

MSCT IN NON-OPERATIVE MANAGEMENT OF HIGH GRADE BLUNT RENAL TRAUMA, A PROSPECTIVE STUDY

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ABSTRACT

Aim: To highlight the validity of MSCT in predicting the efficacy of non-operative management in patients with high grade blunt renal trauma using American Association for the Surgery of Trauma (AAST) renal injury scale

Patients and methods:

Through a prospective study included 39 patients with high grades blunt renal traumas (grade III, IV and V), MSCT was done for all included cases and correlated to AAST grading system then we followed up non-operated cases by clinical, laboratory and US for all cases and CT in 12 cases along two weeks period. Statistical analysis was done for planed management immediately after CT and proper management done through two weeks of follow up.

Results:

MSCT graded the injury into grade III, IV and V according to AAST grading system presented in 48.7%, 33.3% and 17.9 % respectively. 74.4% of cases underwent conservative management, 5.1% underwent immediate surgical nephrectomy, 7.7 % underwent intervention embolization and double J fixation was done in 7.7%. Within 2 weeks of follow up conservative management was sufficient in only 64.1% as some patients developed other predisposing factors demanded further interventions and a total percentage of 17.9% of our cases underwent surgical laparotomy (6 cases nephrectomy and one case renorrhaphy), surgical percutaneous drainage of urinoma in one case and renal artery embolization raised to 10.3% of our cases.

Conclusion: MSCT can determine the exact criteria for selecting patients for conservative management in hemodynamic stable patients. Non-operative management strategy in line with repeated imaging and close clinical follow up salvaged the affected kidney in most of the cases.

Key words: Renal trauma, MSCT, nephrectomy, AAST

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INTRODUCTION

In management of renal trauma, current concepts tend to promote the use of conservative management and less invasive procedures, however, surgical intervention is mandatory in cases with severe injury. Therefore it is important to precisely determine whether to provide conservative or surgical treatment. (1, 2, 3)

AAST grading system, nowadays, is the most widely used and accepted classification system for renal injuries. Its grading is based upon surgical

findings (the standard for renal injury staging). (4,5)

Haemodynamic stability is the main parameter determining management in almost all cases. The American Association for the Surgery of Trauma (AAST) grading system with CT modality are capable of delineating low and high-risk injuries. (6)

Multislices computed tomography (MSCT) with intravenous contrast (IV) is the gold standard diagnostic modality in hemo-dynamically stable patients with suspected renal injury. (7,8)

The management plan for high-grade renal injuries remains controversial (9,10). As exploring high-grade renal injury usually, inevitably, leads to nephrectomy, many authors advocate non-operative management which has been increasingly applied with success (11,12). 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.

In a prospective study we followed up non operated cases for two weeks aimed to high light the role of MSCT in detecting different forms of renal tissue damage and grading it according to AAST scale of renal trauma to select patients who should get benefit from conservative management and enumerate the most obvious predisposing factors leading to failure of the non-operative management.

PATIENTS AND METHODS

This was a prospective study carried out at Zagazig University Hospital, from May 2016 to April 2018. It included all adult patients (aged 34±5.6 years, 53% were male) with high-grade blunt renal injuries (grade III–V) diagnosed and graded with MSCT using AAST grading system for renal trauma. We excluded all hemodynamic unstable patients (systolic blood pressure < 90 mmHg in spite of adequate fluids and packed RBC replacement) as they underwent immediate laparotomy without preoperative CT (15 cases) also we excluded patient died before completion of follow up management (two cases) and those with renal anomalies, pathology (3 cases) or iatrogenic trauma (1 case).

The present study was approved by the institutional review board. All patients were informed of the study and provided written informed consent.

All patients were subjected to 1) full history taking including mode of injury and present complaint 2) Full clinical examination. 3) Focused assessment sonography in trauma (FAST). 4) Contrast-enhanced multiphasic renal CT study.

Methods:

The hemodynamically stable patients were evaluated by MSCT scan of the chest, abdomen and pelvis. We included only cases with high-grade renal injury (grade III–V).

All patients in this study were examined in axial planes, using Siemens; Somatom Spirit 128 multi slices CT scanner and GE; 128 multi slices high speed SYS, Milwaukee scanner).

Our institute MSCT-protocol for renal trauma included two axial helical acquisitions. The first acquisition was CT of the chest, abdomen and pelvis without contrast, followed by post contrast nephrographic phase within 50-65 s of IV administration. Adding more phases were individualized to reduce the radiation dose and tailored according to required information. Delayed scan of the urinary tract was obtained after 3–5 m in 20 cases when pelvi-calyceal system injury was suspected, also we added arterial phase (25 second after contrast injection) and venous phase (45 second after contrast injection) to detect arterial and venous injury respectively in 6 cases.

Scan parameters were 0.6 mm detector collimation, 0.75 mm slice thickness, an interval of 0.5 mm and 120–140 Kvp; 250 mAs, with the data reconstructed at 0.5 mm intervals.

Contrast media (1.5–2.0 mL/kg of nonionic contrast material) were given by means of an automatic injector (Medrad Vistron CTTM injection system) 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.

Sagittal and coronal multiplaner reformatted (MPR) images were acquired at 4 mm intervals with 3-D VR processing. All images were reviewed by an independent radiologist who was blinded to the clinical state of the patients. Presence of parenchymal laceration > 1 cm, perinephric hematoma and its size, intravascular contrast extravasation in the perirenal hematoma, vascular injury, shattered kidney and segmental infarction or complete devascularised kidney were reported, analyzed and graded according to AAST grading system. (13)

Conservative management and follow up:

Follow up to all patients along 1-6 days extended to 14 days in only 12 cases. Conservative management generally consisted of rest, hydration, and analgesics. Bed rest is proposed until clinical signs become stable and microscopic hematuria has cleared. Intravenous broad spectrum antibiotics was used if there is suggestion of damage to the collecting system and urine leak, to prevent secondary infection of the retroperitoneal hematoma Serial hematocrit was obtained.

Follow up with US for confirming stability of the patient was done every day for all cases using 3.5 curved array probe using GE Logic3 expert ultrasound system. Repeated CT scan was done in 12 cases (within 24–27h) according to physician request due to instable patient condition or delayed improvement was done to allow detection of newly developed 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 open surgery and total nephrectomy in six cases or renorrhaphy in one case.

Non-operative interventions:

Double J fixation was done for cases with urine extravasation, urinoma,.

Subcutaneous drainage by nephrostomy tube used for enlarging urinoma or infected one.

Vascular embolization to achieve hemostasis, control pain due clot obstruction and for revascularization in case of venous or arterial thrombosis

Operative laparotomy

Failure of non-operative management as in size progression of the retroperitoneal hematoma, uncontrolled hemostasis, complete renal pedicle avulsion and persistent non enhanced kidney in follow up CT demanded surgical laparotomy.

Statistics:

All analyses were performed using IBM SPSS statistical software (V. 24.0, IBM Corp., USA, 2016). Contiguous variables were demonstrated as the mean \pm SD and the unqualified variables were demonstrated as a number and (%).

RESULTS

This study included 39 patients with high grade renal injury with mean age 34 ± 5.6 years. 47% were male and traffic road accident was the most common case of trauma.

Renal injury was part of multi-organ injury in majority of the cases, either, intra-abdominal injury (21 cases) or intra and extra-abdominal injury (2 cases). It was the only injured organ in 16 cases

Hepatic lacerations and bone fractures were the most common associated intra-abdominal and extra-abdominal injuries respectively

The most common renal injury was renal lacerations (48.7%) followed by retroperitoneal perinephric hematomas (35.9%) (**table 1**)

Table (1): Frequency distribution of renal injuries CT findings among the studied group:

CT findings	Studied group (n=39)	
	No	%
Deep laceration >1 cm, not reaching pelvi-calyceal system	19	48.7
Deep laceration reaching collecting system		
Sub-capsular hematoma	7	17.9
Perinephric hematoma <2.5 cm	5	12.8
Perinephric hematoma >2.5 cm	10	25.6
Urine extravasation	4	10.3
IV contrast extravasation	3	7.7
Segmental infarction	3	7.7
Renal pedicle avulsion	3	7.7
Shattered kidney	4	10.3
Renal artery thrombosis	2	5.1
	1	2.6

Frequency distribution of each injury demonstrated in (fig 1).

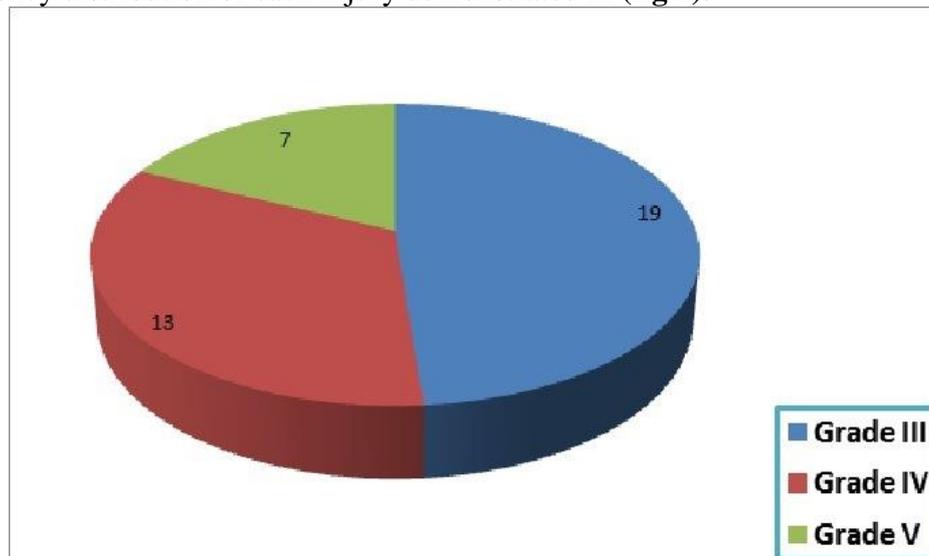


Fig 1): Pie chart for Frequency distribution of renal injuries grads according to AAST scale of renal injury using MSCT among the studied group.

The primary CT finding management plane and developing risk factors during two weeks follow up period and actual management were displayed in **tables 2, 3 and 4**

Table (2): Grading versus suggested CT management among the studied groups:

Management	Grading (n=39)			
	III	IV	V	Total
Conservative (follow up):	19 (48.7 %)	8 (20.5 %)	4 (10.2%)	31 (79.5%)
Conservative (double j and follow up):	0 (0%)	3 (7.7%)	0 (0%)	3 (7.7%)
Angiographic embolization or revascularisation:	0 (0%)	2 (5.1%)	1 (2.6%)	3 (7.7%)
Surgical (nephrectomy, renorrhaphy,):	0 (0%)	0 (0%)	2 (5.1%)	2 (5.1%)
Total	19	13	7	39

Table (3): Risk factors developed during follow up CT in different studied group:

Grade	Persistent nonfunctioning kidney	Increasing subcapsular hematoma	Significant urinary leak	Pain related to clot obstruction
Grade III:	--	2	----	--
Grade IV:	--	1	1	1
Grade V:	1	1	--	--

Table (4): Grading versus actual follow up- management among the studied group:

Management	Grading (n=39)			
	III	IV	V	Total
Conservative (follow up):	17 (43.6%)	6 (15.4%)	2 (5.1%)	25 (64.1%)
Conservative (double j and follow up):	0 (0%)	2 (5.1%)	0 (0%)	2 (5.1%)
Angiographic embolization or revascularization:	0 (0%)	3 (7.7%)	1 (2.6%)	4 (10.3%)
Surgical (nephrectomy or renorrhaphy):	2 (5.1%)	1 (2.6%)	4 (10.3%)	7 (17.9%)
Percutaneous nephrostomy		1 (2.6%)		1 (2.6%)
Total -	19	13	7	39

Seven cases with Grade III renal injuries were hemodynamically stable and revealed IV associated with perinephric hematomas less than 2.5 cm. (fig 2&3) and multiple previously measured hematoma. One patient subcapsular hematomas detected in five cases underwent nephrectomy due to presence of Conservative management of these cases was pulsatile expanding perinephric hematoma and the first choice; however, two cases underwent the other was non pulsatile so renorrhaphy was repeated CT scan due to failure regaining the sufficient to salvage the kidney.

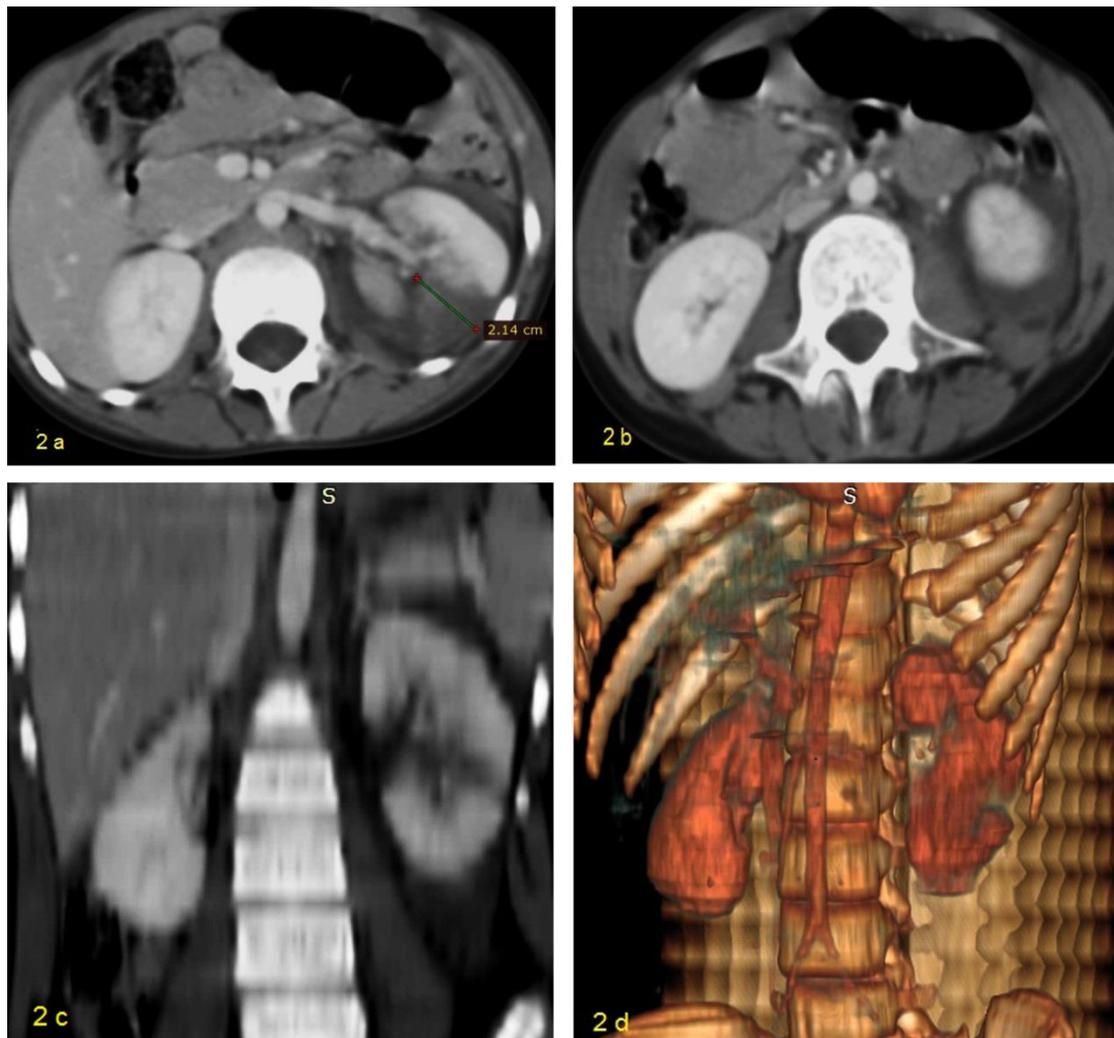


Fig 2: AAST grade III renal trauma. A & B: axial CT cuts showing a perinephric hematoma surrounding the left kidney associated with a deep (2.14 cm) cortical laceration. **C:** coronal reformatted image showing the cortical laceration appearing as linear defect involving the lateral middle zone of the kidney **& D** 3D volume rendering (VR) cut showing cortical laceration of left kidney.

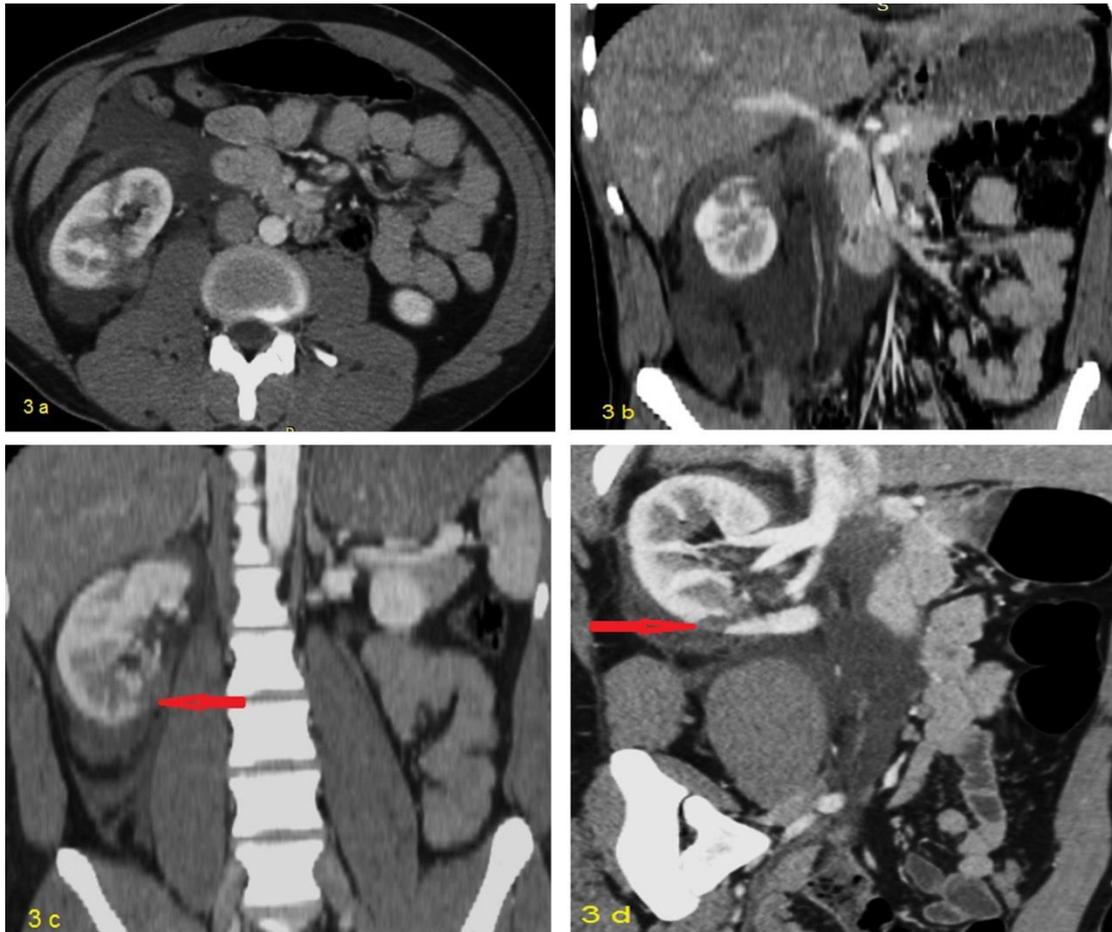


Fig 3) AAST grade III renal trauma. **A and B:** axial and coronal CT cuts showing a small hyperattenuated perinephric hematoma surrounding the right kidney associated with a deep cortical laceration and peritoneal free fluid. **C & D)** coronal & sagittal reformatted images shows another multiple cortical lacerations (arrows).

Regarding AAST Grade IV, 7cases had deep lacerations reaching the renal pelvis (**fig 4-5**)with urine extravasation in 3 cases (**fig 6 & 7**)which managed by double J fixation and in only one of them urinoma progress in its size and percutaneous nephrostomy was done. And two cases demonstrated shuttering with fragmentation (**fig 7 & 8**). Also we had 3 cases with segmental infarction and non-enhancement in nephrographic phase (**fig 4& 8**). On follow up only one case had continuous renal pain not responding to analgesics so angiographic intervention and revascularization was done. Three cases showed intravenous contrast extravasation within the perinephric hematoma (**Fig 5**). Angiographic embolization in two cases salvaged the affected kidney however the progressive increase in the size of the perinephric hematoma and continuous IV extravasation favor the surgical nephrectomy of the third case (**fig 5**)

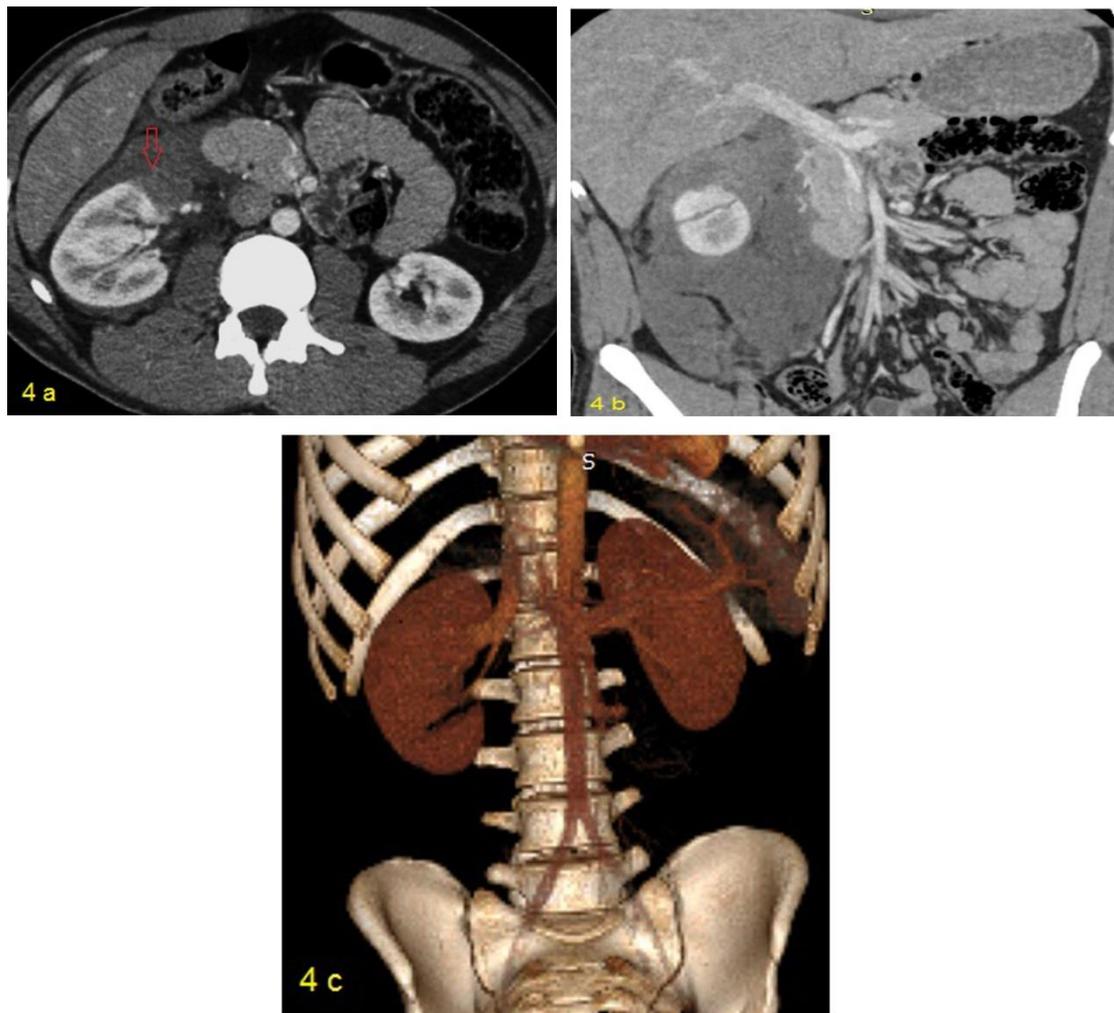


Fig 4) **AAST grade IV renal trauma.** **A:** axial CT cut showing non enhanced anterior upper pole of the RT kidney with perinephric hematoma. **B:** coronal reformatted image showing the cortical laceration appearing as linear defect involving both cortical margins of the upper pole of the RT kidney (shattered) & **C)** 3D VR showing absent upper pole of the RT kidney (segmental infarction) associated with another deep laceration in its medial aspect reaching the renal hilum.

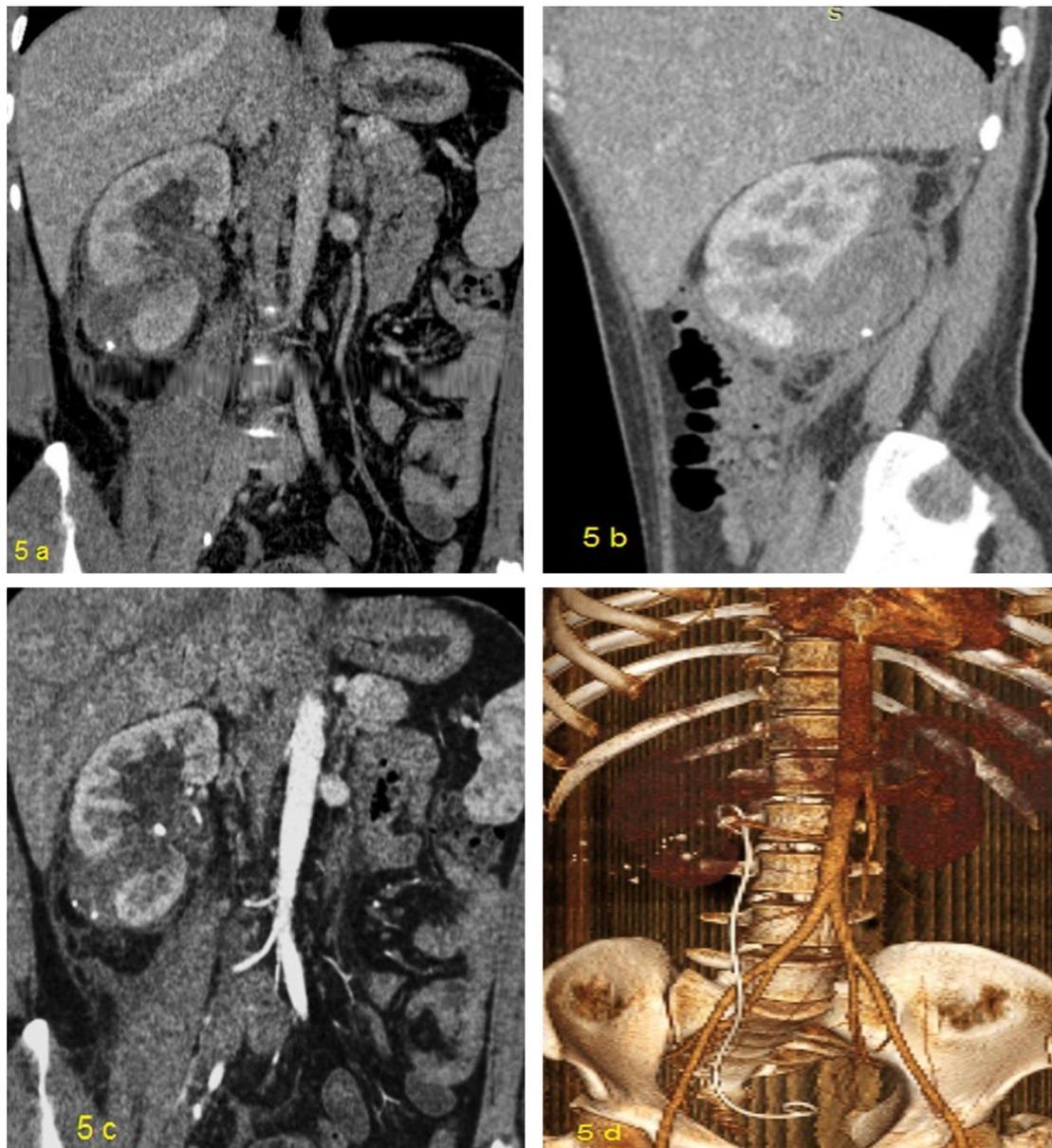


Fig 5) **AAST grade IV renal injury.** **A& B:** coronal and sagittal reformatted cuts showing right renal laceration reaching the hilum appearing as linear non enhanced defect involving the lower pole. There are traces of contrast extravasation within a large perinephric hematoma.

Follow up CT Coronal reformatted image C) shows still contrast extravasation after double J fixation and failure of the conservative management **D)** 3D VR showing double J fixation and persistent contrast extravasation.

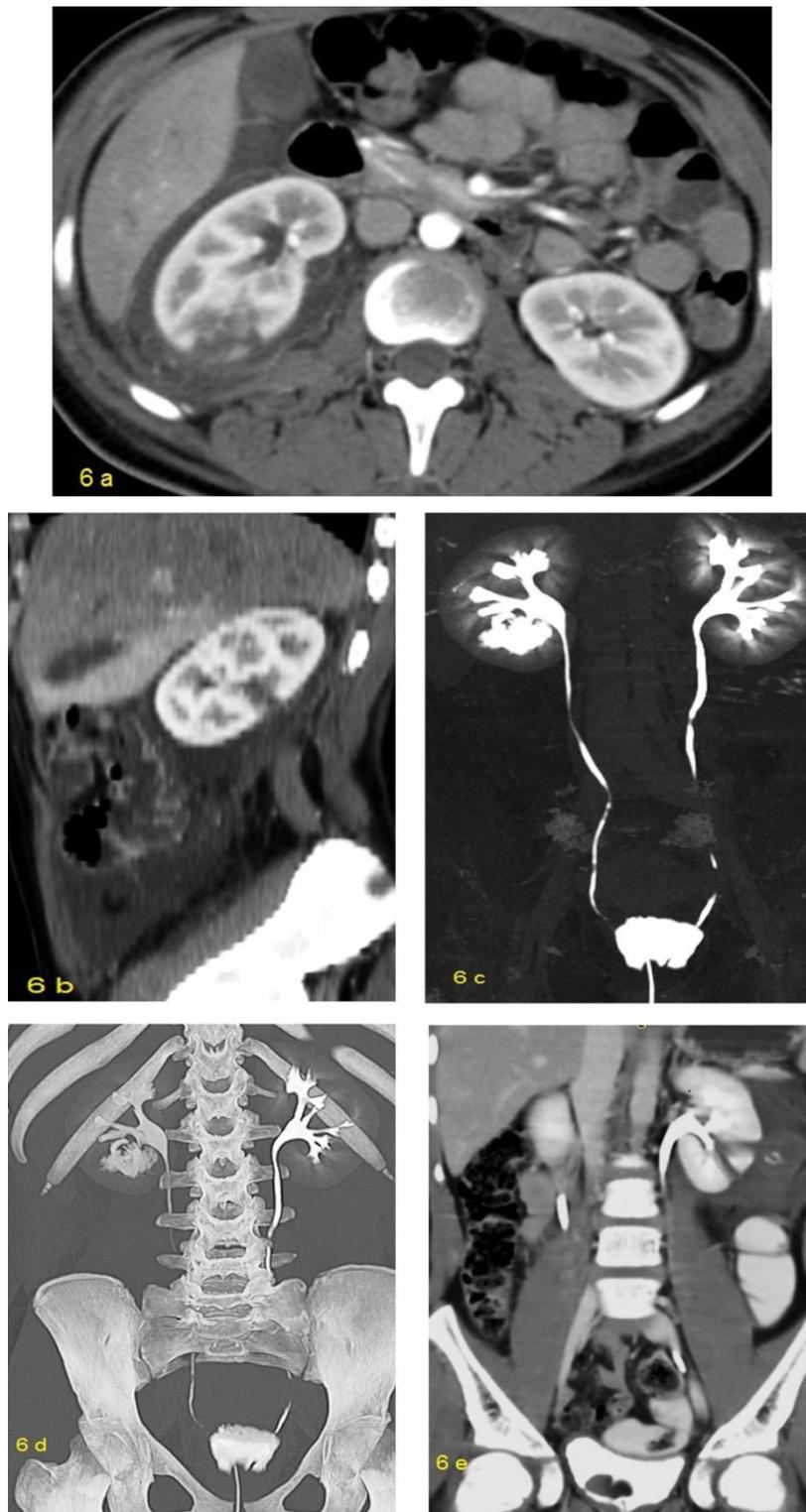


Fig 6) **AAST grade IV renal injury.** **A:** axial CT cut showing an ill-defined non enhanced parenchymal area in the posteromedial aspect of the RT kidney particularly evident in the nephrographic phase associated perinephric hematoma and free fluid. **B:** sagittal reformatted cut in the nephrographic phase showing right renal cortical deep laceration appearing as linear non enhanced defect predominantly involving the posterior mid zone with large perinephric hematoma **C & D:** VR and 3D MIP coronal cut in the delayed phase showing contrast extravasation in lower pole (urinoma)



Fig 7) **AAST grade IV renal injury.** A axial CT cut showing a large inhomogeneously hyperattenuated LT sided perinephric hematoma (5.5x6.7 cm) occupying the renal and perirenal spaces with posterior cortical deep laceration extending to the renal pelvis B & C: coronal and sagittal reformatted cuts in the nephrographic phase show two deep laceration with fragmentation of part of the lower pole of the left kidney (shattered) D& E: **Follow up CT** axial and coronal cuts in the excretory phase shows continuous increase of the size of the perinephric hematoma and continuous urine extravasation and nephrectomy was done.

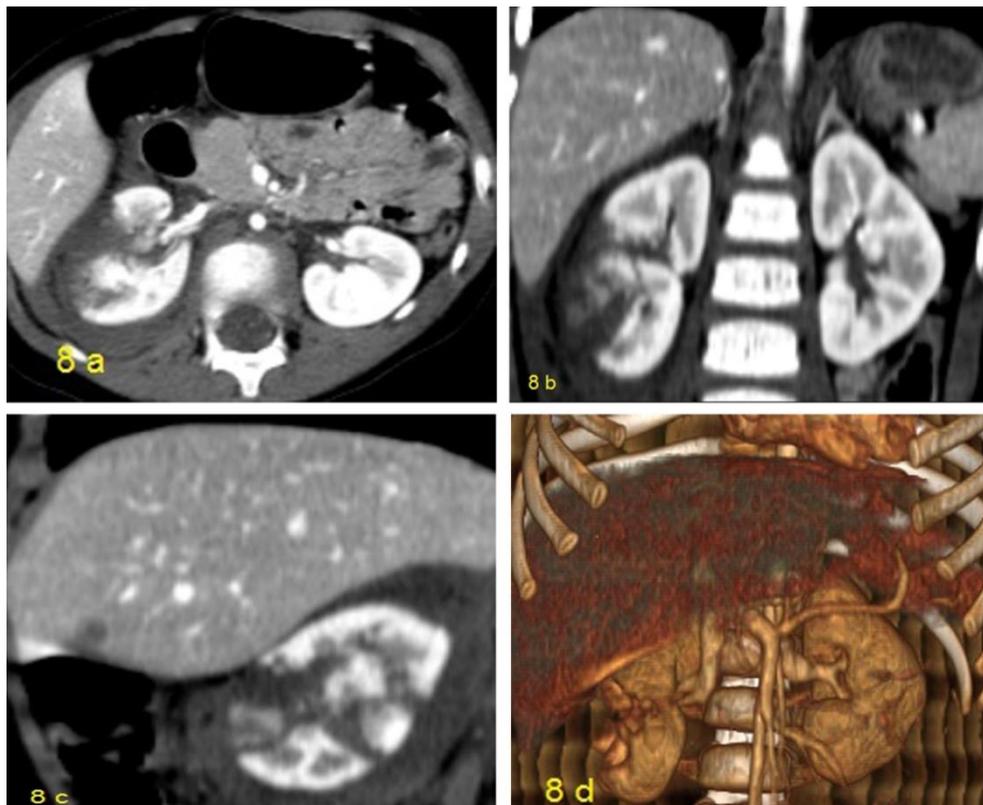


Fig 8) AAST grade IV renal trauma managed conservatively. **A:** axial CT cut showing multiple non enhanced fragments of the RT kidney with perinephric hematoma. **B & C:** coronal and sagittal reformatted images show multiple cortical laceration with fragmentations (shattered kidney with segmental infarctions) **& D)** 3D VR showing the multiple fragments

Regarding AAST Grade V injuries severity spectrum varies from the less severe (non-enhanced kidneys with minimal hematoma), detected in 3 cases who managed conservatively and in follow up one of them showed persistent non enhancement in follow up CT and surgical nephrectomy was done, to more severe forms (uncontained pedicle avulsion in 2 cases) who underwent planned nephrectomy immediately after first CT imaging. Also one shattered kidney

with multiple fragmentations and enlarging perinephric hematoma during follow up underwent nephrectomy. Only one case had unilateral renal artery thrombosis with complete obstruction and angiographic revascularization regained its vascularity (**fig 9**).

Conservative management and close follow up were sufficient in management of 67.6% of the cases (**table 5**)

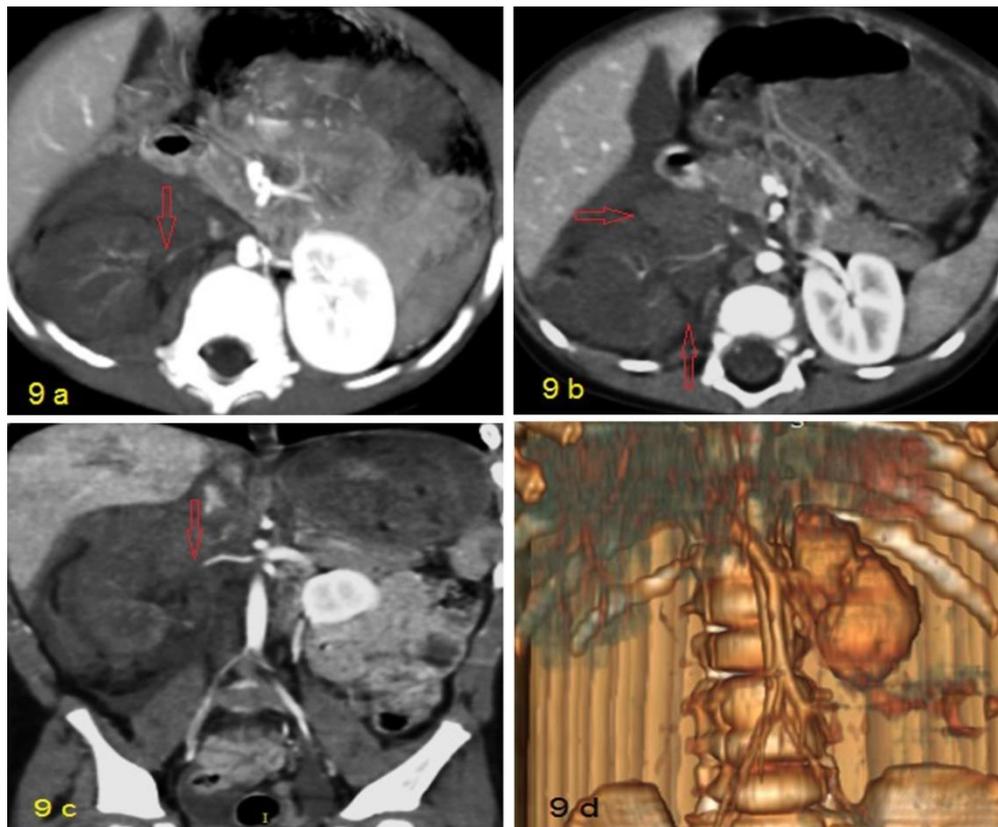


Fig 9) **AAST grade V renal injury.** **A&B:** axial CT cuts reveals non enhanced right kidney as a consequence of Rt renal artery thrombosis with retrograde opacification of the renal vein from the inferior vena cava(arrow in a),. There are multiple parenchymal lacerations (arrows in b). The right kidney surrounded by large perinephric hematoma extending to the hilum and medial aspect of the kidney. **C:** coronal reformatted cut showing hypovasclurized right kidney with abrupt truncation of the renal arterial lumen at the point of occlusion (arrow). A large perinephric hematoma surrounds the kidney, liver contusion, huge splenic hematoma in its upper part and LT subphrenic collection are noted. **D:** 3D VR showing non visualized right kidney.

Table (5): conservative Vs non-operative and operative intervention (nephrectomy or renorrhaphy) of the studied group:

Grade(n)	Studied group		
	Conservative	Non-operative intervention	Nephrectomy-or renorrhaphy
Grade III (19)	17(89.5 %)	----	2(10.5 %)
Grade IV (13)	6 (46.2 %)	6(46.2 %)	1(7.7 %)
Grade V (7)	2(28.6%)	1(14.3 %)	4(57.1 %)

DISCUSSION

MSCT is considered the gold standard method for the radiographic evaluation in patients with renal trauma and has replaced conventional IVP (7)

In the last 3 decades, there is a trend to follow the non-operative management (NOM) rather than the operative management (OM) in the treatment strategy of the renal trauma (14), however, the initial decision whether to explore or monitor high-grade renal injuries remains controversial (11)

The morbidity rate for unnecessary laparotomy is between 8.6% -25.9%. Multislices CT plays an effective role in accurate radiologic classification of renal injury as well as in selecting patients who need urgent surgical intervention, as opposed to those in whom NOM is possible (15)

Specific guidelines in management of renal trauma are still lacking and the few studies providing recommendations are not supported by relevant grades of evidence. (16)

Immediate operative management of post traumatic life-threatening hemorrhage is widely accepted; however, when this clear-cut emergency is lacking, several different management strategies emerge (17-19).

Nowadays at most trauma centers, CT is available and provides easily interpreted images which demonstrate

all different positive findings in renal trauma and correlate them to the surgical observation. (5)

A meta analysis(16) demonstrated that, in hemodynamically stable patients surgical exploration is not always needed, as major renal injuries may resolve either after minimally invasive procedures or spontaneously.

Altman et al compared two groups of patients affected with grade 5 injuries.(7) Six were managed conservatively and seven were operated on. The authors affirmed that patients treated conservatively had a lower morbidity rate than operated cases and at follow-up CT scan they showed good functioning kidney (19).

This study included 39 patients with high grade blunt renal trauma. 51.2% of the cases were grade IV and V, however grade III renal injury was the most common injury. All the patient were hemodynamically stable at the time of CT scanning, surgical laparotomy and nephrectomy was planned for only two cases (5.1%) immediately after CT examination due to uncontained pedicle avulsion and failure of hemostatic control by fluid replacement.

Only 13.5% from the remaining 37 cases underwent planned laparotomy after different periods of close follow up; 4 cases underwent nephrectomy and one renorrhaphy.

Conservative management and close follow up were sufficient in management of 67.6% of the cases. Non operative interventions as, double J fixation, vascular embolization, revascularization and percutaneous drainage of urinoma were sufficient to preserve renal tissue and regain its function.

This is an agreement with a retrospective study by Maarouf et al., 2015 (20) who reported nephrectomy in only 8.2% of their patients who had been planned for non-operative management compared to 63.2% of the patients who had been subjected to immediate laparotomy and concluded that limiting renal exploration to life-saving indications may help in achieving the goal of maximum renal preservation. (20)

Also we agreed with a study by Moudouni et al, who studied 20 patients with grade 4 and 5 renal injuries and were conservatively treated, they reported 6 open delayed procedures, whereas 70% (14 patients) healed spontaneously or after ureteral stent positioning (21).

The recent treatment strategy in managing patients with high grade renal injury preferred non-operative management for nearly all patients with grade III injuries, while 13.2% of the patients with grade IV and 39.4% of those with grade V injuries needed intervention (20)

In our study most of grade III renal injury (89.5%) conservative management was sufficient with spontaneous absorption of the subcapsular or perinephric hematoma , also 46.2% and 28.6 % grade VI and Grade V respectively were managed conservatively with no need for laparotomy. However laparotomy was the main management needed in grade V renal trauma (57.1 %)

Doing a phasic scan helps in differentiating active hemorrhage

(detected in the nephrographic phase) from urine extravasation (detected in delayed phase) (22)

In our study urine extravasation detected as leaking of contrast during the excretory phase and they were managed conservatively with double J fixation in 66.7% , however in one case urinoma progress in size and percutaneous nephrostomy was needed. This was compatible with other studies (10-11) which reported that urinary extravasation resolves spontaneously in 76% to 87% of cases and intervention may be required if there is urine collection or a persistent leak. The percutaneous nephrostomy or insertion of a retrograde stent typically aids the resolution (23, 24).

Several studies have been conducted to evaluate the rate and predictors of angiographic intervention as first-line treatment of renal hemorrhage after trauma (25-26) and found that contrast extravasation, the extent of hematoma and the perirenal hematoma rim distance predicted the need for angioembolization (27).

In our study 10.7% of our cases underwent angiographic intervention, one case with segmental infarction appears as wedge shape hypodense segment in nephrographic phase, two cases with IV contrast extravasation in nephrographic phase within perinephric hematomas ranging from 2-3 cm. The forth case underwent angiographic revascularization due to renal artery thrombosis and complete devascularized kidney with abrupt truncation of the renal artery and retrograde filling of the renal vein from the IVC. This is nearly agreeing with Charbit et al (25) who found that the angiographic intervention rate was 20% in 52 cases with renal trauma.

Administration of intravenous contrast provides information about renal function and renal vessels which is helpful in evaluating segmental

infarction, total devascularization and injury of the pelvicalyceal system (22)

Injuries with nonviable renal segments can be managed conservatively but require close monitoring as these injuries are always associated with a higher complication rate and need delayed intervention.(10, 28) In our study only one case with segmental infarction need embolization after developing continuous pain.

Grade V injuries usually are an absolute indication for exploration, but hemodynamic stable patients may be safely treated conservatively (29). This is compatible to our study as most of our patients (57.1 %) with grade V renal injury underwent planned laparotomy.

Indications for exploration in renal trauma are renal pedicle avulsion, life-threatening hemorrhage, or pulsatile/expanding hematoma at the time of laparotomy (11, 30). In our study uncontained pedicle avulsion in 2 cases managed by surgical nephrectomy, however in three cases with non-enhanced kidney, only one case need surgical interference in follow up due to persistent non enhancement in follow up CT and also in one patient with multiple fragmentations in a shattered kidney and progressive increase in perinephric hematoma size underwent nephrectomy

Chiron et al.2015 (31) proposed an update of the AAST grade IV renal injury scale and highlight the role of three factors (perirenal hematoma > 3.5 cm (which can be accurately measured in CT), intravascular contrast extravasation and medial renal laceration as predictors for the need to surgical interference.

In our study size of the perinephric hematoma estimated at first CT didn't affect the outcome however, development of expanding hematoma required surgical

management as it represents combination of continuous vascular extravasation in the existing hematoma. Persistence non-enhanced kidney during follow up as well as pain intolerance was also risk factors demanded surgical laparotomy.

New CT machines with helical multislice scanner and improved multiplanar reconstruction options provide faster imaging and increase the volume of coverage which can help to overcome long scan time and motion artifact with accurate assessment and proper grading of the renal injury.

The lack of long-term follow-up to the patients successfully treated conservatively is one of our limitations; also being a prospective study limited the available number of included patients

CONCLUSIONS

It was one of the little prospective studies which highlighted the critical role of MSCT in selecting certain patients for conservative management in hemodynamic stable post traumatic high grade renal injury. Other surgical non operative management as vascular intervention, double J ureteric stent and subcutaneous drainage in line with repeated imaging and close clinical follow up were alternative treatment options salvaged the traumatized kidney in most of the cases.

Development of expanding hematoma, persistence non-enhanced kidney during follow up CT as well as pain intolerance were the most developing risk factors demanded surgical laparotomy

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