FROM THE GUEST EDITOR

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Traumatic injury to the genitourinary system, while uncommon, can often be life-threatening or potentially grossly disfiguring. In addition, some of the management principles used for diagnosis and treatment in adult patients are slightly different in children. The current issue arose as an invitation from Dr. Yerkes to put into a print the topics discussed in a panel presentation at a recent meeting. For this issue we have assimilated a team of experts who succinctly discuss some very timely topics in the area of pediatric urologic trauma.

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FROM THE EDITOR

Elizabeth B. Yerkes, MD

This edition is an invited reprise of a panel chaired by our Guest Editor Dr. John Pope on a vital topic that many of us consult on relatively infrequently yet always emergently. I appreciate the efforts of Dr. Pope and all of his contributors in providing a handy reference for these emergencies: up to date indications for imaging and re-imaging in renal trauma, contemporary recommendations for aspiring athletes with solitary kidney, antibiotic coverage for various bite injuries, tips for removing a zipper from genital skin, and threshold for exploration of hematocoele with equivocal testicular rupture. You will be able to put these contributions to good use when teaching and when managing genitourinary trauma.

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“Is a horseshoe kidney considered a solitary kidney for purposes of sports/activity restrictions? Presuming not, what do you recommend to your patients?”

Dr. Franco: “No, it is not considered a solitary kidney, and the only risk this boy has is with a seatbelt injury or a very aggressive blunt abdominal injury. There is no reason to keep him from playing sports. I would recommend that he not be a boxer or mma fighter due to the blows to the stomach. I did not come across any increased incidence of injuries to horseshoe kidney with football.”
Renal Trauma in the Pediatric Patient

Introduction
Greater than 90% of pediatric genitourinary trauma in the US involves the kidney, with >95% of children sustaining renal trauma due to a blunt traumatic injury.1

Evaluation
Evaluation of the child presenting with a history of blunt abdominal trauma is based on four critical findings; the mechanism of injury, physical examination findings, the degree of hematuria and the presence of shock (systolic BP < 90 mm Hg). Three key points in evaluating children compared to adults need to be remembered; specifically, unlike the adult, the presence of hypotension, early hematocrit assessments and the degree of hematuria are not initially related to the severity of the renal injury. These major inconstancies are primarily due to the increased vasculogenic responsiveness of children to traumatic stimulated catecholamine secretion. The increase in vascular tone will allow the child to better maintain both their blood pressure, Hb/Hct levels and reduce blood flow to the kidney than the adult with a similar degree of renal injury.2-3

Who to evaluate:
Due to the inability in children to correlate vasculogenic shock and the degree of hematuria to the grade of renal injuries, significant controversy regarding the indications for radiographic evaluation in children went on for decades. Recent studies however, have revealed that similar criteria can be used in both adults and pediatric patients, provided that two additional considerations—the mechanism of injury and physical examination findings—also be taken into consideration. Specifically the two standard considerations for work up of patients with a suspected renal injury following blunt abdominal trauma are: 1) gross hematuria 2) microscopic hematuria (≥50 RBC’s/HPF) with a concurrent history of shock (systolic BP < 90 mm Hg). In children, two additional considerations need to be addressed: the mechanism of injury and the physical examination findings. Specifically, historical and physical findings that should prompt an evaluation for GU trauma in children are: high speed deceleration injury, fall from a height of > 10 feet, direct strike to the flank with a high speed object (i.e. hockey stick, baseball bat), and/or the physical findings of lower rib, thoracic or lumbar spinal fractures or flank ecchymosis. In addition to historical and physical findings listed above any penetrating traumatic wounds to the lower thoracic or upper abdomen would prompt radiographic evaluation.2-3

CT Evaluations:
Although the gold standard to rule out renal injuries remains the classic triphasic CT evaluation, attempts to reduce radiation exposure to children has resulted in the use of a single CT series of images taken 5-10 minutes after the injection of contrast.

If after reviewing these single phase CT images concern arises regarding a possible major renal pedicle injury, UPJ or distal ureteral avulsion, a delayed KUB or limited CT cuts obtained 15 minutes post injection may be highly beneficial.

MRI evaluations:
Although MR angiography is feasible for the assessment of renal trauma in older children, it requires significant sedation in younger children and is less sensitive for spatial resolution in determining blood flow through distal segmental vessels and in determining distal ureteral patency.4

Staging of Renal Trauma Grading System Revised 2011
In 2011, Buckley and McAninch, recommended revision of the classic 1989 renal organ injury scale. This revision was proposed to alleviate significant discrepancies that were existing in the literature regarding the classification of high grade IV & V renal injuries. This current staging of renal injuries based on their recommendations is outlined below:

- Grade I – Contusion or subcapsular hematoma, no visible renal lacerations
Renal Trauma  (continued from previous page)

Grade II - Renal laceration < 1 cm in depth, no devitalized fragments, no injury to the collecting system

Grade III - Renal laceration > 1 cm in depth, +/- vascular segmental injury, no injury extending into the collecting system

Grade IV – Laceration extending into the collecting system, +/- vascular segmental injury, +/- renal pelvis laceration and/or complete UPJ disruption

Grade V – Main renal artery or vein laceration, or major renal artery or vein thrombosis

Coexisting Renal Injuries

It is important to note that up to 15% of pediatric patients sustaining a traumatic renal injury will have a pre-existing urologic abnormality that may eventually require surgical intervention. Classically these patients present with a degree of renal injury out of proportion to their mechanism of injury. The vast majority of these pre-existing anomalies are either a congenital UPJ obstruction or duplication anomaly.1

CT Scan Findings Indicative of the Need for Interventional Therapy

In patient’s sustaining a renal injury approximately 10% will eventually require interventional management for their traumatic renal injury. The need for intervention is dependent upon the stage of injury, with few if any grade I-III injuries requiring interventional management. Three classic CT findings are indicative that interventional therapy may become necessary: medial extravasation of contrast (concern for UPJ disruption or rupture of renal pelvis especially concerning if no contrast is seen in the ipsilateral distal ureter), lateral extravasation of contrast with no distal ureter visualized (concern for ureteral injury), perinephric hematoma of >3.5 cm (a hematoma of >3.5 cm is usually associated with persistent renal cortical bleeding and/or if the hematoma occurs medially, concern for major renal artery or vein injury exists).1

Impact of New Grading System

Key in interpreting the new grading system is that the “shattered kidney” that was classically defined as a grade V injury is now a Grade IV. With this reclassification the majority of Grade IV “shattered kidneys” are being managed by active surveillance and angiographic embolization of persistent bleeding vessels. This new classification greatly enhances the ability to compare previously published literature. The current classification of grade V injuries as including patients only with vascular injury of either the main renal artery or vein serves to characterize a class of patients with a severe and life threatening injury. Using this classification the vast majority of the patients with Grade V injuries are hemodynamically unstable and immediate surgical exploration is usually necessary to salvage the patient. This results in an emergent nephrectomy rate for grade V renal injuries of approximately 75%, and a functional salvage rate (>25% residual function of the involved kidney on differential renal scan) of less than 5%. Active surveillance in grade V renal injuries is currently reserved for individuals where either complete or partial thrombosis of the major renal artery or vein has occurred, the thrombosis limiting the active hemorrhage.3

Treatment

Active Surveillance

Hemodynamically stable patients are treated with bed rest, hydration and antibiotic coverage. Serial vital signs are obtained at 1-2 hour intervals serial physical examinations every 2-4 hours and serial Hb/ Hct at 4-6 hour intervals , with gross visual examination of the urine following each void. The frequency of these evaluations is variable depending on the severity of the renal injury. Bed rest is maintained until gross hematuria has cleared for an 8 hour interval.

The need for blood transfusion is directly related to grade of renal injury, with approximately 10% of patients with grades II-III injuries requiring transfusion, 40% of grade IV and almost 100% of grade V. The incidence of transfusion, although related to the degree of renal injury, is also associated with patient injury score.1

Interventional Indications

Absolute indications for surgical intervention are pedicle avulsion, life threatening hemodynamic instability due to renal hemorrhage uncontrollable by angiographic embolization, ureteropelvic and/or ureteral avulsion. In a patient with a missed ureteropelvic or ureteral avulsion injury timing of repair is critical. A delay of ≥7 days is associated with a statistically significant risk for eventual nephrectomy. This is believed to be due to the significant desmoplastic response that results from the urinary extravasation at the time of the injury. If the UPJ disruption is diagnosed within 5 days of the injury surgical exploration with repair is preferred provided the patient is clinically stable. In a clinically unstable patient, or if a delayed diagnosis occurs, management with placement of a nephrostomy tube and delayed repair at 3months post traumatic insult is indicated.1

Indications for endoscopic or angiographic intervention are: persistent or developing hemodynamic instability, the repeated need for blood transfusion, failure to resolve gross hematuria in > 72 hours, persistent fever or ileus for > 72 hours (usually due to a urinoma and will require ureteral stent placement), and worsening flank pain (may be due to either an expanding hematoma or urinoma).

Follow-up Radiographic Evaluations

Currently, the need to reimaging in the immediate post injury time period is based strictly on the patient’s symptomatology, i.e. persistent ileus or fever > 38.5°C for ≥ 3 days, unremitting severe flank pain, Hct drop of ≥ 20% of baseline value.

No delayed reimaging of the patient with a grade I-III injury is currently recommended. In grade IV and V renal injuries, although not mandatory, reimaging is recommended at 3 months. This consensus opinion is based on the fact that the long term decrease in renal func-

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Renal Trauma (continued from previous page)

Recommendations for Patients with Solitary Kidneys

Introduction

The question begs to be answered if a child with a solitary kidney should be allowed to play in contact sports. Unfortunately the lack of evidence-based medicine has led us to make recommendations over the last 25 years that were based on assumptions and personal biases and not on objective facts. As we scour through the literature in the last ten years we start to see a more objective means of evaluating sports injuries starting with some important publications in the early years of the new century.1-3

If we look back in time and see the recommendations put forth by the American Academy of Pediatrics (AAP) Committee on Sports Medicine and Fitness in 1988 we see that it was suggested that children with a solitary kidney not participate in contact sports.4 In this original publication the data was based on studies extending as far back as 1960 and up to 1981. The incidence of partial nephrectomy or nephrectomy in the collected cases that were used to base the foundation of the study totaled 557 cases with a nephrectomy rate which ranged from 0.03% to 13.2%. These numbers are high by today’s standards, but unfortunately there was little added to the literature when the new recommendations came out in 19945 and again in 2001.6 In both publications they referred back to their original publications to set the standards. There was a softening of the language in the latter publications stating that for those with the “absence of one kidney” a “qualified yes” is granted with “individual assessment for contact, collision, and limited-contact sports”. Publications which polled the members of the American Society of Sports Medicine revealed that 54.1% would allow an individual with a solitary kidney to fully participate in contact and collision sports at the high school or college level.7 In the same survey if the participant was the physician’s son or daughter, the percentage dropped to 41.6%. Similarly, in a survey of pediatric urologists in 2001 made up of members of the AAP Section of Urology, it was found that 68% would recommend that patients with a solitary kidney avoid contact sports even though the general consensus was that the risk of renal injury is low.8 This does not sound or look like evidence based medicine in any way, and since that publication there have been several publications which have looked at this subject in a more objective fashion and have been able to draw on national or regional trauma databases as well as databases maintained by academic sports organizations.

The lack of more specific guidelines and data regarding the incidence of renal injuries associated with these activities makes offering an informed recommendation difficult. We will look at the objective evidence-based medicine has led us to make recommendations over the last 25 years that were based on assumptions and personal biases and not on objective facts. As we scour through the literature in the last ten years we start to see a more objective means of evaluating sports injuries starting with some important publications in the early years of the new century.1-3

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In patients sustaining grade I and II renal injuries participation in contact sports may occur once the microhematuria has resolved. Most studies reveal this will occur within 2 weeks following a grade I – II renal injury. Classically patients sustaining renal lacerations of grade 3 or higher are by consensus opinion held from participation in contact sports for 6 weeks and released to participate only following confirmation that the microhematuria has cleared. Persistence of the microhematuria at 6 weeks will prompt continued restriction of sporting activities along with the need to consider reimaging the patient.

Return to Sporting Activities

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data that is presently available and help define a more realistic approach to the recommendations to children with solitary kidneys and their participation in sports.

The primary concern regarding renal injury is participation in sports; 62% of pediatric nephrologists would not allow contact/collision sports participation. Eighty-six percent of respondents barred participation in American football, whereas only 5% barred cycling. Most cited traumatic loss of function as the reason for discouraging participation, but in our review of the national pediatric trauma database registry (NPTR) from 1995-2001, it was motor vehicle accidents (MVA) that accounted for the largest percentage of injuries to the kidneys (Fig 1). Sports related injuries lagged behind bicycle injuries and falls as a cause of renal injury. Do we tell our children not to ride bicycles or cross the street or ride in cars? Of course not, but we are telling children to not play certain sports. In reality when one looks at the list of sports that are consider non-contact, we see that horseback riding is in that list and this accounts for more nephrectomies and severe injuries than football, lacrosse or hockey given the number of participants.

### Renal injury data from the National Pediatric Trauma Registry from 1995-2001

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Mean Age</th>
<th>Total Deaths</th>
<th>Nephrectomy</th>
<th>Partial Nephrectomy</th>
<th>Repair of Renal Lac</th>
<th>Renal Exploration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVA (293) (30%)</td>
<td>10.7</td>
<td>20</td>
<td>9 (2 died)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Ped Struck (19)</td>
<td>7.8</td>
<td>12</td>
<td>7 (2 died)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fall (107) (13%)</td>
<td>9.5</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Bicycle (92) (11%)</td>
<td>11.3</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sports (85) (10%)</td>
<td>13.6</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other (117) (15%)</td>
<td>9.1</td>
<td>8</td>
<td>3 (1 died)</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total (813)</td>
<td>10.6</td>
<td>47</td>
<td>28 (5 died)</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

### “Contact Sports”

Statistically speaking we can see that the risk of drowning has a 1-year risk of 1 in 88,000 and a 1 in 1100 lifetime risk. The risk of dying in a fire is about the same as drowning. How about being murdered? A one-year risk of 1 in 16,500 and a lifetime risk of 1 in 210. These all appear to be greater than any risk to the kidney when a literature search was done. Wan et al found an incidence of catastrophic sports-related kidney injury of 0.4 per 1 million children per year from all sports. Incidence of sports-related kidney injuries in patients with 2 kidneys: 6.9 per 1 million kids/year (1/144,000 kids/year). An extrapolated risk of 1 out of 215 million kids would be expected to have an injury to a solitary kidney.

Cycling was the most common cause of sports-related kidney injury causing 3 times as many kidney injuries as football. American football alone accounted for 0.9 to 5.3 fatal brain injuries and 4.9 to 7.3 irreversible spinal cord injuries per 1 million players per year. Commotio cordis causes 2.1 to 9.2 deaths per year. Clearly the numbers do not substantiate the fears associated with contact sports.

If we look at the data that is available, we see that Radelet et al followed 1659 children ages 7 to 13 over a two year period; there were no documented renal injuries in these children who participated in football, baseball, softball and soccer. In another prospective study DeLee and Farney followed 4000 varsity high school football players for one football season, and they reported 2228 football related injuries of which 97 injuries required hospitalization and surgical treatment. There were 3 splenectomies, 1 appendectomy and no renal injuries were reported. Goldberg et al followed 5128 boys participating in youth football and there were no reported renal injuries. A similar study by Stuart et al, which was a prospective observational analysis of 915 youth football players ages 9 to 13, there were no identified renal injuries. From this data we can ascertain that the younger football player is less prone to renal injury, whether this is due to mandatory wearing of rib protection or decreased mass of the players and slower velocities is unclear. What we do know is that the smaller athlete is less likely to have a renal injury.

When we look at older players—in particular college and professional athletes— we see that there is a different picture that emerges. Brophy et al surveyed 31 professional football teams in the NFL; they responded to a questionnaire regarding renal injuries. There were 52 cases for a rate of 2.7/year with an overall injury rate of 0.000012 per exposure. The risk of injury was 10x greater in games (0.000055 per exposure) vs. practice (0.000005 per exposure). There were 42 contusions, 6 lacerations, 2 stones and dysfunction. One respondent was aware of a professional player who ultimately required a partial nephrectomy. Two teams were aware of a player who had lost a kidney while playing football at the college level and one at the high school level.

A database that is maintained for college injuries (DataLysercenter) collected data on 15,805 injuries over a period of 5 years (2004-2009). There were 10 injuries to the kidneys listed for an annualized incidence of renal injury of 0.0013% of all college sports injuries. The database did not elaborate on the type or severity of the injury, thereby making it difficult to ascertain whether any patient required a nephrectomy.

Again we do not know if any of the injuries reported occurred when the player was using protective gear. What we do know is that renal injury or contusion is rare under 12 yrs of age based on the literature and reporting. It is almost impossible to ascertain what the real rate of kidney loss would be based on the present data other than to say that it would be exceptionally rare. We have to assume that injury rates in hockey and lacrosse can be on par with football. Wan et al reported a high incidence of hockey related injuries. These regional differences will obviously be noted in the sports that are played in each area.

### “Limited Contact” Sports

Skiing, sledding, rollerblading, and horseback riding are listed by the American Academy of Pediatrics Committee on Sports Medicine and Fitness as limited contact sports. Again the use of this term is a misnomer and should not be used since there are a high number of injuries that occur with these sports. When we examine winter sports in the NPTR database we see that winter sports resulted in three of the four reported sports associated nephrectomies (sledding (2), skiing (1) and rollerblading (1)), and two deaths were related to skiing and jet skiing. Radmayr et al examined a 26 year history of renal trauma transferred to their department in Austria. There were 254 renal traumas resulting in four nephrectomies, and the majority of the injuries were

(continued on next page)
due to injuries resulting from skiing accidents. The majority of the renal injuries were managed conservatively. It is clear that the participants in skiing, snowboarding and sledding travel at a high velocity, and this appears to present the greatest risk for renal injury/loss. Our own personal experience over the last 20 years has corroborated these findings, with the only nephrectomies performed in our center being due to skiing, sledding and snowboarding accidents and none due to traditional contact sports. Velocity plays a role in horseback riding, which is also listed as a limited contact sport. There were three nephrectomies associated with equestrian activities, as well as one death.

**Sport and Recreational vehicles Injuries**

Cycling is the predominate mode of injury in this field and in the NPTR data we saw that cycling accounted for more renal injuries than all sporting activities combined. The renal injury rate was 2.2% in cycling injuries. The difference was that the ISS was higher in cycling (Fig 2). In a study looking at ATV injuries we see 7 boys and 6 girls sustained GU trauma, for a total of 13 (3%) of the injuries. Renal injuries were most common (12/13, 92%). Of the 13 patients, 7 (54%) presented with renal contusions and 5 (38%) suffered renal lacerations (2 grade I, 1 grade II, 2 grade III). None were treated surgically.

**Conclusions**

The loss of a kidney in a traditional contact sport is quite uncommon even though these injuries do occur. The likelihood is diminished in the younger patient due to body mass and velocity being smaller in the younger patient. This is just a simple fact of physics.

The older patient participating in sports such as football, hockey and lacrosse are at greater risk for renal injury due to the increased speed and mass of the players involved. Regardless of the activity, when the velocity is increased and or the mass of the object hitting the patient is increased, regardless of the age of the patient, the risk for injury increases. This explains why the vast majority of renal injuries associated with childhood activities are linked to bicycles, falls, motor vehicle collisions and sports classified by the AAP as limited contact (horseback riding, skiing). The majority of trauma nephrectomies in children are associated with motor vehicle accidents, pedestrians struck by a vehicle or other objects, and falls. The likelihood of a player with a solitary kidney sustaining an injury is even higher in the younger patient due to body mass and velocity being smaller in the younger patient. This is just a simple fact of physics.

Grinsell et al have concluded from their meta analysis that limitations of single kidneys from collision/contact sports is unwarranted. They felt that loss of function of a single kidney would be devastating to an individual and would necessitate dialysis and transplantation. However, quadriplegia/quadriparesis because of spinal cord injury, loss of life from traumatic brain injury, or cardiac arrest are also devastating events that apparently occur more frequently than kidney injury within the pediatric population. Bicycle associated renal injury is the most common sports related urologic injury in the pediatric population. Bicycle associated renal injuries occur at the same rate as renal injuries in all other sports combined. Despite this data, cycling is considered only a limited contact sport with few restrictions or recommendations passed down to parents, schools, or camps regarding children riding bicycles. We need to increase awareness of the dangers of cycling in patients with solitary kidneys.

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The present recommendations are based on incomplete information and mislead physicians, school officials and parents into believing that limited contact sports are safer than contact sports with regard to renal injuries. Current recommendations prohibiting children with solitary kidneys from participating in what are considered contact sporting activities appear to be overly protective and need to be reestablished. It would behoove the subspecialty organizations to put forth a formal statement regarding recommendations based on recent data to protect its practioner from the vagaries of indiscriminate lawsuits.

**Renal Injury by Sports**

<table>
<thead>
<tr>
<th>Sports (total)</th>
<th>Male</th>
<th>Female</th>
<th>Avg. Age in years (Range)</th>
<th>Avg. ISS (Range)</th>
<th>Renal injury grade (0 1 2 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Football (20)*</td>
<td>20</td>
<td>0</td>
<td>14.4 (12-19)</td>
<td>4.1 (4-5)</td>
<td>1 7 12 0</td>
</tr>
<tr>
<td>Shing (13)</td>
<td>7</td>
<td>6</td>
<td>13.9 (10-19)</td>
<td>4.85 (3-6.1)</td>
<td>1 3 3 6</td>
</tr>
<tr>
<td>Snowboard (7)</td>
<td>7</td>
<td>0</td>
<td>12.9 (6-16)</td>
<td>7.7 (4-16)</td>
<td>0 4 1 2</td>
</tr>
<tr>
<td>Skiing (7)</td>
<td>7</td>
<td>0</td>
<td>15.7 (12-19)</td>
<td>17.7 (8-60)</td>
<td>1 4 2 3</td>
</tr>
<tr>
<td>Skateboard (6)</td>
<td>6</td>
<td>0</td>
<td>13.5 (9-18)</td>
<td>14.8 (4-24)</td>
<td>0 3 2 1</td>
</tr>
<tr>
<td>Basketball (1)</td>
<td>1</td>
<td>0</td>
<td>14.33 (12-16)</td>
<td>7 (4-16)</td>
<td>2 2 1 1</td>
</tr>
<tr>
<td>Rollerblade (5)</td>
<td>5</td>
<td>0</td>
<td>12.8 (10-16)</td>
<td>12.5 (5-24)</td>
<td>1 3 1 0</td>
</tr>
<tr>
<td>Baseball (5)</td>
<td>5</td>
<td>0</td>
<td>14.4 (11-17)</td>
<td>8 (4-19)</td>
<td>0 2 2 1</td>
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<tr>
<td>Hockey (3)</td>
<td>3</td>
<td>0</td>
<td>13 (13-17)</td>
<td>5.6 (4-9)</td>
<td>0 0 2 1</td>
</tr>
<tr>
<td>Jet Skiing (3)</td>
<td>1</td>
<td>2</td>
<td>11 (8-13)</td>
<td>20 (6-38)</td>
<td>0 2 1 0</td>
</tr>
<tr>
<td>Soccer (2)</td>
<td>2</td>
<td>0</td>
<td>12 (8-16)</td>
<td>4 (4-4)</td>
<td>0 1 1 0</td>
</tr>
<tr>
<td>Skating (2)</td>
<td>1</td>
<td>1</td>
<td>14.5 (14-15)</td>
<td>4 (4-4)</td>
<td>0 1 1 0</td>
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<tr>
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* Youngest child with renal injury was 12 years old

**Current recommendations prohibiting children with solitary kidneys from participating in what are considered contact sporting activities appear to be overly protective and need to be reestablished. It would behoove the subspecialty organizations to put forth a formal statement regarding recommendations based on recent data to protect its practioner from the vagaries of indiscriminate lawsuits.**

**References**

Solitary Kidney (continued from previous page)


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N/A indicates not applicable; NC, not calculated.
* One patient with single kidney suffering contusion during American football participation.

Regarding your program:

Parent Urology institution:
Vanderbilt University

Is that a Department or Division of Urology?
Department.

What is your relationship to the parent program?
All one group in all regards.

Pediatric Urology Division Head:
John W. Brock III

Fellowship Program Director:
John W. Brock III

How many years have you had a fellowship (include years that pre-date ACGME)?
11

Who are the full-time (clinical) pediatric urologists in your group:
Brock, Adams, Pope, Thomas, Tanaka (Stacy T.), Clayton (Douglass B.)

Do you have any part-time pediatric urologists? (please name and indicate what they do with nonclinical time)
Tanaka outcomes/database research 60% clinical; Clayton 60% basic science 40% clinical.

Briefly, what is your basic science research niche(s)?
Bladder fibrosis and neurogenic bladder.

What are you best known for clinically? (one only, please):
“Everything” ~JWB.

Describe the flavor of your group / program in four words or less:
Collegial, efficient, academic, patient-friendly.

FROM THE GUEST EDITOR (continued from page one)

Drs. Bean and Minevich discuss penile trauma from minor childhood accidents such as toilet seat injuries to devastating injuries such as penile avulsion/amputation - the timely and successful treatment of which can be critical to the patients’ future functional and cosmetic outcome. Drs. Saltzman and Ortenberg give an update on pediatric scrotal and testicular trauma. Dr. Husmann reviews the evaluation and management of children with renal trauma – an area that is often managed differently in children than adults. Finally, Dr. Franco gives us some very practical information on the ins and outs of patients with a solitary kidney, giving hard data on how to counsel these patients in the area of life activity (sports, etc.).

These reviews have been very helpful to me and my associates as we manage these patients and I have even referenced some of this information to my referring pediatric providers. It is my hope that you will find this review as interesting and useful as I did.
Penile Trauma

Christopher Bean, MD and Eugene Minevich, MD, Cincinnati Children's Medical Center, Cincinnati, OH

More than 250,000 children ≤ 18 years of age were evaluated for genitourinary (GU) injuries in US emergency departments from 2002 to 2010 with penile trauma accounting for 22.8%. Trauma to the external genitalia can be associated with pelvic injury due to blunt and penetrating forces. Compared to other body organs, trauma to the penis is rare due to a relatively protected location and the ability to resist traumatic forces during a flaccid state. The mechanism of genital injury in pediatric patients can be similar to adults in some regards however there are different etiologies to consider as well. Although there is no uniformly accepted classification for pediatric penile trauma, it can generally be classified into blunt, penetrating, iatrogenic, or ischemic injuries.

The American Association for the Surgery of Trauma (AAST) introduced an organ injury scale for the external genitalia in 1996. Penile injury is graded on a scale of I for contusions or superficial lacerations to V for total penectomy. A corresponding Abbreviated Injury Scale (AIS) score is used to determine the life threatening severity of the injury with values of 1 for AAST grades I and II, and a score of 3 for AAST grades III-V (AIS 1=minor, 2=moderate, 3=serious, 4=severe, 5=critical, 6=un-survivable). Blunt trauma is the most common cause of pediatric penile injuries. The toilet seat falling onto the penis is the number one etiology of injuries due to the toilet seat, or “penile slam syndrome.” It usually results in AAST grade I injuries consisting of contusions or superficial lacerations with 97% of patients able to be treated on an outpatient basis. Urethral injury must be excluded in more severe cases. The incidence of penile slam syndrome is on the rise and believed to be related to the manufacture of larger and heavier toilet seats and no zipper or fly-fasteners with buttons or Velcro. Several non-operative methods have been used to successfully release prepuce skin from the zipper. The least invasive method involves the liberal application of mineral oil with gentle traction to the zip fastener. If mineral oil is unsuccessful a small flat screw driver can be placed between the face plates of the zip fastener to widen the space between the plates and release the prepuce. Bone cutters may be used to cut the median bar, which connects the anterior and posterior plates of the zip fastener, as well as the zipper inferior to the entrapped prepuce to allow the zipper to separate. Of the patients with zipper related injuries, more than 98% are able to be treated in the emergency department without surgical intervention. However, more severe injuries have resulted in the development of urethrocutaneous fistulae.

Penile fracture, while more common in adult patients, has been described in adolescence. The majority of penile fractures result from the bending of an erect penis against the pubic symphysis or perineum during sexual intercourse. Frequently a delay in presentation is seen. The tunica albuginea of a flaccid penis becomes thinner during an erection—to around 0.25mm—and is overcome by pressures that can exceed 1500mm Hg. This results in traumatic rupture of the corpus cavernosum and sometimes corpus spongiosum in which a pop or snapping sound is heard. Adjunctive symptoms include acute pain, swelling, and rapid detumescence. The classic “eggplant deformity” occurs when Buck’s fascia remains intact and blood spans along the penile shaft. However, one may also see a perineal, or “butterfly hematoma”, when Buck’s fascia is violated and blood is contained within Colles fascia. Hematuria is consistent with urethral injury; however, absence of blood at the urethral meatus or in the urine does not exclude urethral injury. Patients with penile fractures require surgical exploration, which should include “optimal surgical exposure through a circumferential degloving incision, evacuation of the hematoma, identification and closure of corporal defects, and repair of any associated urethral injuries.” Conservative management for penile fracture is no longer recommended due to an increased potential for complications such as missed urethral injuries, erectile dysfunction, corporal fibrosis, and penile curvature. For patients with questionable clinical histories and an equivocal physical exam several imaging studies have been used to rule out corporal injury, including penile cavernosography, MRI, and ultrasound. Cavernosography requires injection of diluted nonionic contrast directly into the corpora cavernosa; however, this method has been associated with allergic reactions to contrast, corporal fibrosis, and false negative results. MRI provides excellent anatomical delineation of corporal injury, but expense and availability have limited its routine use. Penile ultrasound has the advantages of being noninvasive, more readily available, and cost effective compared to MRI, but false negative rates are high due to examiner variability. Penetrating trauma is the second most common injury to the penis and usually due to zippers, animal and human bites, gunshot wounds (GSW), amputation, and mechanized machinery. Approximately 16.6% of pediatric penile injuries are due to zippers, which makes them second only to toilet seat injuries in emergency room visits in the U.S. Patients aged 8 to 11 years are affected most by zippers. Zipper injuries entrap foreskin mostly in uncircumcised boys; however, the number of zipper related injuries remained stable from 1999 to 2009 during which time circumcision rates dropped from 63% to 54%. In an effort to reduce the number of zipper related injuries, Bagga et al. recommend zipper operator instruction and trousers with an elastic waist and no zipper or fly-fasteners with buttons or Velcro. Several non-operative methods have been used to successfully release prepuce skin from the zipper. The least invasive method involves the liberal application of mineral oil with gentle traction to the zip fastener. If mineral oil is unsuccessful a small flat screw driver can be placed between the face plates of the zip fastener to widen the space between the plates and release the prepuce. Bone cutters may be used to cut the median bar, which connects the anterior and posterior plates of the zip fastener, as well as the zipper inferior to the entrapped prepuce to allow the zipper to separate. Of the patients with zipper related injuries, more than 98% are able to be treated in the emergency department without surgical intervention. However, more severe injuries have resulted in the development of urethrocutaneous fistulae.

Animal and human bites to the genitalia are a rare cause of penile trauma. The grade of injury can vary from a simple penile laceration to complete amputation of the penis, scrotum, and testicles. Pasteurella multocida is the most common bacterial isolate from infected dog and cat bites, and empirical treatment should consist of amoxicillin plus beta-lactamase inhibitor. Treatment alternatives include oral dicloxacinil, cephalixin, or chloramphenicol; however, cautious use of chloramphenicol is a priority due to potential bone marrow suppression. Patients with incomplete immunization to tetanus should receive both tetanus immunoglobulin and tetanus toxoid while patients with prior completion of immunization and last booster more than 5 years should receive a tetanus toxoid booster. Rabies prophylaxis is indicated when the animal demonstrates signs of abnormal behavior or is not captured. Human bites can result in the transmission of hepatitis B, hepatitis C, herpes simplex, syphilis, and rarely HIV. Treatment of bites should include irrigation of the wound with large amounts of povidone-iodine solution, debridement of necrotic tissue, and additional reconstruction based on the level of involvement. Primary closure of animal bites should be attempted in wounds without delayed presentation and obvious signs of infection. Human bites on the other hand are more likely to be contaminated, thus primary closure is not indicated.

(continued on next page)
Penile Trauma (continued from previous page)

recommended.19

GSWs to the external genitalia are rarely isolated to the penis with up to 84% having significant associated injuries.20, 21 Retrograde urethrogram is recommended in all GSWs to rule out urethral injury; that is identified in up to 22% of patients.23-26 Treatment should begin with stabilization of the patient and assessment by trauma surgery to rule out concomitant injuries. Excessive bleeding from the penis due to corporal injury should be controlled with compressive dressings until associated injuries have been addressed. Non operative management is appropriate for isolated penile GSWs superficial to Buck’s fascia.22, 23, 25, 26 Surgical exploration is required for patients suspected to have urethral or corporal involvement and should involve an approach similar to that described above for penile fracture. Debridement should be limited only to necrotic tissue, which might be confused with hematoma.26 It is imperative to search for foreign bodies in the wound such as clothing material or bullet fragments. Wessells et al. recommends transverse closure of the tunica albuginea to prevent corporal narrowing and approximation of large corporal defects using dermal grafts or commercially available products.2 Suprapubic cystostomy in addition to a urethral catheter should be considered in patients with urethral injury due to concern for later urethral stricture.23

Amputation of the penis can occur due to penetrating injury, self-mutilation, iatrogenic complication of circumcision, and ischemic injury secondary to tourniquet syndrome. Self-mutilation, or Klingsor syndrome, usually occurs in patients with acute psychosis that require jury secondary to tourniquet syndrome. Self-mutilation, or Klingsor syndrome, usually occurs in patients with acute psychosis that require jury secondary to tourniquet syndrome.27 The FDA warned of potential injury from the Gomco® and Mogen® clamps in the year 2000 after 105 reported injuries were reported from July 1996 to January 2000.28 In a literature review Pippi Salle et al. identified 31 cases of glans injury during clamp circumcisions and noted a common theme of an oblique ventral injury.27 During clamp circumcision it is imperative to completely separate the glans from the prepuceal adhesions to insure the glans is not inadvertently trapped within the clamp. Partial and complete glans amputation due to circumcision should be treated with re-anastamosis as previously mentioned. The most dreaded complication includes complete penile loss due to electrocautery, requiring feminizing genitoplasty.29

References


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Pediatric Scrotal & Testicular Trauma

Amanda Saltzman, MD1 & Joseph Ortenberg, MD, FAAP1,2

1Department of Urology, Children’s Hospital of New Orleans, Louisiana State University Health Sciences Center, New Orleans, LA
2WB Reily Professor of Urology, Louisiana State University Health Sciences Center, New Orleans
Director of Urologic Education, Children’s Hospital of New Orleans

Scrotal injuries comprise < 1 % of all pediatric and adult trauma cases in the United States and Wan reported 1 testicular injury in 81,913 trauma cases in 2003.1 Children less than 10 years of age account for just 5% of all trauma cases. Injury occurs most commonly during sporting events2 and blunt trauma is more frequent in children than adults. McAleer reported 16 blunt testicular injuries in a series of 14,793 pediatric trauma cases between 1984 and 2000, and 25% of these involved team sports.3 In another recent article, injuries occurred with a variety of sports, including soccer, rugby, handball, gymnastics, karate and judo.4

It has been estimated that 252,392 children sustained urotrauma between 2002 and 2010, with 28,000 children visiting the emergency department annually due to these injuries – the majority of whom are between 4 and 7 years of age. Girls sustained slightly more injuries than boys overall, but boys sustained injuries more frequently after the age of 7. The most common diagnoses were contusions and lacerations of the genitourinary system (68%) and the most common mechanism for injury was a fall (45%). A straddle injury or direct blow to the scrotum is also a common mechanism of trauma. Male testicular and scrotal trauma accounted for 20% of GU injuries.5

Initial presentation of scrotal trauma is usually to an emergency room or urgent care clinic physician. The mechanism of injury (blunt vs penetrating) will guide initial management (Fig 1). Physical exam is often limited by pain and swelling causing distortion of the scrotum. Common findings include severe edema, scrotal ecchymoses and exquisite tenderness of the testicle (Fig 2). If an abnormal lie of the testicle or the cremasteric reflex is absent, suspicion of coincident torsion should be high (5-8% of cases of torsion).6,7 Scrotal ultrasonography (US) with Doppler is the study of choice for evaluation of scrotal trauma. Pathologic findings include a heterogenous pattern in the testicular parenchyma – compatible with hemorrhage/hematoma or infarction. A hematocoele (collection of blood within the tunica vaginalis) may occur due to bleeding from the scrotum or testis, potentially associated with rupture of the tunica albuginea. As the incidence of testicular torsion has been noted to be increasing, a rapid and accurate diagnosis is essential.

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Testicular Trauma

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ticular rupture (and thus the need for urgent operative intervention) is about 50%, clinicians must actively screen for this condition. A fracture site in the testis may be difficult to identify conclusively, but disruption of the capsular blood flow or extrusion of testicular parenchyma strongly suggest testicular rupture (Fig 3). The sensitivity, specificity, positive predictive value and negative predictive value of scrotal US in various situations is summarized in Table 1. The sensitivity and specificity of hematocele identification is 87% and 89% respectively, and 100% and 65% for testicular rupture.

T2-weighted MRI imaging with gadolinium has recently been shown to have 100% accuracy in diagnosing testicular rupture. The tunica albuginea is dark on T2 imaging, allowing visualization of the disruption.8 Given the cost of MRI and widespread availability of US, the latter is still the mainstay in management. Although we do not advocate CT for the primary purpose of evaluating testicular trauma, it is frequently used in patients with polytrauma involving the pelvis. CT can be useful in identifying testicular dislocation to an ectopic position as well as identifying breeches in the tunica albuginea.9

BLUNT SCROTAL TRAUMA

Blunt force is the mechanism of 85-91% of testicular injuries. It can cause injury to the spermatic cord, scrotum or testicle. Testicular injury typically results from the result of a crushing of the testis against the symphysis pubis or between the thighs. The testicle is naturally protected from injury by free mobility within the scrotum, laxity of the overlying skin, the contraction reflex of the cremasteric muscles and the density of the tunica albuginea. The tunica albuginea can withstand a force of 490 Newtons (50 kg) without rupturing. As men age, the outermost layer of the tunica albuginea thins while the inner 2 layers thicken, possibly decreasing elasticity of the tunica with aging.10

In the case of minor trauma with a large hematocele, there should be suspicion for a testicular tumor. In adults with scrotal trauma, tumor identification rates as high as 10-15% have been reported.11 Given the lower incidence of testicular tumors in children, this rate is much lower in the pediatric population – 4%.4 With minor trauma and disproportionate pain, suspect torsion. With a fluctuant hematocele, suspect an intra-abdominal source of bleeding (i.e. splenic laceration) and a patent processus vaginalis, which can occur bilaterally in up to 25% of cases.12 An empty scrotum after blunt trauma usually indicates testicular dislocation, usually to the subcutaneous or inguinal areas. This is typically seen with motorcycle injuries from impact with the fuel tank. Testicular dislocation must be diagnosed and corrected early as

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Testicular Trauma (continued from previous page)

delay renders the surgery more difficult. It has also been reported that testicular dislocation, when uncorrected for more than 1 month, causes diffuse atrophy of seminiferous tubules and absent spermatogenesis, seen histologically on testicular biopsy. However, viable germ cells were present in these biopsy specimens.13 There has also been a single case report showing improvement of these abnormalities at 8 months following reduction of dislocation, suggesting that the histological changes may be reversible after surgical correction.14 Epididymal injuries can occur, such as hemotoma, rupture or detachment and these always have associated severe testicular trauma.15

The majority of data regarding testicular rupture comes from the adult literature, but the same principles are usually applied to pediatric patients. Testicular rupture occurs in about 50% of all high impact scrotal injuries16,17 and is defined as a breech in the tunica albuginea with protrusion of the seminiferous tubules. The definitive diagnosis may only be established during surgical exploration. The major physical finding associated with testicular rupture is extreme pain on palpation. At times it may be difficult to identify tunica albuginea disruption on US. The combination of parenchymal heterogeneity and loss of contour (due to extrusion of seminiferous tubules) is used to diagnose testicular rupture, improving sensitivity and specificity to 100% and 93.5% respectively.18 Additional findings on US can include hematocoele formation and loss of blood flow.19 The goal in testicular rupture is early diagnosis and operative intervention when appropriate to achieve high testicular salvage rates, thus prompt evaluation for this condition is essential.20 With a diagnosis based on either physical exam or scrotal US and operative intervention within 72 hours of injury, testicular salvage rates as high as 83% have been reported.18 Early repair prevents infection, disability, prolonged pain, and testicular ischemia. With smaller and stable hematocoeles, observation is appropriate, although a precise upper limit in size for age has not been established.21

Historically, testicular rupture was initially treated with observation. Cass was a major proponent of early surgical intervention. In patients treated conservatively he reported a 45% rate of orchietomy, usually for chronic pain that developed after missed testicular rupture, compared with an orchietomy rate of 9% in those explored immediately. The risk of hematoma, secondary infection, pressure atrophy of the testis and prolonged recovery were all more common in those undergoing conservative management and were minimized by early exploration.4 Early exploration has now become the standard of care, because of this data. In children, a recent report from France noted that all testicular ruptures managed surgically with primary repair or partial orchietomy had no atrophy after short follow up.22

In the vast majority of testicular ruptures, the testicle can be repaired rather than removed. Every effort must be made to salvage the remaining viable testicular tissue, provided the child is hemodynamically stable and there are no other immediately life-threatening injuries. The tunica albuginea is thoroughly inspected to identify the rupture site. Sharp debridement of extruded seminiferous tubules is performed until viable bleeding tissue is identified. The tunica albuginea

The testicle is naturally protected from injury by free mobility within the scrotum, laxity of the overlying skin, the contraction reflex of the cremasteric muscles and the density of the tunica albuginea. The tunica albuginea can withstand a force of 490 Newtons (50 kg) without rupturing. is closed primarily; a tunica vaginalis graft is rarely needed (Fig 3). A drain is left through a separate incision to minimize swelling and is usually removed a few days postoperatively. Gram-positive coverage antibiotics are started preoperatively. Orchietomy is reserved for those with a clearly unsalvageable testicle, prolonged ischemia or critically ill patients with other complex traumatic injuries, in which case testicular reconstruction is not a life-saving priority.22

Although the traditional approach to testicular rupture excludes non-operative management22, there has been a new trend towards conservative management of testicular rupture, as with renal trauma. Lardellier observed 2 of 15 testicular ruptures without any apparent long term sequelae.17 Cubillos et al reported a series of 7 boys with testicular rupture, presenting between 6 hours and 5 days after blunt scrotal trauma. Scrotal US showed that all boys had testicular rupture and hematocoele. All patients were managed conservatively (scrotal elevation, oral antibiotics, rest) without surgical exploration and all patients had complete resorption of the hematocoele and no atrophy of the affected testicle. Time to resolution was <1 month on average and 3 months in the longest case. 1 boy developed late symptoms and required secondary hydrocelectomy.23 Of note, 5/7 boys presented >24 hours after trauma, suggesting that perhaps the study involved less severe cases. The average size of hematocoele was not reported. Based on this limited experience, we are hesitant to advocate conservative management in all cases of testicular rupture after blunt scrotal trauma without further support from the literature.

Some authors argue that all testicular contusions resulting in hematocoele, with or without testicular rupture, should be explored, citing earlier return to daily activities, earlier resolution of pain and shorter hospital stay.24 Alternatively, since surgery itself is not without risks, it has been suggested that a hematocoele less than 5 cm in size which is not expanding could be observed without exploration. Indeed, 20% of significant hematocoeles are not due to testicular rupture.20 When a hematocoele is small and not expanding, it is postulated that the integrity of the scrotal skin is important in preventing infection. A small, stable hematocoele will usually resolve on its own and not require delayed orchietomy for chronic pain due to missed testicular rupture.22 The absolute maximum size of a hematocoele suitable for conservative management has not been established.

Srinivas et al examined prepubertal rats after blunt unilateral testicular trauma, without operative repair. After puberty, these rats demonstrated decreased germ cell maturation bilaterally, with the traumatized testicle being affected to a greater degree than the contralateral side. They also reported a decreased serum testosterone with increased FSH and estradiol and normal LH. This raises further questions about the long-term effects of non-operative management of testicular trauma and reinforces the potential benefit of early intervention. Advantages of early operative repair include preservation of spermatogenesis and theoretical prevention of anti-sperm antibodies.25

(continued on page)
Lin et al showed that patients who underwent primary testicular reconstruction for unilateral testicular trauma had no abnormalities of semen quality or endocrine abnormalities compared to controls. Conversely, those that underwent orchiectomy had lower sperm density, increased baseline LH, FSH and post-stimulation LH levels. This further substantiates the goal of an aggressive attempt at testicular reconstruction rather than orchiectomy, during exploration for rupture.

**PENETRATING SCROTAL TRAUMA**

In cases of penetrating trauma, the vast majority of cases have associated penile, urethral, perineal, thigh or femoral vessel injuries. Accurate assessment of the extent of injury is paramount. Penetrating trauma involves both testes in 30% of cases. The testicles are more likely to be involved bilaterally in penetrating trauma than in blunt trauma. The SIU consensus on scrotal trauma advocates for exploration for all penetrating scrotal injuries to assess the extent of injury and allow immediate repair (Fig 4).

Phonsombat et al report a 50% testicular salvage rate for all penetrating genital injuries, however testicular salvage from gunshot wounds (GSW) is 75% compared to 23% from stab wounds. This difference is likely multi-factorial, but perhaps is due to the fact that GSWs rarely involve the spermatic cord and thus testicular blood supply is maintained, while stab wounds commonly involve a vascular component of the cord adding the risk of prolonged ischemia and this makes reconstruction more difficult. This group advocates exploring all penetrating trauma except for cases with superficial wounds of the scrotal skin (i.e. those injuries superficial to Dartos fascia). They do not recommend the use of scrotal US in penetrating trauma, unlike in blunt trauma, as operative intervention is indicated as primary treatment.

**AVULSION INJURIES**

Avulsion of the scrotum is seen in 20-60% of penetrating scrotal injuries. Closure of the remaining scrotum in 2 layers is optimal, if feasible. Antibiotic therapy with penicillin and clindamycin is essential to treat for any contamination with Clostridium or Tetanus. In cases of animal bites (Fig 5), primary closure is performed when technically feasible, with broad spectrum antibiotic coverage for *Pasteurella multocida*.

In cases of complex avulsion, debridement and delayed management is appropriate, with either grafting or secondary closure. In the presence of severe scrotal loss or burn, the testicles should be placed in temporary thigh pouches.

Testicular avulsion is rare. Re-anastomosis may be performed immediately if the testis is intact, the patient is stable and the ischemia time is < 9 hours.

**Conclusion**

Information about the mechanism of injury is crucial to the management of scrotal trauma. In blunt trauma, physical exam is often limited by the injury itself and scrotal US remains the cornerstone for diagnosis of testicular pathology. The role of surgery for testicular trauma in children is evolving, although early surgical exploration for testicular rupture is still the standard of care, with preservation of testicular tissue whenever feasible. Further research could focus on management algorithms to minimize morbidity, while optimizing both fertility and endocrine function.

**References**


**Figure 4:** Operative repair of testicular rupture after blunt trauma. A - initial opening of the hematocoele. B - disrupted tunica albuginea inferiorly (white arrow). C - repair of tunical rupture after excision of non-viable tissue (green arrow). D – excised, non-viable segment of testicle.

**Figure 5:** Penetrating scrotal trauma causing testicular injury after farming accident. A - full extent of testicular injury. B - operative repair. Photos courtesy of Dr. John Pope.
Figure 6: Avulsion of scrotum, 1 testis and glans penis after dog bite


Table 1: Scrotal US characteristics

<table>
<thead>
<tr>
<th>Hematocoele</th>
<th>Tunica Albuginea Breach</th>
<th>Testicular Rupture</th>
<th>Intratesticular Hematoma</th>
<th>Scrotal Hematoma</th>
<th>Epididymal Injury</th>
<th>Testicular Avulsion</th>
<th>No Injury</th>
</tr>
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<tbody>
<tr>
<td>Sensitivity</td>
<td>87%</td>
<td>50%</td>
<td>100%</td>
<td>71%</td>
<td>86%</td>
<td>57%</td>
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<tr>
<td>Specificity</td>
<td>89%</td>
<td>76%</td>
<td>65%</td>
<td>77%</td>
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<td>85%</td>
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<tr>
<td>PPV</td>
<td>95%</td>
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<td>45%</td>
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<tr>
<td>NPV</td>
<td>72%</td>
<td>62%</td>
<td>100%</td>
<td>91%</td>
<td>85%</td>
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