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Non-operative management of renal trauma in very young children: Experiences from a dedicated South African paediatric trauma unit

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ABSTRACT

Blunt abdominal trauma results in renal injury in 10% of paediatric cases. Over the last twenty years, the management of paediatric renal trauma has shifted towards a primarily non-operative approach that is now well-established for children up to 18 years old. This retrospective study reviews our experiences of non-operatively managing blunt renal trauma in a very young cohort of patients up to 11 years old.

Between June 2006 and June 2010, 118 children presented to the Red Cross War Memorial Children's Hospital in Cape Town with blunt abdominal trauma. 16 patients shown to have sustained renal injury on abdominal computed tomography (CT) scanning were included in this study. Medical records were reviewed for the mechanism of injury, severity of renal injury, clinical presentation, associated injuries, management method and clinical outcomes. All renal injuries were graded (I–V) according to the American Association for the Surgery of Trauma Organ Injury Severity Scale.

All renal trauma patients included in this study were aged between 1 and 11 years (mean of 6.5 years). 1 patient sustained grade V injuries; 2 grade IV, 6 grade III and 7 grade I injuries. The majority of injuries (9/16) were caused by motor vehicle crashes, whilst 5 children fell from height, 1 was struck by a falling tree and 1 hit by a moving train. 1 of 16 patients was haemodynamically unstable on presentation as a result of multiple splenic and hepatic lacerations. He was resuscitated and underwent immediate laparotomy. However, his renal injuries were not indications for surgical management. 15 haemodynamically stable patients were non-operatively managed for their renal injuries. Following lengths of admissions ranging from 4 to 132 days, all 16 patients were successfully discharged with no mortalities. No significant complications of renal trauma, such as new-onset hypertension, were detected during their first follow up outpatient appointments.

Our findings successfully extend non-operative management of haemodynamically stable renal injuries to a very young cohort up to 11 years old. However, we still advocate immediate resuscitation and surgical intervention for any haemodynamically unstable child who had sustained any abdominal injury. We also argue for a limited role for abdominal CT imaging for diagnosing renal injury and routine follow up, instead recommending a greater emphasis on clinical observations for possible complications.

Introduction

Trauma is the most common cause of paediatric mortality and morbidity, leading to 1.5 million injuries and 20,000 deaths each year in children between 1 and 18 years old worldwide.[34] Of these cases, approximately 80% are caused by blunt forces, of which the abdomen is the second most common site of injury. Renal injury is consequently reported in 10% of paediatric abdominal blunt trauma cases.[30] In addition, children with congenitally abnormal kidneys are at particularly high risk of damage from renal trauma, with this subset of children accounting for 8% of all paediatric renal trauma injuries.[19]

Kidneys in young children are more vulnerable to blunt trauma than in adults. Firstly, they are relatively larger organs and also considerably more mobile. In addition, they are less well protected by a more flexible posterior chest wall whilst being surrounded by less perirenal fat.[30]

Clinical examination of children with suspected abdominal trauma is difficult and particularly unreliable in pre-verbal children or in patients with multisystem injuries. Clinicians frequently rely on non-specific diagnostic markers such as

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haematuria, abdominal tenderness and lap-belt ecchymoses. More specific organ damage in the haemodynamically stable child is frequently confirmed only by diagnostic imaging. In the context of renal trauma, computed tomography (CT) scan from the lower chest to symphysis pubis is generally regarded as the gold standard technique for grading injury severity.

There has been a shift in attitudes regarding the management of paediatric renal trauma over the last 40 years.[17,15,32,2,12] In view of physiological differences between paediatric and adult trauma patients, paediatric trauma centres worldwide have progressively trended towards a non-operative approach. Young children have much smaller blood vessels, with relatively faster and greater vasoconstrictive responses. Any bleeding is likely to cease earlier in young children, thus making catastrophic haemorrhage, the most serious consequence of solid viscus injury, much less likely. Non-operative management therefore has significant potential in paediatric trauma patients.

In this study, we review the management of blunt renal trauma in very young children up to 11 years old at the Red Cross Children's Hospital in Cape Town, South Africa, over a four year period from June 2006 to June 2010. As a medical centre with the only dedicated paediatric trauma unit in Southern Africa, receiving children up to 12 years old from both developed and developing catchment areas, the Red Cross War Memorial Children's hospital holds a unique position for a review of blunt renal trauma management in a very young cohort (Fig. 1).

Materials and methods

This study retrospective reviewed medical records of 118 young children who presented to Red Cross War Memorial Children's Hospital (RXH) with abdominal trauma between June 2006 and June 2010. Of these 118 patients, 17 children were found to have sustained renal trauma on abdominal computed tomography (CT) imaging, performed either immediately or at later stages of their admission. 16 children aged between 1 and 11 years old (mean 6.5 years, median 6.5 years; 11 males, 5 females) were included in the study with one patient excluded as a result of incomplete medical records.

On presentation to our dedicated trauma unit, all patients were initially managed according to Advanced Trauma Life Support (ATLS) protocols. Only haemodynamically stable abdominal trauma patients underwent abdominal CT imaging. Haemodynamically unstable patients were resuscitated and prepared for immediate surgical intervention.

Medical records were reviewed for the mechanism of injury, severity of renal injury, clinical presentation, associated injuries, management method and clinical outcome, defined by survival and presence of complications on outpatients follow-up.

The severities of all renal injuries were separately interpreted by two radiologists and graded (I–V) according to the American Association for the Surgery of Trauma Organ Injury Severity Scale.[28] Whilst one radiologist reported the initial CT scan with

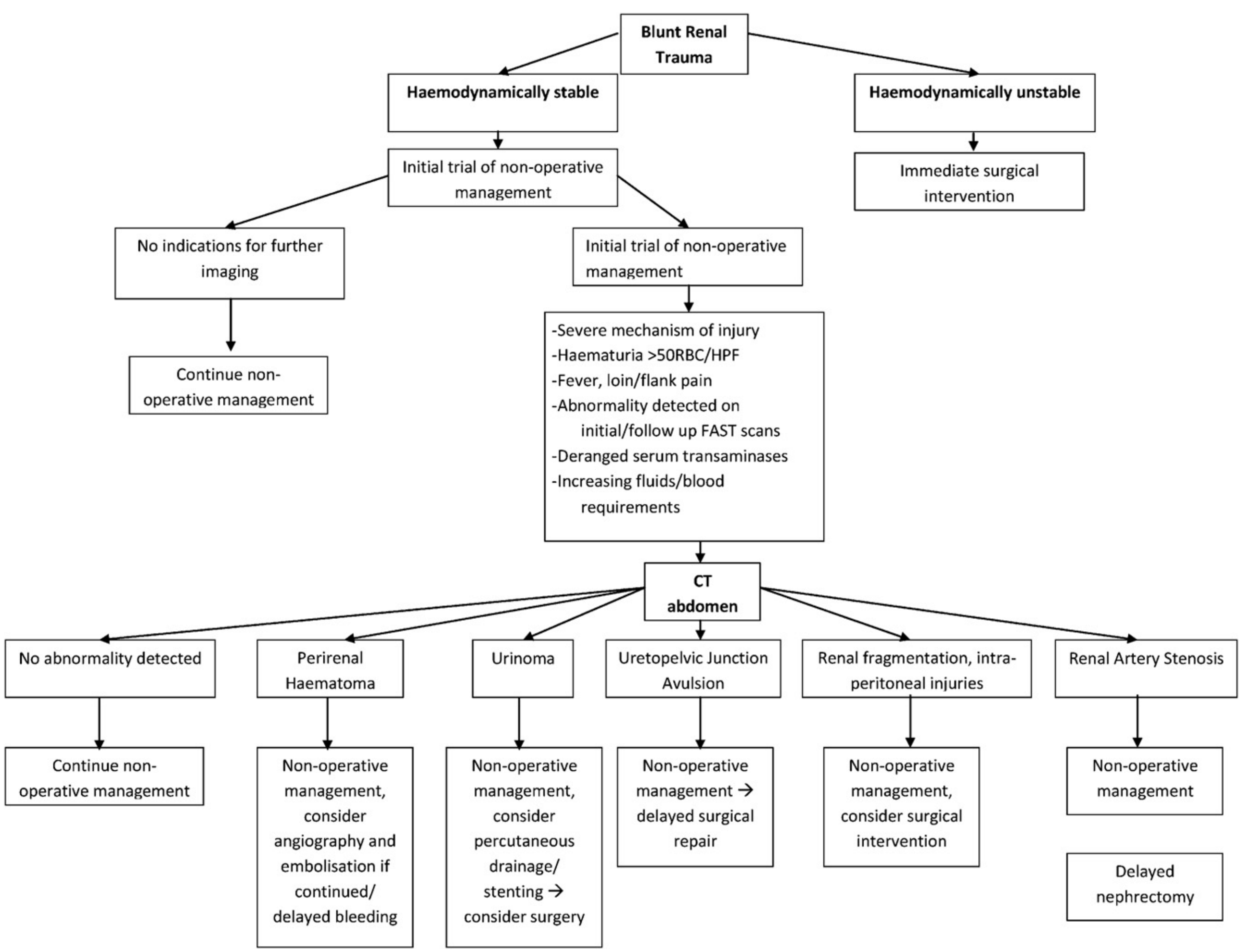

Fig. 1. Proposed management flowchart for suspected blunt renal trauma in paediatric patients.

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Table 1
American association for the surgery of trauma organ injury severity scale (AAST) as applied to renal injuries.

Grade	Injury description	
I	Contusion	Microscopic or gross haematuria, urological studies normal
	Haematoma	Subcapsular, nonexpanding without parenchymal laceration
II	Haematoma	Nonexpanding perirenal haematoma confined to renal retroperitoneum
	Laceration	<1 cm parenchymal depth of renal cortex without urinary extravasation
III	Laceration	>1 cm depth of renal cortex, without collecting system rupture or urinary extravasation
IV	Laceration	Parenchymal laceration extending through the renal cortex, medulla and collecting system
	Vascular	Main renal artery or vein injury with contained haemorrhage
V	Laceration	Completely shattered kidney
	Vascular	Avulsion of renal hilum which devascularises kidney

Advance one grade for multiple injuries to same organ.

Table 2
Specific details of sixteen paediatric patients presenting to RXH between June 2006 and June 2010 with renal injuries following blunt renal trauma.

Patient	Age	Gender	Mechanism of injury	GCS on presentation	Injury grade	Associated injuries	Length of stay (days)
1	11	Female	Fall from height	15	I	Liver laceration, pelvic free fluid	21
2	5	Female	Fall from height	15	IV	None	5
3	1	Male	Hit by train	9	I	Liver and splenic laceration	15
4	3	Male	Hit by falling tree	9	I	Closed head injury, pelvic, tibial, hand, parietal fractures	4
5	6	Male	MVC (pedestrian)	15	I	Femoral, humeral, base of skull fracture	4
6	10	Male	MVC (pedestrian)	15	I	Superficial abrasions	4
7	7	Male	MVC (pedestrian)	15	III	Superficial abrasions, pneumothorax	5
8	2	Male	MVC (pedestrian)	14	V	Diaphragmatic rupture, splenic laceration	16
9	4	Male	MVC (pedestrian)	15	III	Closed head injury	6
10	7	Male	MVC (passenger)	15	I	None	4
11	6	Male	MVC (pedestrian)	15	I	Scalp laceration, femoral fracture	9
12	8	Female	Fall from height	15	III	Superficial abrasions, splenic lacerations, free gas in pelvis	13
13	6	Female	MVC (pedestrian)	15	IV	Splenic lacerations	14
14	10	Male	Fall from height	15	III	None	9
15	7	Male	Fall from height	15	III	None	3
16	11	Female	MVC (pedestrian)	8	III	Liver and splenic lacerations, head injury, pneumothorax, tibial and fibula fractures	132

clinical details, a second re-interpreted the scan at a later date without clinical information provided (Tables 1 and 2).

Non-operative management of the patient was defined as a primarily non-surgical approach, with close monitoring of haemodynamic status, serial measurements of the patient's blood count, inflammatory markers, electrolytes and provisions for blood transfusion when appropriate. This approach did not however exclude surgery for associated injuries sustained elsewhere as a result of the same traumatic event.

Results

Of the 16 children with CT-confirmed renal trauma, 8 had sustained injuries to the left kidney, 8 to the right kidney, with no cases of bilateral renal damage. Two radiologists reported 7 (43%) grade I injuries, 6 (38%) grade III injuries, 2 (13%) grade IV injuries and 1 (6%) grade V injury. There were no grade II injuries. No deaths were reported from our cohort as a result of renal trauma or associated injuries.

Five patients presented with isolated renal injury whilst 11 reported associated injuries, including 4 splenic lacerations, 3 hepatic lacerations, 1 diaphragmatic rupture, 2 pneumothoraces, 1 haemothorax, 3 closed head injuries and 6 skeletal fractures. Two patients suffered multi-organ lacerations.

The most commonly associated intra-abdominal injuries with renal trauma were hepatic and splenic lacerations. However, one patient with significant hepatic and splenic lacerations sustained only unilateral grade I renal injury, suggesting that whilst associated, severities of injury to the liver, spleen and kidneys do not necessarily correlate. The severity of injury to each abdominal solid viscus is most likely to be determined by the direction of the blunt force, damaging these three structures independently instead of as one entity. Extra-abdominally, skeletal fractures and closed head injuries were the most commonly associated extra-abdominal injuries, indicating the degree of blunt forces required for a child to sustain renal injuries.

Immediate complications of blunt renal trauma were found in 6 patients. Perinephric haematomas were observed in 7 patients, all of whom sustained grade III or more severe renal injuries. Free gas and fluid in the pelvis were reported in one patient with grade IV renal injuries. Extravasation of intravenous contrast was not observed in any patients.

Perhaps indicative of South African road safety, the majority of our paediatric renal trauma cases were caused by motor vehicle crashes (MVC); one as a passenger and eight as pedestrians. 89% of our motor vehicle crash-related patients were pedestrians, again implicating the need for greater public awareness for pedestrians in our car-cultured region, not just for other vehicles. Five young children presented after falling from height, one after being struck by a falling tree and one after having been hit by a moving train. No significant correlation was found between the mechanism of injury and the grade of renal injury sustained.

On presentation, twelve patients scored 15/15 on the Glasgow Coma Scale (GCS), one scored 14, two scored 9, and one scored 8. Only one patient was haemodynamically unstable on presentation and was clinically noted to have been shocked, with cold peripheries and pallor. Ten patients complained of abdominal discomfort or flank pain in the trauma unit whilst 3 patients reported no abdominal or flank discomfort at all. Macroscopic or microscopic (4+) haematuria was present in the majority of our renal trauma patients (11/16). 4 of 5 patients (80%) presenting without haematuria sustained only grade I–III renal injuries. Haematuria appears to be the most sensitive clinical indicator of renal injury. However, the degree of haematuria was not a good predictor of renal injury severity: macroscopic haematuria was found in 3 patients with grade I injury whilst one patient with more severe grade III injury presented with only microscopic haematuria (4+). Abdominal tenderness and flank pain, whilst suggestive of abdominal injury, does not necessarily point to renal injury and is thus not a useful indicator for specifically diagnosing renal injury.

Abiding by RXH's approach to operatively manage only haemodynamically unstable patients, our 15 haemodynamically stable renal trauma patients were managed non-operatively, with all undergoing abdominal CT scanning as part of initial management. One haemodynamically unstable patient was resuscitated and underwent an emergency laparotomy as a result of hepatic and splenic lacerations. Surgery was not indicated by his renal injuries. Of the non-operatively managed cohort, surgery was considered at later points in their admission only for associated injuries. No patient required abdominal surgery following an initial decision to manage renal injuries non-operatively.

The length of hospital stay ranged from 3 to 132 days. All 16 patients were followed up in the out-patients department (OPD) between one and six weeks after discharge by a trauma surgeon or a urologist. Additional paediatric neurosurgical input was requested if head trauma was suspected. No complications were reported during this OPD appointment for any of the 16 children. Unfortunately, the majority of cases were lost to follow-up after one OPD appointment.

Discussion

Non-operative management of haemodynamically stable paediatric renal trauma patients up to 18 years old is well supported by current literature. Carvajal Busslinger and Kasier in Switzerland reported improved outcomes for renal trauma patients managed non-operatively compared to those treated surgically.[9] Studying an older range of patients, with a mean age of 9.4 years compared to 6.5 years in our cohort, non-operatively managed patients spent less time in intensive care units and in hospital overall, required fewer units of blood transfusion and presented lower incidences of long-term complications. Baumann et al. also reported no increase in incidences of long-term renal complications in non-operatively managed renal patients up to 18 years old.[3] We demonstrate the successful extension of non-operative management of haemodynamically stable renal trauma to very young patients up to 11 years old. Although a smaller cohort with fewer high grade injuries than a retrospective study by Mohamed et al.[21] we demonstrate a higher rate of kidney salvage (100% vs. 81%), whilst managing a greater proportion of our patients non-operatively (94% vs. 64%).

An increasing number of publications report improved rates of kidney salvage with non-operative management for haemodynamically stable grade V renal trauma patients. In a study by Eassa et al. 9 out of 18 grade V paediatric renal trauma patients were successfully managed non-operatively alone. Another five haemodynamically stable patients were successfully treated with an initial period of non-operative management followed by delayed non-surgical intervention for renal trauma complications, achieving a net kidney salvage rate of 78%. Only one haemodynamically unstable patient underwent immediate nephrectomy.[11]

Despite previously being indications for immediate surgery, continued and delayed bleeding from high grade renal trauma, most commonly from renal artery pseudoaneurysms or traumatic arteriovenous fistulas, are increasingly managed non-operatively with selective embolisation. Dinkle et al. successfully controlled bleeding in 9 consecutive patients with renovascular injuries, including two presenting with haemodynamic instability.[10] 8 out of 9 patients demonstrated no procedure-related loss in renal tissue. Similar outcomes were reported by Halachmi et al. in an eleven year old boy with grade III renal trauma[13] and also by Eassa et al. in two grade V renal trauma patients.[11]

In view of recently published data and effectiveness of selective embolisation, there is now convincing evidence for at least a trial of non-operative management for all grades of haemodynamically stable renal injuries, with or without subsequent non-surgical interventions, to significantly increase kidney salvage rates following blunt trauma. All haemodynamically stable paediatric injured kidneys should thus initially be assumed to be salvageable.

Children are known to be up to fifteen times more radiosensitive than adults.[29] The doses of radiation involved in CT abdomen are staggering, at around 5mGY for children, approximately 1000 times greater than that of an adult chest X-ray.[6] Worryingly, this equates to a 1:1000 lifetime risk of developing a fatal cancer as a result of a single CT abdomen, often presenting after at least a 40 year latency period,[14,4] with the thyroid, bone marrow, breast and lung being the most likely malignant organs.

There is general agreement that haemodynamically unstable patients are best managed surgically immediately without imaging. In the context of such significant radioactive risk from CT abdomen in children, is it possible to reduce the number of negative CT abdomen scans in haemodynamically stable patients? In addition, as an increasing number of trauma centres no longer guide their management by the grade of renal injury,[33] is immediate CT abdomen scanning appropriate for all patients suspected of renal trauma?

Initial CT abdomen is useful in haemodynamically stable patients for accurately defining the scale of renal injuries and detecting early traumatic complications such as haematomas, urinomas, urinary extravasation, renal fragmentation and associated abdominal injuries. However, most findings on initial CT abdomen in a haemodynamically stable patient are likely to be best managed non-operatively, with the initial scan unlikely to influence immediate management. We argue that following the successful precedence of CT head and C-spine imaging in head and neck trauma, respectively,[16,24] well-stratified "decision rules" based on clinical history, examination, investigations and non-invasive non-radioactive imaging have a similar place in haemodynamically stable paediatric renal trauma, limiting the number of negative CT abdomen scans without missing significant renal or intra-abdominal injuries.

For example, although grades of haematuria on urine dipstick are poor indicators of renal injury severity, it has been demonstrated that a haematuria threshold of 50 RBC/HPF can be a sensitive and specific laboratory indicator for serious renal injury.[7] In addition, clinical signs such as fever, flank pain, increased blood transfusion and fluid requirements are also helpful indicators of significant injuries requiring further definition by CT abdomen.[25] In combination with serum transaminases, injury mechanism severity scores, initial and follow up focused abdominal sonography for trauma (FAST) scans, decision scores have been shown to detect significant renal injuries with sensitivities of up to 96.7%.[5]

Whilst patients with significant renal trauma complications will almost certainly trigger CT abdomen imaging by these proposed algorithms, any delays in CT abdomen do not necessarily change subsequent management of immediate complications in haemodynamically stable patients. Detection of any congenital renal abnormalities also do not affect immediate management despite the patient being at higher risk of future renal trauma.

Even significant haematomas are recommended for at least a trial of initial non-operative management by a number of centres, with detection on immediate imaging unlikely to warrant urgent surgical intervention. Instead, clinical signs suggestive of continued or delayed bleeding, such as increased blood and fluid requirements, and rarely, systemic hypotension, are more significant indicators for angiography and selective embolisation. Interestingly, immediate CT abdominal scan may inaccurately define any expanding haematomas. Without taking into account progression of bleeding, the scale of the haematoma is usually underestimated unless repeat CT scans are performed.[31]

Similarly, urinomas and urinary extravasations also are now increasingly treated with an initial period of non-operative management. In one study, spontaneous resolution was reported in 7 of 9 patients with non-operative management alone or by an initial trial of non-operative management followed by delayed non-surgical interventions such as percutaneous drainage and stenting.[22] The decision to pursue drainage and stenting was not necessarily guided by initial CT findings but instead by appearance of suspicious clinical signs such as progressive or persistent flank pain and pyrexia.

In cases of full avulsion of the uretopelvic junction, recent evidence has demonstrated improved outcomes with initial percutaneous drainage followed by delayed surgical reconstruction after 10–12 weeks. Unfortunately, single-phase CT abdomen often fails to detect UPJ avulsion, particularly when the classical signs of non-opacifying ipsilateral ureter and medial extravasation are obscured by large urinomas or haematomas.[11] Whilst delayed phase CT abdominal imaging achieves greater detection rates, UPJ avulsion is often only suspected via the mechanism of injury, severity of injury and clinical observations.

Previous absolute indications for immediate surgical interventions, such as renal artery stenosis, shattered and fragmented kidneys and intraperitoneal injuries, are increasingly also treated with an initial period of non-operative management. Renal artery thrombosis secondary to trauma does not require immediate surgery and has long been advised for delayed nephrectomy.[27] Experience from penetrating renal trauma have also deemed shattered and fragmented kidneys, as well as intraperitoneal injuries such as bowel and pancreatic injuries, only relative indications for surgical intervention, despite a higher risk of requiring surgical intervention later in the admission.[26]

Unfortunately, variable time-frames in post-discharge follow up and involvement of different specialties meant follow up data could not be fully interpreted. In the first OPD appointment post-discharge, either no complications were detected or no complications had yet arisen. In particular, patients were assessed for new-onset hypertension following renal trauma. However, with current literature suggesting incidence of post-traumatic hypertension at 0–6.6% and presentation up to 14 years after the traumatic event, prognostication of whether post-renal traumatic hypertension will occur was not possible from a single OPD appointment.[11,18] OPD patients did not routinely undergo a CT scan as part of their follow-up. After Abdalati et al. first rejected routine follow-up imaging in mild renal injuries,[1] and Mizzi et al. reported no significant contributions of routine follow-up imaging following blunt paediatric abdominal trauma, we saw little indication to adopt a separate protocol for renal injuries in very young children.[20]

Lastly, we urge particular attention to the rare but very serious complication of hyperammonianaemia. A number of non-operatively managed renal trauma patients, particularly those who had suffered higher grade injuries, resolve relatively large haematomas. The subsequent rise in deamination during haematoma breakdown leads to sudden increases in blood ammonia concentration, causing lethargy, delirium and other more serious encephalopathic symptoms. Coma and death could result, whilst survivors might incur permanent cortical damage.[8] Although relatively uncommon, medical staff should nonetheless be aware of this complication, particularly in the context of abnormal ammonia loading in non-operatively treated renal trauma patients, as well as the rising incidence of urea cycle disorders in the paediatric population, estimated to number one in 10,000 live births.[23]

Conclusions

The safe management of haemodynamically stable paediatric renal trauma with a non-operative approach can be extended to a very young cohort of children up to 11 years old. However, patients who are haemodynamically unstable on presentation should still be immediately resuscitated and managed surgically. Considering the significant risks of CT imaging and its limited influence on subsequent management when performed on the haemodynamically stable patient, there is a place for well-stratified decision rules based on mechanism of injury, clinical signs, serum markers and ultrasonography to select only patients at high risk of severe renal injury and complications for CT abdominal imaging, limiting unnecessary radiation whilst continuing to detect serious injuries.

From a public health perspective, the high proportion of renal injuries caused by abdominal trauma following motor vehicle accidents indicate an urgent need to increase public road safety awareness in Southern Africa. It should be noted that non-operatively managed renal trauma patients often resolve large haematomas and are thus at high risk of developing hyperammonianaemia and its consequent serious neurological sequelae. We therefore urge particular attention on performing neurological observations on such patients.

Conflict of interest

There are no financial or other relationships that might lead to a conflict of interests.

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