All patients presented as flank pain clinically. Unilateral renal involvement occurred in 89 patient, while bilateral injury was seen in one. The left-to-right ratio was 1:1. Among ninety patients, fifty displayed gross hematuria and forty showed microscopic hematuria on urinalysis. According to the CT classification, sixty-three patients (70%) had grade I lesions, nine (10%) had grade II lesions, fifteen (16.7%) had grade III lesions and three (3.3%) had grade IV lesions (Fig. 1-4). The average age of grade I, II, III and IV lesion is 32.2, 23.9, 25.5 and 13 years, respectively. Correlation between the degree of hematuria and severity of renal trauma based on the CT classification.

<table>
<thead>
<tr>
<th>CT classification of renal trauma</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Total</th>
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<tbody>
<tr>
<td>Hematuria</td>
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<tr>
<td>Microscopic</td>
<td>34</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>40</td>
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<tr>
<td>Gross</td>
<td>29</td>
<td>5</td>
<td>13</td>
<td>3</td>
<td>50</td>
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<tr>
<td>Total</td>
<td>63</td>
<td>9</td>
<td>15</td>
<td>3</td>
<td>90</td>
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**Figure 1.** Grade I blunt renal trauma: perirenal hematoma. Axial, contrast-enhanced CT on the level of upper pole of the right kidney shows subcapsular and perirenal hematoma (arrows). There are duodenal perforation with some free air (arrowheads) accumulated between the contrast-filled duodenum and the inferior vena cava.

**Figure 2.** Grade II blunt renal trauma: deep corticomedullary laceration. Axial, contrast-enhanced CT on the level of lower pole of the left kidney shows a lacerated band involving the superficial cortical layer and the deep medullary layer (arrowheads) with a large perirenal hematoma. The curviform hyperdense bands (arrows) represent ongoing hemorrhage.
was summarized in the Table 1 and shown in the Figure 5.

Concomitant injury was encountered in sixty-two patients, including 11 with liver laceration (I/II/III/IV: 7/1/3/0), 10 with splenic rupture (I/II/III/IV: 8/1/1/0), two with bowel laceration, five with intracranial hemorrhage (I/II/III/IV: 3/0/2/0), 26 with bony fracture, 16 with brain contusion (I/II/III/IV: 10/2/2/1), one with gallbladder perforation (grade I) and three with hypovolemic shock (I/II/III/IV: 2/0/1/0).

In 63 patients with grade I lesions, one patient with concurrent splenic rupture received renorrhaphy after splenectomy, one patient with simultaneous duodenal perforation required percutaneous drainage of the perirenal abscess (Fig. 1). In 13 patients with shattered kidneys, one had renorrhaphy and five required nephrectomy due to unstable vital sign. In two patients with main vascular pedicle injuries, one expired due to fatal active hemorrhage (Fig. 3a), while the other received nephrectomy due to renal infarction (Fig. 3b). One of three patients with grade IV lesion was subjected to a renorrhaphy due to severe urine extravasation (Fig. 4). One patient with grade I lesion expired due to hypovolemic shock following concomitant multiple fractures of the pelvis and femur. With the purpose of preserving the injured kidney, conservative

Figure 3. Grade III blunt renal trauma: a. Renal arterial rupture with active bleeding. Axial, contrast-enhanced CT on the level of middle portion of the left kidney during the early arterial phase shows accumulation of contrast-opacified blood in the left perirenal and pararenal regions (black arrows) and small caliber of the contrast-filled abdominal aorta (white arrow) in response to hypovolemic shock. The contraction of the abdominal aorta then decreased the blood supply to bilateral kidneys. b. Renal artery dissection with renal infarction. Axial, contrast-enhanced CT on the level of middle portion of the left kidney shows no enhancement of the left renal parenchyma and a dense renal artery (arrows). c. Shattered injury on the left part of congenital horseshoe kidney. Axial, contrast-enhanced CT on the level of the junction of the horseshoe kidney demonstrates complete disruption of the left kidney shown as a heterogeneously mass mixed with hypodense and amorphous hyperdense hematoma.
Figure 4. Grade IV blunt renal trauma: renal pelvic injury. Axial, contrast-enhanced CT on delay phase shows separation of the enhanced right renal parenchyma and the contrast-filled right renal pelvis by a deep lacerated injury a. The extravasated and opacified urine (arrows) extends cranially to the Morison’s pouch b. and caudally along the right ureter c.

Figure 5. Correlation between the degree of hematuria and grade in the CT classification in patients with blunt renal trauma. The percentage of gross hematuria increases as the the grade in the CT classification increases. On the contrary, the percentage of microscopic hematuria decreases as the the grade in the CT classification increases.
account of renal injury.

DISCUSSION

Kidneys are retroperitoneal organs that are less commonly injured than intraperitoneal solid organs such as liver and spleen during a blunt abdominal trauma on account of the protection by the lumbar spine and psoas muscles posteriorly and intraperitoneal organs such as liver, spleen and bowels anteriorly. A mechanical force that causes renal trauma usually brings severe concomitant trauma, such as liver laceration, splenic rupture, bony fracture, or bowel loop injury, which is frequently unrelated to the severity of renal trauma [1, 5, 8].

Patients with blunt renal trauma usually present symptoms such as flank pain and/or hematuria that bring them to the imaging examination. In most cases (38 in 40 cases, i.e. 95%), microscopic hematuria occurred in patients with mild renal injury (grade I and II). However, injury of the renal vascular pedicles may also presented as microscopic hematuria clinically. In our series, two patients with microscopic hematuria on urinalysis were found to have renal arterial injury (grade I and II). The percentage of gross hematuria increased as the grade of CT classification increased in a linear correlation ($R^2=0.9583$). A total of 68% of patients with gross hematuria had mild renal injury (grade I and II), while the rest (32%) of patients showed renal trauma in higher grade (grade III and IV).

Because organ-preserved management has become the trend of treatment for a patient with blunt renal trauma, accurate diagnosis of the presence and the severity of a blunt renal trauma are of paramount important [1-3]. Ultrasonography, a noninvasive, low-cost, radiation-free and convenient diagnosing tool, is commonly used for the first line examination on patients with blunt renal trauma [5-6]. The presence of perirenal hematoma resulting from a corticomedullary laceration or severe shattered injury can be easily diagnosed sonographically. However, since the sensitivity of ultrasonography decreases in patients with severer renal trauma [6], a negative ultrasonogram does not necessarily exclude a renal injury. Both vascular pedicle injury and renal pelvic injury may be underestimated or even missed by gray-scaled ultrasonography alone. When injury of the renal artery is suspected, color Doppler and duplex ultrasonography may add the diagnosing accuracy noninvasively.

Contrast-enhanced CT is superior to ultrasonography in diagnosing blunt renal trauma in several aspects [9-12]. First, it helps to detect the presence of contrast leakage in the arterial phase from a transected or lacerated renal artery, which is easily mistaken as a hematoma due to renal parenchyma injury. Second, it successfully demonstrates the presence of renal infarction due to renal arterial dissection during an sudden acceleration and deceleration injury, which might be missed on sonographic study. In our series, one case of renal artery injury presented microscopic hematuria on urinalysis only. Gray-scaled sonography failed to demonstrate the presence of renal infarction and renal artery occlusion. CECT clearly demonstrated the absence of nephrogram and pyelogram with subcapsular enhancement (cortical rim sign) and a dense segment of the renal artery, indicating the presence of a renal arterial occlusion. In addition, the presence of urine extravasation may be difficult to be detected or differentiated from a perirenal hematoma by ultrasonography alone. With CECT, it is easy to detect the leaked urine and differentiate it from a hematoma due to the high-density contrast medium in the urine. Sometimes, injury to the renal collecting system may be missed during routine abdominal spiral CT for trauma [13]. Therefore, repeating scans of the kidneys following a routine abdominal scan is necessary to detect the urine leakage that might be not seen initially. Finally, CECT is able to depict an ongoing renal hemorrhage on a shattered kidney by showing the active contrast leakage within the low-density hematoma [14].

It has been recognized that patients with pretraumatic renal abnormalities are more prone to serious injury [15]. We encountered a patient with a severe shattered injury on an underlying horseshoe kidney that required a nephrectomy. It is not clear that whether the serious renal injury is due to the sensibility of a renal abnormality to a blunt injury or due to a more violent force that will cause serious injury to an otherwise normal kidney. In another three cases of ureteropelvic junctional obstruction with hydronephrosis we encountered, only grade I lesions of the injured kidneys were observed. We didn’t have any case of renal injury with a preexisted renal tumor. The relationship between the severity of blunt renal trauma and the preexisting renal disease or tumor deserves further study to clarify.

Treatment of a blunt renal trauma consists of conservative management, renorrhaphy and nephrectomy. For most patients, conservative management is enough for the treatment of blunt renal trauma even in some cases of shattered kidney and renal caliceal injury if the patient is in a stable hemodynamic condition [16]. In our study, 78 of 90 cases (86.7%) required conserv-
ative management only without complication. Renorrhaphy may be necessary on patients with a shattered kidney without or with renal pelvic injury. Nephrectomy is required only in those with severe shattered kidney with unstable vital sign or major vascular pedicle injury. In a rare circumstance, percutaneous drainage may be necessitated due to abscess formation complicated by duodenal perforation.

In conclusion, microscopic hematuria represents mild blunt renal trauma in most cases. Patients with vascular pedicle injury may present as microscopic hematuria only. Gross hematuria does not infer severer renal injury but the percentage of gross hematuria does increase in higher grade of renal trauma in CT classification. CECT enables diagnosing a blunt renal trauma accurately and allowing a precise preoperative decision to undergo nephrectomy, renorrhaphy or conservative management. The shortening of scanning time on a spiral CT makes it more convenient and safer for the emergent evaluation of a patient under a relatively stable hemodynamic condition. We suggest the liberal use CECT on patients with blunt renal trauma, which may lead to an accurate diagnosis and provide a guideline on the surgical decision and planning.

REFERENCES

腎臟鈍傷之電腦斷層影像：比較血尿程度、電腦斷層之分類、治療與預後

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本研究的目的是針對腎臟鈍傷病患之血尿情況、電腦斷層影像之發現、處置與預後加以分析。本研究收集在過去五年的期間90個因腹部鈍傷而有腰痛及血尿之症狀的病患，所有的病患皆經電腦斷層攝影確定腎臟鈍傷。根據電腦斷層攝影的特徵，我們進一步將所有的病患分為4組（第一組為表面的腎臟皮質撕裂傷或腎臟外圍血腫；第二組為深層的腎臟皮質髒層撕裂傷；第三組為粉碎性的腎臟皮質髒層傷或是主要的腎臟血管傷害；第四組為腎盂或是腎盂與輸尿管交界處之傷害）。所有的病例及手術紀錄均加以詳細的回顧。本研究共包括72位男性，18位女性，男女比例為4:1。病患的年紀從一歲到八十三歲，平均為二十九點七歲。有六十三人為第一級腎臟傷害，九人為第二級，十五人為第三級，三人為第四級。在治療方面，有七十八人僅需要保守性療法，三人接受腎臟縫合手術，六人接受腎臟切除手術，有一人因為合併有十二指腸破裂導致腎臟周圍膿瘍而需接受經皮引流術之治療。在預後方面，九十個病患中有兩個死亡病例（2.2%）。其中一多人因為腎動脈出血而另一人因為骨盆及骨多處骨折導致低血容量性休克而死亡。雖然在絕大多數病患身上輕微血尿(microscopic hematuria)代表著輕微的腎臟傷害，嚴重的腎臟傷害像腎動脈的傷害也可以僅表現出輕微血尿，且容易被超音波所忽略，故仍需要電腦斷層攝影檢查。對比較顯影之電腦斷層攝影能夠準確的顯現出腎臟鈍傷的嚴重性。配合病患血液動力學的情況，電腦斷層攝影能夠幫助外科醫師決定適當治療的方式。除了兩位因大量出血而死亡的病患外，絕大多數腎臟鈍傷病患的預後良好。

關鍵詞：腎臟鈍傷，電腦斷層攝影，血尿