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ORIGINAL ARTICLE

Does routine repeat imaging change management in high-grade renal trauma? Results from three level 1 trauma centers

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Abstract

Purpose Guidelines call for routine reimaging of Grade 4–5 renal injuries at 48–72 h. The aim of the current study is to evaluate the clinical utility of computed tomography (CT) reimaging in high-grade renal injuries.

Materials and methods We assembled data on 216 trauma patients with high-grade renal trauma at three level 1 trauma centers over a 19-year span between 1999 and 2017 in retrospectively collected trauma database. Demographic, radiographic, and clinical characteristics of patients were retrospectively reviewed.

Results In total, 151 cases were Grade 4 renal injuries, and 65 were Grade 5 renal injuries. 53.6% (81) Grade 4 and 15.4% (10) Grade 5 renal injuries were initially managed conservatively. Of the 6 asymptomatic cases where repeat imaging resulted in intervention, 100% had collecting system injuries at initial imaging. Collecting system injuries were only present in 42.9% of cases where routine repeat imaging did not trigger surgical intervention. Collecting system injury at the time of initial imaging was a statistically significant predictor of routine repeat imaging triggering surgical intervention ($p=0.022$). Trauma grade and the presence of vascular injury were not significant predictors of intervention after repeat imaging in asymptomatic patients.

Conclusion In asymptomatic patients with high-grade renal trauma, the number needed to image is approximately one in eight (12.5%) to identify need for surgical intervention. There is potentially room to improve criteria for routine renal imaging in high-grade renal trauma based on the more predictive imaging finding of collecting system injury.

Keywords High-grade renal trauma · Vascular injury · Collecting system injury · Renal trauma grade · Repeat imaging

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Introduction

Management of high-grade renal trauma is a historically controversial topic. Guidelines dictating appropriate management of patients with high-grade traumatic injuries to the kidney have evolved as knowledge on the sequela of renal trauma has grown. Kidney injury occurs in 8–10% of patients with abdominal injuries [1] and 1–3% of all traumatic injuries [2, 3]. Most injuries occur due to blunt trauma [2]. The American Association for the Surgery of Trauma (AAST) divides renal trauma into 5 major grades [4]. Management of renal trauma has evolved from aggressive treatment recommendations to conservative management in recent years [3]. This is particularly well studied for low-grade renal trauma, or Grade 1–3 injuries [5–8]. For low-grade renal injury, evidence suggests that conservative management without reimaging is appropriate, provided there are no prompting indications such as hemoglobin drop, hemodynamic instability, expanding abdominal mass, fevers, or any other concerning clinical symptoms [9]. High-grade renal trauma (Grade 4–5) can also be managed conservatively if the patient is clinically stable without any concerning symptoms [9–12].

According to the American Urological Association (AUA) guidelines, unlike Grade 1–3 injuries, Grade 4–5 injuries require repeat imaging even in the absence of clinical findings that would otherwise indicate obtaining repeat imaging [13]. However, there is growing evidence that repeat imaging without clinical indication may not necessarily change clinical management [6, 14]. This suggests that obtaining repeat imaging for every asymptomatic high-grade trauma is unnecessary, but data to support this are lacking.

We believe that repeat imaging in all asymptomatic patients with Grade 4 and Grade 5 renal injuries is not necessary. Repeat imaging in asymptomatic patients after high-grade injury is predominantly indicated in instances where there is concern for an enlarging urinoma based on collecting system injury witnessed at the time of initial evaluation. It is our hypothesis that the indication for repeat imaging in asymptomatic high-grade renal trauma should be based on the presence or absence of collecting system injury rather than grade of trauma alone. Here, we present our findings from three level 1 trauma centers over a 19-year period with the objective to demonstrate collecting system injury as a superior predictor of need for intervention after conservatively managed asymptomatic high-grade renal trauma.

Methods

Data collection

We assembled data on patients with high-grade renal trauma at three level 1 trauma centers over a 19-year span between 1999 and 2017 in a retrospectively collected trauma database. Data were collected retrospectively on patient demographics such as age, sex, presence or absence of vascular injury, presence or absence of collecting system injury, renal trauma grade, and treatment course. Renal trauma grade was generated based on retrospective review of each patient's renal imaging as read by radiologists at the time of imaging and confirmed by urologist re-review of imaging and/or imaging reports. Grade was assigned using the AAST organ injury severity scale for renal trauma.

Patient categorization

High-grade renal trauma patients were categorized as undergoing immediate intervention (surgery or embolization) after initial CT scan versus conservative management (observation). Conservative management patients who underwent repeat imaging were further subdivided as symptomatic (imaging triggered by fevers, blood loss, etc.) or asymptomatic (no symptoms that would otherwise trigger imaging). Our database included imaging obtained both inpatient and outpatient, but did not include imaging obtained at institutions outside of the three trauma centers studied.

Statistical analysis

The primary outcome was intervention after repeat imaging. Associated variables were investigated in both symptomatic and asymptomatic patients. Statistical analysis was performed in R (R Studio Version 3.3.3) and mean variable frequencies were compared using Fisher's Exact Test for binary variables and Welch two sample t test for continuous variables.

Results

In total, we accumulated data on 216 high-grade traumas. 151 cases were Grade 4 renal injuries and 65 were Grade 5 renal injuries. Of the Grade 4 renal injuries, 53.6% (81) were managed conservatively, and of the Grade 5 renal injuries, 15.4% (10) were managed conservatively (Fig. 1). In four cases, reimaging was performed for a decrease in hemoglobin level; in two cases, reimaging was performed due to fever, and in one case repeat imaging was performed by

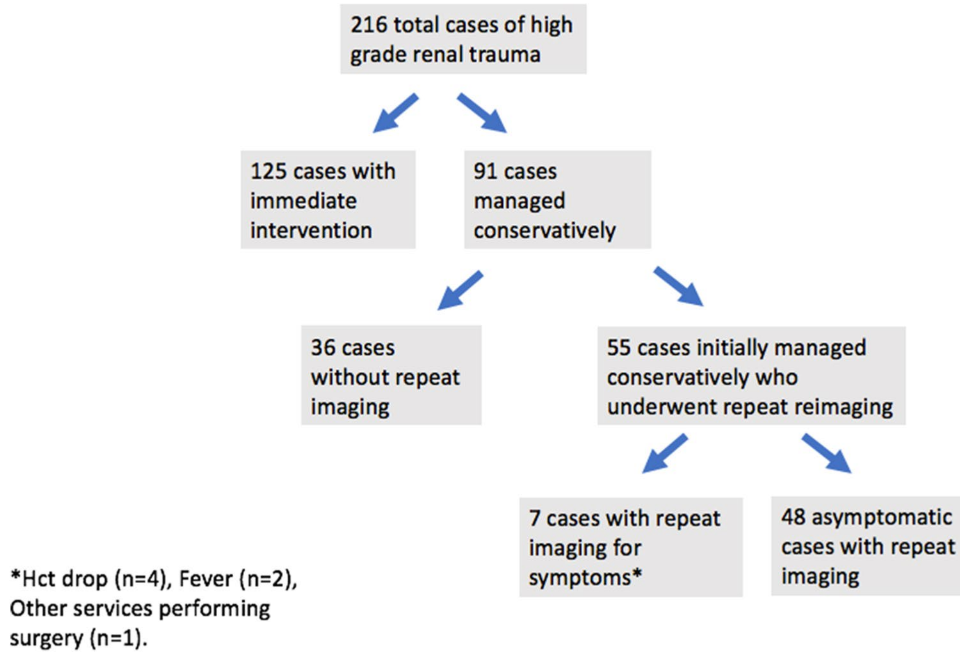

Fig. 1 Trauma cases selected for review

Table 1 Demographics of all high-grade renal trauma patients who underwent reimaging

	Symptomatic reimaging	Asymptomatic reimaging	p
Total cases	7	48	
% Male	85.7%	81.3%	1
Age	41.9	31.6	0.323
Grade (% Grade 4)	4.00 (100%)	4.04 (95.8%)	1
% Penetrating trauma	0%	21.4%	0.577
Vascular	28.6%	33.3%	1
Collecting system injury	71.4%	50.0%	0.427

another surgical service in preparation for intervention to treat non-urological traumatic injuries (Table 1). Of these seven symptomatic cases, only one required operative intervention after repeat imaging. The patient who was reimaged due to fever ended up getting percutaneous drainage for what was thought to be an infected renal hematoma while the remaining 6 patients were managed non-operatively.

There was no significant difference in blunt versus penetrating trauma in symptomatic compared to asymptomatic patients (Table 1), nor in asymptomatic patients requiring intervention versus those not requiring intervention after repeat imaging (Table 2).

The average time to repeat imaging for symptomatic patients was 2.14 days, or 51 h after initial imaging (range 0.06–4.51 days or 1.4–108 h). For asymptomatic patients, the average time for repeat imaging was 3.55 days, or 85 h after initial imaging (range 0.44–28.9 days or 10–693 h). This difference was not statistically significant ($p=0.127$).

Comparing the 36 high-grade renal trauma patients who did not undergo repeat imaging to the 55 who did undergo repeat imaging, we found no statistically significant difference in median age (32.2 without imaging vs 32.9 with imaging; $p=0.858$), gender (75.0% male vs 81.8% male;

Table 2 Asymptomatic patients with high-grade renal trauma who were managed conservatively. Significant values are highlighted in bold

	Cases where routine imaging resulted in intervention	Cases where routine imaging did not result in intervention	p
Total cases	6	42	
% Male	83.3%	81.0%	1
Age	30.7	31.7	0.911
Grade (% Grade 4)	4 (100%)	4.05 (95.2%)	1
% Penetrating trauma	18.8%	28.6%	0.617
Vascular	33.3%	33.3%	1
Collecting system injury	**100%**	**42.9%**	**0.022**

$p=0.443$), trauma type (9.1% penetrating vs 20% penetrating; $p=0.235$), frequency of vascular injury (48.0% vs 32.7%; $p=0.219$), or frequency of collecting system injury (29.2% vs 52.7%; $p=0.085$). Patients who did not undergo repeat imaging had a higher average renal trauma grade compared to patients who did undergo repeat imaging (4.22, or 77.8% Grade 4 vs 4.04, or 96.3% Grade 4; $p=0.0124$).

In 48 cases, patients were asymptomatic and reimaged for staging purposes only. Of these cases, there were only 6 instances in which repeat imaging triggered intervention and, in each of these instances, retrograde pyelogram with stent placement was the only intervention (Table 2). Of the six asymptomatic cases where repeat imaging resulted in intervention, all six, or 100%, had collecting system injury at initial imaging. At initial imaging, collecting system injury was present in 18/42, or 42.9% of cases where subsequent routine repeat imaging did not trigger surgical intervention. Fishers exact test demonstrates collecting system injury at the time of initial imaging as a statistically significant predictor of need for surgical intervention triggered by routine repeat imaging ($p=0.022$) (Table 2). Trauma grade and the presence of vascular injury were not associated with need for intervention in asymptomatic patients.

Of the 24 patients with collecting system injury, 6 patients underwent stent placement after repeat imaging, but 18 did not. When comparing these patients, there were no significant predictors of likelihood for stent placement based on patient demographics including age (28.6 without stent placement vs 30.7 with stent placement; $p=0.823$), gender (83.3% male vs 88.9% male; $p=1$), trauma type (14.3% penetrating vs 20.0% penetrating; $p=1$), vascular injury frequency at initial imaging (33.3% vs 27.8%; $p=1$), renal trauma grade at initial imaging (4.0, or 100% Grade 4 vs 4.06, or 94.4% Grade 4; $p=1$), or time between initial and repeat imaging (73.4 h vs 64.9 h; $p=0.854$).

Discussion

Our results demonstrate that collecting system injury is a more reliable predictor of need for intervention in asymptomatic high-grade renal trauma patients than either renal trauma grade or vascular injury. We show that in 6/48 (12.5%) cases of asymptomatic high-grade renal trauma, repeat imaging changed management. In these 6 cases, patients who were asymptomatic underwent surgical intervention as a result of findings on their repeat imaging. Based on our data, collecting system injury was significantly more common among cases where routine imaging changed management ($p=0.022$).

Previous studies have shown that high-grade renal traumas can be managed conservatively [15]. Non-operative management of high-grade traumas results in a higher kidney salvage rate (87% vs 93%) with minimal complications as a consequence of non-operative management [15]. The success of non-operative management with high-grade renal injury has also been demonstrated in the series presented by Buckley and McAninch in which 58% of isolated grade 4 renal injuries were managed conservatively with a renal salvage rate of 88%, with no non-operative case requiring delayed nephrectomy [16].

In a series by McGuire et al., 9 out of 90 patients who were managed conservatively initially with Grade 3 to Grade 5 renal trauma eventually required surgical intervention.

Of these 9 cases, 6 presented with hemorrhage requiring embolization or nephrectomy, 2 had urinoma requiring stent placement, and one required a percutaneous drain placement for a perinephric abscess [17]. They mention that the two urinomas requiring stent placement were identified based on routine imaging [17], but they do not mention if the other interventions were based on clinical indications or routine imaging.

Limitations of this study include the fact that the study is retrospective and that there is a low frequency of available data on repeat imaging. Many of these patients were originally treated at the level one trauma centers in this study but were lost to follow-up due to reappropriation by primary institutions. Of the 36 patients where repeat imaging data were not available, we do not know whether these patients were reimaged at their primary institutions after reappropriation or if these patients required subsequent intervention. Also, this study is limited by lack of information on concomitant injuries in our database. Furthermore, given the low frequency of intervention after routine reimaging, sample size is small. When looking specifically at the patient characteristics that predicted reimaging, given small patient sample size of our primary endpoint, we were unable to perform multivariate analysis on patient characteristics.

The decision to intervene after repeat imaging was not based on stringent criteria but rather individual surgeon decision based on size of the urinoma. Consequently, we do not have objective criteria to determine why some patients with urinoma on repeat imaging underwent stent placement while others did not.

Our database uses the 1989 classification for renal trauma to categorize our trauma cases by grade. In 2011, Buckley and McAninch proposed changing the renal trauma classification to account for segmental vascular injury as Grade 4 trauma in addition to all collecting system injuries [18]. We believe that by including data accounting for both trauma grade, presence or absence of collecting system injury, and presence or absence of vascular injury in our database we are able to address the crucial factor of collecting system injury rather than vascular injury or trauma grade as a driver of intervention after repeat imaging.

Current AUA guidelines recommend repeat imaging in all high-grade renal trauma in the presence or absence of symptoms. Current routine repeat imaging recommendations are based on renal trauma grade alone [14]. These data suggest that high-grade vascular injuries do not require repeat reimaging in asymptomatic patients. Our data also suggest that it is reasonable to recommend repeat reimaging in asymptomatic patients based on the presence of collecting system injury alone. Reimaging based on the more specific indication of collecting system injury would produce an intervention rate of 23.1%, and would miss no cases in need of intervention after initial conservative management. This compares to a less efficient 12.5% rate for intervention after reimaging for all high-grade renal traumas.

Future research may reveal that repeat imaging of collecting system injury can be reasonably followed by ultrasound as urinoma is frequently picked up on ultrasonography. Indeed, a recent study investigating renal trauma in pediatric patients suggests that ultrasonography may be useful in evaluating renal trauma and beneficial in reducing unnecessary radiation [19]. In addition to limiting radiation, transition from CT scan to ultrasound could also reduce health care costs.

Conclusions

Asymptomatic patients with high-grade renal trauma require surgical intervention at a low rate of 12.5%. The number needed to image is approximately one in eight to produce need for surgical intervention. There is potential room to improve criteria for routine renal imaging in high-grade renal trauma based on the more specific imaging finding of collecting system injury.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Research involving human participants and/or animals All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent This is a retrospective review. For this type of study formal consent is not required.

References

1. McAninch JW (1996) Renal injuries. In: Gillenwater JY, Grayhack JT, Howards SS, Duckett JW (eds) Adult and pediatric urology, 3rd edn. Mosby, St Louis, pp 539–553
2. Voelzke Bryan B, Leddy L (2014) The epidemiology of renal trauma. Transl Androl Urol 3.2:143–149 **(PMC. Web. 12 June 2017)**
3. Wessells H et al (2003) Renal injury and operative management in the United States: results of a population-based study. J Trauma 54.3:423–430
4. Moore E et al (1989) Organ injury scaling: spleen, liver, and kidney. J Trauma 29(12):1664–1666
5. Thall EH et al (1996) Conservative management of penetrating and blunt Type III renal injuries. Br J Urol 77(4):512–517
6. Bukur M, Inaba K, Barmparas G et al (2011) Routine follow-up imaging of kidney injuries may not be justified. J Trauma 70:1229
7. Breen KJ et al (2014) Adult blunt renal trauma: routine follow-up imaging is excessive. Urology 84.1:62–67
8. Cheng DL, Lazan D, Stone N (1994) Conservative treatment of type III renal trauma. J Trauma 36(4):491–494
9. Blankenship JC, Gavant ML, Cox CE et al (2001) Importance of delayed imaging for blunt renal trauma. World J Surg 25:1561
10. Shariat S et al (2008) Features and outcomes of patients with grade IV renal injury. BJU Int 102(6):728–733 **(discussion 733)**
11. Buckley J, Jack M (2006) Selective management of isolated and nonisolated grade IV renal injuries. J Urol 176(6):2498–2502 **(discussion 2502)**
12. Bonatti M et al (2015) MDCT of blunt renal trauma: imaging findings and therapeutic implications. Insights Imaging 6(2):261–272
13. Morey AF, Brandes S, Dugi DD et al (2014) Urotrauma: AUA guideline. J Urol 192(2):327–335. https://doi.org/10.1016/j.juro.2014.05.004
14. Davis P, Bultitude MF, Koukounaras J et al (2010) Assessing the usefulness of delayed imaging in routine followup for renal trauma. J Urol 184:973
15. May AM et al (2016) Successful nonoperative management of high-grade blunt renal injuries. Adv Urol 2016:3568076
16. Buckley Jill, McAninch Jack (2011) Revision of current American Association for the Surgery of Trauma Renal Injury grading system. J Trauma 70(1):35–37
17. McGuire J et al (2011) Predictors of outcome for blunt high grade renal injury treated with conservative intent. J Urol 185(1):187–191
18. Buckley Jill, McAninch Jack (2011) Revision of current American Association for the Surgery of Trauma Renal Injury grading system. J Trauma Injury Infect Crit Care 70(1):35–37
19. Gaither T et al (2018) Missed opportunities to decrease radiation exposure in children with renal trauma. J Urol 199(2):552–557