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Conservative Management vs Early Surgery for High Grade Pediatric Renal Trauma—Do Nephrectomy Rates Differ?

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Abstract

Purpose—Guidelines for management of pediatric high grade renal injuries are currently based on limited pediatric data and algorithms from adults, for whom initial nonoperative management is associated with decreased nephrectomy risk. Using a national database, we compared nephrectomy rates between children with high grade renal injury managed conservatively and those undergoing early surgical intervention.

Materials and Methods—All children with high grade renal injuries were identified in the National Trauma Data Bank®. High grade renal injuries were defined as American Association for the Surgery of Trauma grade IV or V renal injuries. After excluding fatalities within 24 hours of hospitalization, 419 pediatric patients comprised our study cohort. A total of 81 patients underwent early (within 24 hours of hospitalization) surgical intervention, while 338 were initially treated conservatively. Using stratified analysis with adjustment for relevant covariates, we compared nephrectomy rates between these groups.

Results—Nephrectomy was performed less often in patients treated conservatively (RR 0.24, 95% CI 0.16 to 0.36, adjusted for age, renal injury grade and injury mechanism). The decreased risk of nephrectomy was more marked among children with grade IV vs grade V renal injuries (adjusted RR 0.16, 95% CI 0.08 to 0.23). Multiple procedures were more common in patients initially observed. Of pediatric patients with grade IV and V renal injuries 11% still underwent nephrectomy.

Conclusions—Conservative management of high grade renal injuries is common in children. Although mechanism of injury and renal injury grade impact initial clinical management decisions, the risk of nephrectomy was consistently decreased in children with high grade renal trauma managed conservatively regardless of injury characteristics.

Keywords

adolescent; child; kidney; retrospective studies; wounds and injuries

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Children are at increased risk for renal injury following blunt abdominal trauma.[1] High grade renal injury (American Association for the Surgery of Trauma grade IV to V) affects renal parenchymal function and can require nephrectomy.[2] Furthermore, there is significant morbidity from trauma, requiring possible subsequent surgical intervention.

During the last 3 decades management of high grade renal injury in adults has gradually shifted from immediate surgical intervention to initial observation consisting of intensive care monitoring followed by surgical intervention only when indicated by deteriorating clinical signs such as hemodynamic instability.[3] Support for initial nonoperative (conservative) management was evident after a study using NTDB data demonstrated a 65% rate of nephrectomy after early surgical intervention for renal trauma regardless of whether the initial operative intent was renal salvage.[4] Initial conservative therapy has been explored in the pediatric population, although most studies to date are small, single institution series. These studies are supportive of conservative management.[5–11] Currently the guidelines for management of high grade pediatric renal trauma are based on these limited data, and practice varies by practitioner and facility. To establish relevant guidelines, there is a need for additional studies to support the development of evidence-based recommendations.

We conducted a retrospective cohort study using data from the NTDB to assess optimal care practices in children with high grade renal injuries. Specifically we compared nephrectomy rates among children with high grade renal injury treated conservatively (more than 24 hours of observation) to those among children undergoing surgical intervention less than 24 hours after hospitalization. We hypothesized that nephrectomy rates would be greater for pediatric patients undergoing early exploration. Our secondary aim was to examine the described secondary procedures other than nephrectomy among the conservative and initial surgery cohorts.

MATERIALS AND METHODS

We conducted a retrospective cohort study using data from the NTDB, a voluntary national database comprised of participating trauma centers. The NTDB is currently the largest trauma data registry in the United States, containing more than 3 million records, with 567 trauma centers contributing data in 2009. Participating hospitals provide data on all trauma cases admitted to their emergency and inpatient facilities. Only dedicated trauma centers are included in the NTDB (ie level I to V hospitals only). These institutions include 94% of level I trauma centers and 118 level I or II pediatric trauma hospitals.[12] Performance of nephrectomy during the initial hospitalization in children was compared among those with and without initial conservative management. The study used anonymous data, and thus was exempt from institutional review board approval.

Of the 3,247,955 patients available for analysis in the NTDB from 2002 to 2007 a total of 18,348 with renal lacerations were identified in the database by AIS codes. AIS allows for coding of renal injuries without grade. Unfortunately some injuries are coded in the data set as a renal injury “not further specified.” As such, we included only patients whose AIS codes could be assigned a specific AAST injury grade. We defined high grade renal injuries as AAST renal IV and V injuries. Following AAST guidelines, renal injuries were defined as vascular or parenchymal, with vascular injuries consisting of main renal artery or vein injury with contained hemorrhage (grade IV) and avulsion of the renal hilum (V), and parenchymal injuries consisting of laceration extending through the main renal cortex, medulla and collecting system with urine leak (IV), and completely shattered kidney (V).[13]

A total of 2,213 patients younger than 19 years had renal injuries that mapped to a specific AAST renal injury grade. Of these patients 460 sustained grade IV or V renal injuries. After

exclusion of patients who died within the first 24 hours 419 remained for analysis. Of these patients 338 were initially treated conservatively and 81 underwent initial surgical intervention within 24 hours of hospitalization. Time at admission to the emergency department was considered as the starting time for all calculations. Nephrectomy rates during initial hospitalization were compared among children who underwent initial conservative therapy vs surgical intervention in the first 24 hours following hospitalization.

Stratified analysis was conducted to assess nephrectomy during initial hospitalization among pediatric patients undergoing initial surgery within 24 hours of admission vs those receiving conservative treatment. All analyses were a priori adjusted for age (younger than 2, 2 to 4, 5 to 14 and 15 to 18 years). Other potential confounding variables considered in the analysis were hospital region (Midwest, Northeast, South, West), race/ethnicity (white, black, Hispanic, Native American, other), injury severity score (16 to 25, 26 to 35 and 36 or greater), institutional academic status (teaching vs nonteaching hospital), presence of a pediatric ICU, mechanism of injury (blunt vs penetrating), hospital trauma level (I, II or III) and maximum nonrenal abdominal AIS score (on a scale of 0 to 5). Variables altering results by 10% or more were adjusted for in the final estimates. Effect modification was assessed by examining the nephrectomy-treatment relationship for important differences among subgroups and Breslow-Day testing of homogeneity.

As part of our secondary aim, additional urological procedures other than nephrectomy were collected from the NTDB among the initial surgery and conservative therapy cohorts. The time for such procedures was noted relative to nephrectomy, as the NTDB provides time data for such analysis. Statistical analyses were performed with Stata®, version 11.

RESULTS

There were 419 patients with AAST grade IV and V renal injuries. Conservative therapy for high grade renal injury was more common than early surgical intervention (observation in 338 patients vs early surgical intervention in 81). Mean ± SD time to surgery in the early operative group was 2.8 ± 4.9 hours. Blunt trauma and AAST grade IV renal injures were more common in both groups (table 1).

Compared to patients treated conservatively, pediatric patients in the early surgical intervention group were more often older than 14 years, male and identified as black or Hispanic. Early intervention was more common among those who sustained penetrating trauma and/or had an AAST grade V renal injury (47% of the early intervention group vs 17% of the observation group had grade V injuries, and 46% of the early intervention group vs 8% of the observation group had penetrating injuries). A greater percentage of the conservatively treated patients were admitted to hospitals with a dedicated pediatric ICU (97% vs 81%). However, 44% of the patients had data missing for this variable. The 2 treatment groups were similar with respect to hospital academic and trauma level status.

Age, mechanism of injury, AAST renal injury grade and maximum nonrenal AIS score confounded the relationship between early intervention and nephrectomy. Adjusted estimates are presented in table 2. The proportion of conservatively treated patients who underwent nephrectomy during the initial hospitalization (37 of 338, 11%) was significantly lower than in the early intervention group (51 of 81, 63%). The relative risk of nephrectomy was modified by renal AAST score. No significant modification was noted by mechanism of injury ($p = 0.15$), maximum nonrenal AIS score ($p = 0.87$) or geographic region ($p = 0.56$). Overall ISS did not impact the outcome of nephrectomy.

When comparing the number of procedures in both groups, there were 89 procedures in the early intervention group vs 143 in the group initially managed conservatively. Eight patients

(10% of the original 81, or 27% of those remaining after excluding those undergoing initial nephrectomy) in the early intervention group required subsequent urological procedures (no patient underwent more than 1 subsequent procedure). Five of these patients underwent an open procedure, 2 underwent retrograde pyelography and 1 underwent diagnostic angiography. A total of 24 patients (7%) in the observation group required 47 subsequent procedures, of which 41 were endoscopic and 4 were open, including 2 nephrectomies. There were 6 angioembolization procedures performed in each group. Despite an attempt at conservative therapy, 11% of pediatric patients with AAST grade IV and V injuries still underwent nephrectomy.

DISCUSSION

This study contains the largest national case series examining high grade injuries following blunt and penetrating pediatric renal trauma. Nephrectomy rates were compared between 2 groups consisting of initial observation (followed greater than 24 hours from admission) and initial surgical therapy (performed during the first 24 hours of hospitalization). Patients were most commonly observed following high grade renal injury. Nephrectomy rates during initial hospitalization were significantly lower in conservatively treated patients. Although this finding was true for both injury grades examined, the effect was more pronounced in patients with AAST grade IV than grade V renal injuries.

The kidneys are the most commonly injured organ following pediatric blunt abdominal trauma.[14] Pediatric kidneys are also more vulnerable to serious damage as a result of blunt trauma than are adult kidneys. This increased risk is due to several anatomical differences, including less perirenal fat, proportionally smaller abdominal muscles, relative lack of ossification of the rib cage and large kidney size proportional to surrounding organs.[1]

Most decisions made in the setting of pediatric renal trauma are based on the more prolific literature pertaining to adult renal trauma. The data available for adults have provided insight into the presentation and management of adult disease. Recently there has been a trend in the treatment of adult renal trauma toward conservative management.[3] Until recently high grade renal injuries (those involving a disruption of the urinary collecting system or the renal blood supply) generally resulted in a surgical procedure. Unfortunately surgical exploration, unless in experienced hands, often results in nephrectomy instead of renorrhaphy. Analysis of the NTDB supports this belief, revealing that open surgery following all grades of adult renal injury results in nephrectomy in 65% of patients.[4]

Evaluation of high grade pediatric renal trauma has been conducted, with reports limited to small, single institution studies and case reviews. One of the first studies to examine initial conservative therapy for pediatric renal trauma was published in 2002.[8] Blunt renal injury was analyzed across all renal injury grades, with 12 of 19 high grade renal injuries (grades IV and V) successfully managed by conservative therapy alone. Subsequent reports, all single institution studies, evaluating conservative therapy for pediatric renal trauma also suggest that conservative management may preserve the kidney.[5–7,9 –11,15] In the single meta-analysis evaluating the success of nonoperative treatment of nonvascular AAST grade IV renal injury conservative treatment was possible in 72% of 95 patients, and partial renal preservation was possible in 95% of patients.[16]

Some surgeons have been reluctant to observe children following high grade renal injury because significant hemorrhage can occur in the pediatric patient without clinical signs of hemodynamic instability. In addition, the potential increased risk of multiple successive procedures associated with conservative management of pediatric renal trauma has prompted concern. These secondary procedures, required if observation fails, might result in

increased morbidity and mortality due to delayed therapy. A final argument is that initial surgical intervention with possible nephrectomy will be more straightforward and have less impact on recovery from the injury. This potential increase in acute morbidity and cost from multiple procedures is often an argument for immediate surgical intervention.

As Wright et al showed in their 2006 study using data from the NTDB, increasing renal AAST score is the greatest predictor of nephrectomy in the adult population.[4] Although our study was limited to AAST grade IV and V renal injuries, we observed significantly lower rates of nephrectomy in conservatively treated patients in both groups regardless of severity, with the effect being most marked in the less severely injured children.

We hypothesized that nephrectomy rates would be greater for pediatric patients undergoing exploratory laparotomy for concomitant injuries. Of the 419 children with high grade renal injuries in the data set 176 (42%) had no other abdominal injury. As suspected, this group had lower nephrectomy rates than did patients with concomitant abdominal injuries after controlling for AAST grade of injury, mechanism of injury and age. Thus, it appears that patients operated on for concomitant visceral injury are more likely to undergo renal exploration and incidental nephrectomy.

Based on our review of numbers of procedures within the 2 groups, it is clear that patients in the group that was initially treated conservatively underwent more procedures. However, these procedures were typically endoscopic.

We acknowledge several limitations of our study. Most notably some important variables had large amounts of missing data. Pediatric ICU status was unknown for 56% and 42% of children in the intervention and observation groups, respectively. In addition, only 12 hospitals were identified as not having a pediatric ICU, and it is possible that the majority of children with missing data for this variable were treated at hospitals without a pediatric ICU. If so, the data may underrepresent hospitals that are less inclined to observe patients conservatively, and are more likely to elect early surgery and nephrectomy. If this assumption is true, our data would be biased in the direction of no effect of pediatric ICU.

There may also be reporting bias in the data. Despite the large number of hospitals providing data to the NTDB, participation is voluntary. Although 97% of level I trauma centers participate, the proportions of NTDB participants at lower level trauma centers are smaller. Nearly 90% of level II trauma centers participate, whereas only 17% of level III and IV centers are represented. Adjustment for trauma center level had no effect. However, this variable also was missing for more than 20% of subjects.

We had no information about elapsed time between initial injury and hospital arrival. Knowing about delays in hospitalization would have improved our ability to compare nephrectomy occurrence between conservatively treated patients and those who underwent early surgical intervention. Misclassification of more seriously injured patients who were delayed in transfer to a trauma center may have altered our assessment of treatment in the first 24 hours. We cannot address this potential effect. However, our results remain relevant to the decisions made (ie initial surgery vs observation) following admission to a trauma center.

Perhaps most serious is our inability to determine the rationale for the decision to intervene early rather than treat a patient conservatively. In children signs of hemorrhage are not as apparent as in adults, further complicating assessment of the need for early surgical intervention. Measures typically used in adults, such as systolic blood pressure and heart rate, have been demonstrated to be less reliable in children,[17] and thus, these metrics are not as useful in children. To assess the impact of need for immediate surgery, we examined

injury severity score as an indicator of overall patient injury. Although a greater percentage of patients in the early surgical intervention group had a higher ISS, adjustment for ISS did not alter the relationship between type of early treatment and nephrectomy.

We observed a reduced risk of nephrectomy in pediatric patients with high grade renal injury who were conservatively treated compared to those undergoing early surgical intervention. This effect was more pronounced in patients with AAST grade IV vs grade V renal injuries. This finding is not surprising, since grade V renal injuries are life threatening injuries associated with hemodynamic instability. Our findings suggest that, despite the fact that patients are more likely to undergo multiple procedures if observed early, there is benefit to more conservative treatment of pediatric renal trauma, an approach that has already gained wide support in the adult population.

CONCLUSIONS

Conservative management of AAST grades IV and V renal injuries is common in children. Although the mechanism of injury and renal AAST grade impact initial clinical management decisions, the rate of nephrectomy was consistently decreased in children with high grade renal trauma treated conservatively regardless of injury characteristics. These findings suggest benefits to conservative management vs early surgery for high grade pediatric renal injuries when clinically appropriate.

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Abbreviations and Acronyms

AAST	American Association for the Surgery of Trauma
AIS	abbreviated injury scale
ICU	intensive care unit
ISS	injury severity score
NTDB	National Trauma Data Bank

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Table 1

Patient characteristics

	Early Surgical Intervention*	Conservative Treatment*
No. pts	81	338
No. yrs age (%):		
Younger than 2	0 (0)	6 (2)
2–4	5 (6)	19 (6)
5–14	23 (28)	151 (45)
15–18	53 (65)	162 (48)
No. gender (%):		
F	21 (26)	107 (32)
M	60 (74)	231 (68)
No. race/ethnicity (%):		
Black	27 (35)	60 (18)
Hispanic	14 (18)	32 (10)
Native American	0 (0)	2 (0.6)
White	36 (46)	215 (65)
No. United States region (%):		
Midwest	18 (27)	84 (26)
Northeast	3 (4)	13 (4)
South	43 (57)	180 (55)
West	12 (16)	50 (15)
No. AAST score (%):		
IV	50 (62)	276 (82)
V	31 (38)	62 (18)
No. mechanism of injury (%):		
Blunt	46 (57)	311 (92)
Penetrating	35 (43)	24 (7)
No. institutional status (%):		
Community	13 (16)	69 (21)
University	51 (64)	211 (63)
Nonteaching	6 (8)	30 (9)
Other	10 (13)	26 (8)
No. max abdominal (nonrenal) AIS:		
0	17	159
1	1	15
2	19	50
3	14	50
4	14	42
5	16	22

*Numbers may not add up to totals because of missing data.

Table 2

Adjusted relative risk of nephrectomy

	Early Surgical Intervention*	Conservative Treatment*	RR (95% CI)
Total/overall	81 pts	338 pts	0.23 (0.15–0.35)†
No. renal AAST score (%):			
IV	50 (62)	276 (82)	0.18 (0.09–0.35)‡
V	31 (38)	62 (18)	0.29 (0.16–0.50)‡
No. mechanism of injury (%):			
Blunt	46 (57)	311 (92)	0.22 (0.11–0.25)§
Penetrating	35 (43)	24 (7)	0.24 (0.07–0.84)§
Other	0 (0)	3 (1)	—
No. United States region (%):			
Midwest	18 (24)	84 (26)	0.11 (0.02–0.85)†
Northeast	3 (4)	13 (4)	—
South	43 (56)	180 (55)	0.26 (0.16–0.42)†
West	12 (16)	50 (15)	—
No. pediatric ICU present (%):			
No	7 (20)	5 (3)	—
Yes	29 (80)	192 (97)	0.37 (0.22–0.64)†
No. max abdominal (nonrenal) AIS:			
0	17	159	0.14 (0.07–0.30)†
1	1	15	—
2	19	50	0.22 (0.05–0.90)†
3	14	50	0.35 (0.17–0.78)†
4	14	42	0.34 (0.15–0.79)†
5	16	22	0.10 (0.01–0.87)†

*Numbers may not total because of missing data.

†Adjusted for age, kidney AAST score and mechanism of injury.

‡Adjusted for age and mechanism of injury.

§Adjusted for age and kidney AAST score.