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Original article

Factors predicting the outcome of non-operative management of high-grade blunt renal trauma

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Abstract

Objectives: In this retrospective study we reviewed the outcome of non-operative management of high-grade blunt renal injuries (grade III–V) and evaluated the predictive indicators of management failure.

Subjects and methods: The data review included the patients' demographics, the mechanism of trauma and the clinical characteristics, as well as the laboratory and imaging data upon admission and at follow-up. The data of the patients who were successfully managed non-operatively and of those who needed intervention for renal injuries were compared.

Results: Two hundred and six patients were enrolled in this study. Grade III, grade IV and grade V renal injuries were found in 39.8%, 44.2% and 16% of the patients, respectively. The overall success rate of non-operative management was 87.9%, including all patients with grade III, 86.8% of patients with grade IV and 60.6% of those with grade V injuries. Multivariate analysis revealed that trauma secondary to motor vehicle accident, hypotension at presentation, associated injuries to other organs, grade V renal injury

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and computed tomography (CT) imaging features, namely medial renal parenchymal laceration, perirenal hematoma ≥3.5 cm and intravascular extravasation were significant predictors for failure of non-operative management.

Conclusion: Our findings suggest that high-grade renal injuries in hemodynamically stable patients can be managed conservatively with a high success rate. Multiple clinical and radiological variables can predict the treatment outcome.

Introduction

Renal trauma is the most common urologic trauma and represents approximately 10% of all significant abdominal traumas [1,2]. The morbidity and mortality rates of renal trauma vary with the severity of renal injuries, associated injuries to other organs and the management plan utilized [3]. Most of the renal injuries occurring as a result of blunt trauma are of low to moderate grade, and in such cases conservative management has been clearly demonstrated to be an effective therapeutic option.

The management plan for high-grade renal injuries remains controversial [4,5]. As exploring high-grade renal injury usually, inevitably, leads to nephrectomy, many authors advocate non-operative management which has been increasingly applied with success [6–9]. However, the decision must be weighed against related morbidity and mortality, and the exact criteria for patient selection must be identified. In an attempt to help increase the rate of renal salvage, we retrospectively reviewed the outcome of non-operative management of high-grade blunt renal injuries and evaluated the clinical and radiological determinants for non-operative management failure and related complications.

Subjects and methods

This hospital-based retrospective observational study was carried out at King Abdullah Hospital, Bisha, King Khalid Hospital, Al-Kharj and El-Iman Hospital, Riyadh, KSA, from September 2007 to March 2014. It included all adult patients with high-grade blunt renal injuries diagnosed and graded using computed tomography (CT) scan. The data review included the patients' demographics, the mechanism of trauma and the clinical characteristics, as well as the laboratory and imaging data upon admission and at follow-up. Patients with insufficient data or those without initial CT films were excluded from the study.

As per the protocol of our hospitals, patients with blunt abdominal trauma were initially resuscitated according to the advanced trauma life support (ATLS) guidelines provided by the American College of Surgeons [10] and evaluated by a rapid bedside ultrasound examination. After initial resuscitation, the hemodynamically unstable patients were shifted immediately to the operating room to undergo emergency laparotomy. When a lateral retroperitoneal hematoma was found on exploration, the hematoma was inspected for expansion or pulsations without exploring the retroperitoneum in order not to interrupt the tamponade effect of the hematoma. When the hematoma was pulsatile or expansile, renal exploration was mandatory to control bleeding. Hemodynamic instability was defined as a systolic blood pressure of less than 90 mmHg in spite of adequate colloid and crystalloid fluids and packed RBC replacement. The hemodynamically stable patients were further evaluated by contrast CT scan of the chest, abdomen and pelvis. If an evidence of renal injury was found, the injury was graded according to the American Association for the Surgery of Trauma (AAST) injury scale [11].

In the present study, we included only high-grade injuries (grade III–V) with the exception of cases with renal vascular pedicle injury.

Conservative management generally consisted of the patient's admission to the intensive care unit or a monitored setting with bed rest, hydration, analgesics and antibiotics. Serial hematocrit was obtained, and the patients were routinely subjected again to ultrasonography and/or CT scan within 24–72 h to allow early detection of complications. The need for intervention and follow-up imaging was planned according to the patient's clinical course. Failure of non-operative management of renal injuries was defined by the need for invasive interventions, including open surgery and angiographic intervention.

The multidetector computed tomography (MDCT) protocol was pre-programmed and was the same for all patients. CT scan was performed in supine position, using 64-slice scanners. Scan parameters were 0.6 mm detector collimation, 0.75 mm slice thickness, a reconstruction interval of 0.5 mm and 120–140 Kvp; 250 mAs, with the data reconstructed at 0.5-mm intervals. The MDCT-protocol for renal trauma included three axial helical acquisitions. The first acquisition without contrast medium of chest, abdomen and pelvis was performed, followed by a second acquisition after intravenous administration of contrast media with the image taken within 60–70 s of administration. A delayed scan of the urinary tract was obtained after 3–5 m. Contrast media (1.5–2.0 mL/kg of nonionic contrast material) were given by means of a double-syringe automatic injector, at a rate of 4–5-mL/s, followed by injection of 80 ml saline. The images were reconstructed in the axial plane with a section thicknesses and intervals of 2–5 mm. Coronal and sagittal multiplanar reformatted (MPR) images were acquired at 4 mm intervals. The CT images were reviewed by an independent radiologist who was blinded to the clinical outcome of the patients. Special consideration was given to the presence or absence of recently evaluated CT features, namely the presence of medially sited parenchymal laceration, perinephric hematoma ≥3.5 cm and intravascular contrast extravasation in the perirenal hematoma [12,13].

Intravascular contrast extravasation was defined as a linear extension or pooling of extravascular fluid with a density equal to that of adjacent intravascular contrast medium during the CT portal venous phase (Fig. 1), suggesting active bleeding. The size of perirenal hematoma was measured by obtaining the largest measure from the

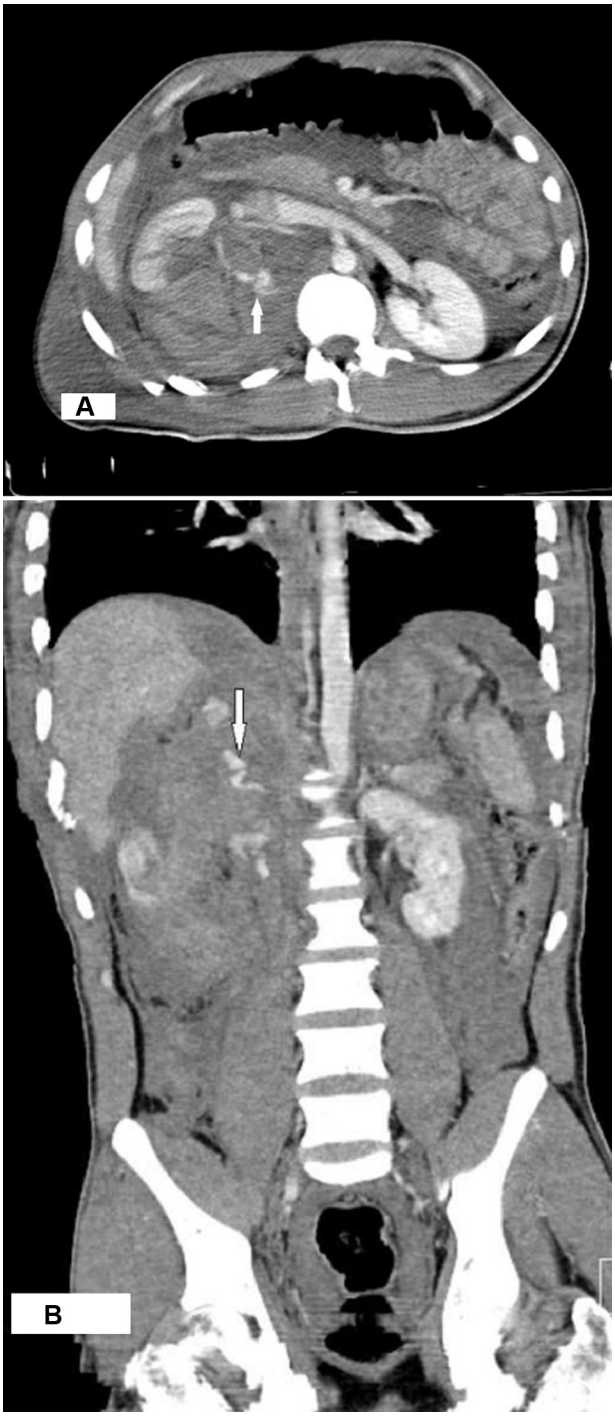

Fig. 1 Contrast enhanced CT scan for a patient with blunt renal trauma during the portal venous phase, (A) axial (B) coronal MPR reformate image reveals a serpentine extravasation of vascular contrast material (white arrow) within a large tissue-attenuation perirenal hematoma indicating intravascular contrast extravasation.

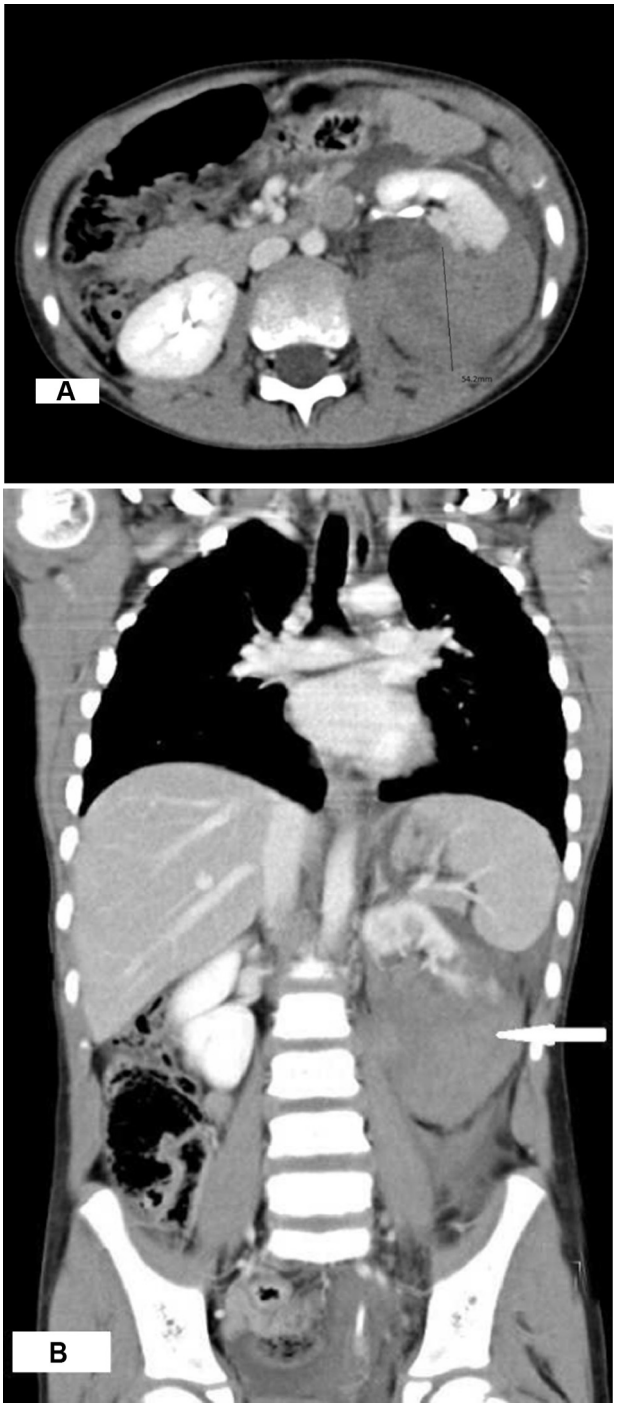

Fig. 2 Contrast enhanced CT scan for a patient with blunt renal trauma during the portal venous phase, (A) axial and (B) coronal MPR reformatted image reveals left renal injury with large tissue-attenuation perirenal hematoma posterior to the kidney measuring 54.2 mm.

renal capsule to the edge of the hematoma (Fig. 2). The site of the laceration was determined according to its position in relation to an axis drawn perpendicularly to another axis placed through the vascular structures; this axis defined the medial and lateral halves of the kidney (Fig. 3).

Statistical analysis

SPSS (SPSS for Windows 10.0, SPSS Inc., Chicago, IL) was used to determine significant differences between the variables and to perform univariate and multivariate analyses of the risk factors. The significance of the difference was estimated using chi square for qualitative variables and unpaired *t*-test for quantitative variables.

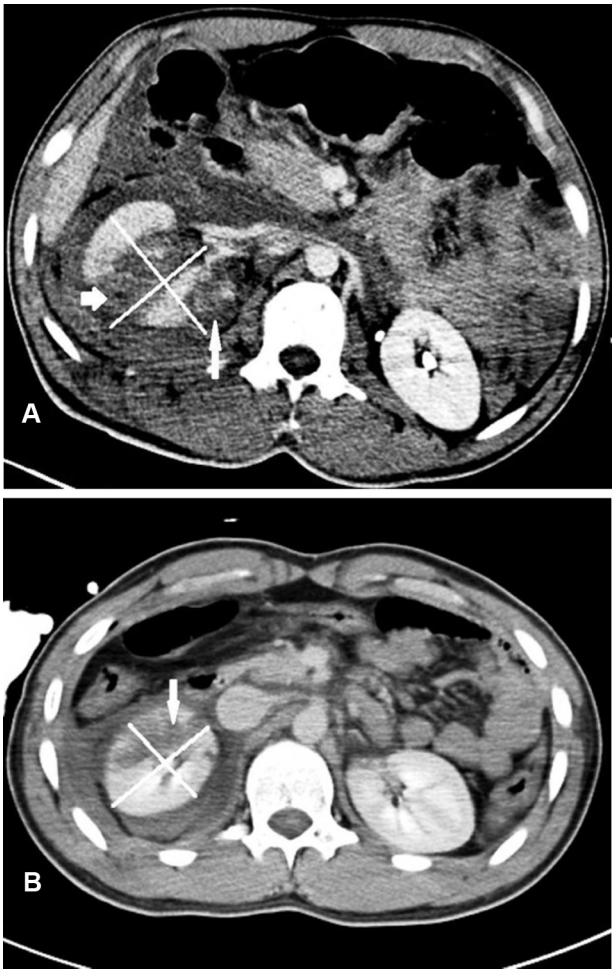

Fig. 3 Contrast enhanced CT scan for two different patients with blunt renal trauma during the portal venous phase showing renal cortical laceration. The location lines represent renal hilum axis and plane perpendicular to it. (A) CT reveals complex right renal laceration, the slim arrow indicates medial laceration and the arrow head indicates lateral laceration. (B) CT reveals medial right renal cortical laceration (white arrow).

Univariate and multivariate logistic regression analyses were performed to identify independent predictors for conservative management failure, presented in terms of the odds ratios and their 95% confidence intervals. The multivariate regression model included only the significant variables of the univariate regression analysis. A probability value (p-value) of <0.05 was considered significant.

Results

During the study period, 238 patients with high-grade blunt renal injuries were admitted. Thirty-two of them were excluded from the analysis due to the necessity of immediate laparotomy without imaging in 19, incomplete records in 9 and death within 24 h of admission due to shock and associated injuries in 4 patients. The remaining 206 patients (131 men and 75 women) with a mean age of 31.1 ± 12.2 (range 18–61) years were enrolled in the study.

The trauma was caused by motor vehicle accident in 165 (80.1%), fall from height in 20 (9.7%), animal attack in 13 (6.3%) and other accidents in 8 (3.9%) patients. Thirty-three (16%) patients had isolated renal injuries, 54 (26.2%) had additional intra-abdominal injuries, 68 (33%) had associated extra-abdominal injuries and 51 (24.8%) had associated intra- and extra-abdominal injuries. Eighty two (39.8%) of the studied patients suffered from grade III, 91 (44.2%) from grade IV and 33 (16%) from grade V renal injuries. Medially located renal lacerations were reported in 95 (46.1%), perirenal hematoma ≥3.5 cm in 146 (70.9%), contrast extravasation outside the collecting system in 108 (52.4%) and intravascular extravasation in 26 (12.6%) cases.

All patients presented with hematuria. It was gross in 194 (94.2%), while microhematuria in grossly clear urine was found in 12 (5.8%) cases. Transfusion of blood products was needed in 173 (84%) patients. However, in cases of isolated renal injury, blood transfusion was required only in 27% (8/33) of the cases. The maximum number of transfused units was 5 units (mean 2.12 ± 1.5).

All 206 patients were admitted for close observation with the goal of non-operative treatment. However, conservative management could only be adopted in 181 (87.8%) cases, as intervention for early renal bleeding was needed in 25 (12.2%). Urinoma was reported in 8 (3.9%) patients and secondary hemorrhage in 4 (1.9%). Nephrectomy was the most frequent surgery performed (17/25) (68%), while renorrhaphy and angioembolization were done in 8 (32%) patients (4 cases each). Out of the 17 nephrectomies, 6 (35.3%) were for grade IV and 11 (64.7%) for grade V renal injuries.

We compared all the clinical and radiological parameters of the patients who had been managed conservatively (conservative management (CM) group; number = 181) with those of the patients where conservative management had failed (failed conservative management (FCM) group; number = 25). We found that there were no significant differences between both groups in terms of age, gender, body mass index (BMI), site and mechanism of the renal injury. However, significant differences between both groups were found with regard to the grade of renal injury, the pulse rate, blood pressure and hemoglobin levels, the need for blood transfusion, associated injuries to other organs, the site of parenchymal laceration, the size of perirenal hematoma and the presence of intravascular and collecting system contrast extravasation (Table 1).

To better define those factors independently associated with failure of conservative management, we carried out a logistic regression analysis (Table 2). In univariate analysis, the data were analyzed as categorical variables. Failure of conservative management was significantly correlated with motor vehicle accidents, a BMI ≥30 kg/m^2, a heart rate ≥110 beats/min, a systolic blood pressure <90 mmHg, a diastolic blood pressure <60 mmHg, a hemoglobin level <10 g/dl, the need for blood transfusion, associated injuries to other organs, renal injury grade V, the presence of medial laceration, perirenal hematoma sized ≥3.5 cm and intravascular extravasation. However, after multivariate analysis only a systolic blood pressure <90 mmHg, motor vehicle accident, associated injuries to other organs, grade V renal injury, the presence of medial laceration, perirenal hematoma sized ≥3.5 cm and intravascular extravasation were independently associated with higher odds of non-operative management failure.

All patients with grade III injuries were managed non-operatively, while 13.2% of the patients with grade IV and 39.4% of those with grade V injuries needed intervention (Fig. 4).

Table 1 Demographic, clinical, and radiological characteristics of patients in both groups.

	CM group ($n=181$)	FCM group ($n=25$)	*P*-value
Age, yr	31.64 ± 12.20	27.48 ± 11.91	0.111
Gender			0.964
Male	115 (63.5)	16 (64)	
Female	66 (36.5)	9 (36)	
BMI	30.62 ± 3.91	28.44 ± 4.46	0.011
Side			0.913
Right	89 (49.2)	12 (48)	
Left	92 (50.8)	13 (52)	
Mechanism of injury			0.070
MVA	140 (77.3)	25 (100)	
Falling from height	20 (11.0)	0 (0.0)	
Animal hit	13 (7.2)	0 (0.0)	
Others	8 (4.4)	0 (0.0)	
HR, beat/min	120.27 ± 17.82	140.12 ± 8.35	<0.001
Systolic blood pressure, mmHg	98.82 ± 15.25	72.00 ± 11.76	<0.001
Diastolic blood pressure, mmHg	68.56 ± 11.68	48.40 ± 11.11	<0.001
Hb level, g/dl	9.55 ± 1.75	8.16 ± 1.23	<0.001
Need for blood transfusion			0.017
No	33 (18.2)	0 (0)	
Yes	148 (81.8)	25 (100)	
Volume of blood transfused, unit	1.88 ± 1.42	3.84 ± 0.69	<0.001
Associated injury			<0.001
No	33 (18.2)	0 (0)	
Other intra-abdominal injury	42 (23.2)	12 (48)	
Extra-abdominal injury	68 (37.6)	0 (0)	
Combined intra- and extra-abdominal injury	38 (21)	13 (52)	
Grade of renal injury			<0.001
Grade III	82 (45.3)	0 (0)	
Grade IV	79 (43.6)	12 (48)	
Grade V	20 (11)	13 (52)	
Medial laceration			<0.001
No	107 (59.1)	4 (16)	
Yes	74 (40.9)	21 (84)	
Size of perirenal hematoma			0.001
<3.5 cm	60 (33.1)	0 (0)	
≥3.5 cm	121 (66.9)	25 (100)	
Intrvascular exravasation			<0.001
No	177 (97.8)	3 (12)	
Yes	4 (2.2)	22 (88)	
Contrast extravasation			0.001
No	94 (51.9)	4 (16)	
Yes	87 (48.1)	21 (84)	

Data presented as mean ± standard deviation or number (percentage).

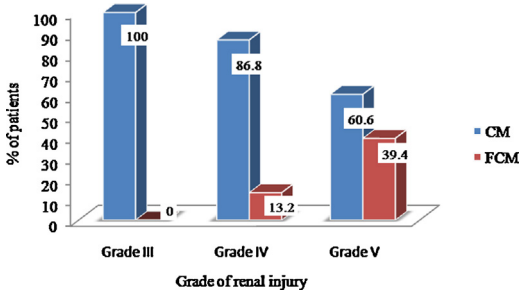

Fig. 4 Outcome of non-operative management of high grade renal trauma according to the grade of renal injuries.

As shown in Fig. 5, we categorized the patients according to the presence and number of the three CT imaging risk predictors. We found that patients without or with only one risk factor did not need intervention, while 11.5% of the patients with 2 and 81.8% with 3 risk factors required intervention.

Discussion

The main target for urologists dealing with trauma is to save the patient's life and to preserve as much functioning renal tissue as possible. At our institutions, renal trauma management decisions were based on the patients' hemodynamic status and their response to initial resuscitation. All stable patients were initially managed conservatively, regardless of the injury grade. We only excluded grade V with vascular pedicle injury as this is usually associated with massive bleeding requiring surgical exploration.

The present study revealed that 87.9% of the patients with high-grade renal injury, including 60.6% with grade V injury, were successfully managed non-operatively. Also, non-operative

Table 2 Univariate and multivariate analysis of the predictors correlated with conservative management failure.

	Univariate analysis			Multivariate analysis		
	OR	95% CI	*p*-Value	OR	95% CI	*p*-Value
Age ≥45 years	0.97	0.93–1.01	0.11	–		
Female gender	0.98	0.41–2.34	0.96	–		
BMI ≥30 kg/m^2	0.87	0.79–0.97	0.01	0.68	0.46–0.84	0.52
Heart rate ≥110 beat/min	4.16	3.08–11.42	0.002	2.19	0.98–2.11	0.08
Systolic blood pressure <90 mmHg	9.76	2.82–14.91	0.005	7.11	3.45–11.38	0.02
Diastolic blood pressure <60 mmHg	1.88	0.94–3.24	0.02	1.46	0.48–2.15	0.09
Hemoglobin level <10 g/dl	2.54	1.38–5.76	<0.001	1.55	0.44–1.89	0.34
Need for blood transfusion	2.44	1.42–2.89	0.01	0.98	0.78–1.04	0.06
Volume of blood transfused (≥4 units)	0.78	0.62–1.02	0.12	–		
Mechanism of trauma (MVA)	1.26	1.12–1.49	0.01	1.30	1.16–1.59	0.01
Associated injuries	3.41	1.77–6.05	0.01	3.55	2.46–5.71	0.02
Renal trauma grade V	5.24	2.76–9.12	<0.001	1.66	1.98–2.45	0.01
Contrast extravasation outside the collecting system	1.98	0.96–3.14	0.01	1.12	0.57–1.89	0.24
Medial laceration	1.34	1.02–2.56	0.03	2.89	1.43–4.35	0.03
Perirenal hematoma ≥3.5 cm	2.89	1.23–3.67	0.01	4.21	2.43–9.05	0.001
Intravascular contrast extravasation	3.12	2.18–9.41	0.001	4.62	2.31–7.83	0.01
Combination of the Parkland CT risk predictors	6.12	2.87–9.34	0.002	3.11	1.89–8.54	0.01

–, not included in multivariate analysis; BMI, body mass index; CI, confidence interval; CT, computed tomography; MVA, motor vehicle accident; OR, odds ratio.

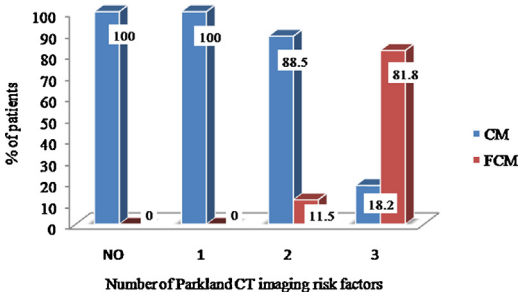

Fig. 5 Outcome of non-operative management of high-grade renal trauma according to the presence and number of the three CT imaging risk predictors.

management was associated with a lower incidence of complications such as early renal bleeding (12.2%), urinoma (3.9%) and secondary hemorrhage (1.9%), as well as with a lower overall nephrectomy rate (17/206; 8.2%).

Although non-operative management of stable blunt low-grade renal injuries has gained popularity in the last two decades, the initial decision whether to monitor or to explore high-grade injuries remains controversial [8]. Many authors support non-operative management as it is associated with a high renal salvage rate, while renal exploration mostly leads to nephrectomy [14,15]. In a population-based analysis of 1360 renal trauma cases, Wessells et al. [16] reported a surgery rate of 23%, ending with nephrectomy in 64% of the cases.

Non-operative management failure creates the potential for emergency nephrectomy and thus limits the possibility of preserving renal tissue. In the current study, 63.2% of the patients who had been subjected to immediate laparotomy underwent nephrectomy, compared with only 8.2% of the patients who had been planned for non-operative management. From this it follows that limiting renal exploration to life-saving indications may help in achieving the goal of maximum renal preservation.

Despite the large number of reports supporting non-operative treatment of renal injuries, there is still some controversy regarding standard indications of renal exploration in high-grade renal injuries. Many studies have been conducted and many tools have been developed to predict the need for surgical exploration after blunt renal trauma [6,17]. McGuire et al. [17] analyzed the records of 117 patients with high-grade renal injury (III–V). 17.1% of their patients required emergency intervention, with grade V injury and the need for platelet transfusion significantly predicting the need for intervention. More recently, in a retrospective review of 73 patients with renal injuries, Yang et al. [18], reported that an injury severity score ≥16 and a renal injury score ≥4 were predictive of the necessity of surgery. Shariat et al. [19] confirmed that the AAST injury severity scale is a powerful predictor of clinical outcome in renal trauma patients. They later developed a nomogram predictive of renal exploration and stated that the kidney injury scale, the mechanism of injury, the need for transfusion and the blood urea nitrogen and serum creatinine levels represented the most important predictors [9]. In another study, Prasad et al. [20] retrospectively reviewed the records of 55 renal trauma cases and evaluated the patients' demographic profile, clinical characteristics and grade of injury as predictors of emergency intervention. They concluded that grade V injuries and the need for more than 10 packed cell transfusions predicted the need for emergency intervention.

In our study, the grade of renal injury predicted the need for intervention as shown by multivariate analysis. Although our result was in agreement with the previous studies, our findings are biased as we selected only cases with high grade injuries and excluded the grades with expected outcome (low grades and grade V with vascular injury).

Although all the patients included in our study were hemodynamically stable after initial resuscitation, we found that hypotension at the time of presentation was a significant predictor of non-operative management failure. Overall, 50% of the patients with a systolic

blood pressure <90 mmHg at the time of presentation failed to be treated conservatively. Also, trauma due to motor vehicle accident and the presence of associated injuries to other organs were significant predictors in our study. When we analyzed the patients with isolated renal injury we found that all 33 patients (20 with grade III and 13 with grade IV) were successfully managed conservatively, and that only 8 (24.2%) patients, all with grade IV, required blood transfusion.

Dugi et al. [12] from Parkland Hospital in Dallas/USA, identified novel radiographic predictors for invasive intervention after renal trauma (perirenal hematoma size, intravascular contrast extravasation and renal laceration site) and evaluated them in 102 eligible grade III and IV renal injury cases. They concluded that these radiographic risk factors were independently associated with the need for urgent intervention. However, unlike in our study, they included blunt and penetrating trauma cases in their study. Later, Hardee et al. [13] re-evaluated the same radiographic predictors in 115 same-grade renal injury cases. They found that both intravascular extravasation and a perinephric hematoma ≥3.5 cm were associated with a 16.4- and 8.4-fold need for intervention, respectively. However, unlike in the Parkland study, the presence of medial laceration was not associated with intervention, in addition to the low intervention rate (7% compared to 18% in the Parkland study).

In the current study, we used the radiographic criteria described by Dugi et al. [12] and other CT findings, in addition to the clinical parameters, in order to predict the outcome. We found that all three Parkland CT criteria were independently associated with the need for intervention. However, the combination of these three CT criteria did not increase their predictive value.

Several studies have been conducted to evaluate the rate and predictors of angiographic intervention as first-line treatment of renal hemorrhage after trauma. Charbit et al. [21] evaluated 52 renal trauma cases and found that the angiographic intervention rate was 20%. Patients who needed more than 2 units of packed RBCs and had intravascular extravasation or a large perirenal hematoma >2.5 cm underwent angiography. Another group from Taiwan [22] retrospectively studied 26 patients with blunt renal injury and concluded that Gerota's fascia discontinuity and pararenal hematoma expansion were associated with the need for angioembolization with an intervention rate of 27%. They later updated their series and, when including cases with high-grade renal injuries ≥grade III, they found that contrast extravasation, the extent of hematoma and the perirenal hematoma rim distance predicted the need for angioembolization [23].

Although renal bleeding was the main indication for intervention in our study, only 4 (16%) cases were managed with renal angioembolization. This is due to the fact that angiographic intervention was available only in one of the study institutions.

One limitation of this multi-center study is its retrospective nature entailing the fact that the consistency in timing and circumstances of intervention among the different institutions and trauma teams cannot be guaranteed. Also, the inclusion of cases with extra-renal injuries definitely modified the need for intervention, particularly surgical exploration. The lack of long-term follow-up to evaluate the renal function of the patients successfully treated conservatively is another important limitation.

Conclusions

Based on our study results, high-grade renal injuries in hemodynamically stable patients can be managed conservatively with a high success rate. Renal trauma secondary to motor vehicle accident, hypotension at presentation, associated injuries to other organs, grade V renal injury, the presence of medial laceration, a perirenal hematoma sized ≥3.5 cm, and intravascular extravasation have been shown to be significantly associated with non-operative management failure.

Conflict of interest

The authors declare no conflict of interest.

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