2 Cases:
Gynecologic Procedure:
38 yr old – LAVH for medically unresponsive uterine bleeding. Post-operative labs show elevated serum Cr, new LL abdo pain. CT urogram confirms L ureteral transection near bladder base. Referred to Uro – successful reimplantation.
Pt brings legal action (Surgeon negligent in not visualizing ureter). Judge sides with Defendant – Dissection at uretine artery and cardinal ligament can cause unwanted bleeding and increase risk of ureteral injury.

Urologic Procedure:
Middle aged F with obstructed 7 mm stone below UPJ. URS causes migration of stone to pelvis – laser litho and basket extraction. Intussuscepted ureter in basket upon removal. Immediate open exploration – Notes injury beyond repair – Proceeds to Nephrectomy!
Legal action – Consent and discussion of risks was incomplete (no mention of losing a Kidney during the operation!). Judge sides with Plaintiff and CMPA pays settlement
Objectives

- Review the etiology and discuss intra-operative and post-operative diagnosis of ureteral injuries
- Examine various management options for ureteric reconstruction
- Discuss recent cases of iatrogenic injuries and the choices made regarding their management

Ureteral Trauma – a review of recent Guidelines

- EUA Urological Trauma – 2014
- AUA Urotrauma guidelines - 2014
- Ureteral trauma: 1-2.5% of all GU trauma
  - External violence: Penetrating (gunshot, stabbings) and blast injuries: 2-3% of all cases.
  - Blunt trauma following MVC: 20 - 30% (Elliot and McAninch 2006)
    - Upper ureter more commonly injured necessitating different surgical management
  - Iatrogenic: By far the majority
    - Various mechanisms: Inadvertent clamping, partial/complete transections, thermal injury or ischemia from devascularization
Ureteral Trauma – A review of recent Guidelines

• Iatrogenic: Who are the culprits???
  – Gynecology, Colorectal, Vascular and Urology

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gynaecological (9,15,16)</td>
<td></td>
</tr>
<tr>
<td>Vaginal hysterectomy</td>
<td>0.02 - 0.5</td>
</tr>
<tr>
<td>Abdominal hysterectomy</td>
<td>0.03 - 2.0</td>
</tr>
<tr>
<td>Laparoscopic hysterectomy</td>
<td>0.2 - 6.0</td>
</tr>
<tr>
<td>Urogynaecological (anti-incontinence/prolapse)</td>
<td>1.7 - 3.0</td>
</tr>
<tr>
<td>Colorectal (8,10,17)</td>
<td>0.15 - 10</td>
</tr>
<tr>
<td>Ureteroscopy (11)</td>
<td></td>
</tr>
<tr>
<td>Mucosal abrasion</td>
<td>0.3 - 4.1</td>
</tr>
<tr>
<td>Ureteral perforation</td>
<td>0.2 - 2.0</td>
</tr>
<tr>
<td>Intussusception / avulsion</td>
<td>0 - 0.3</td>
</tr>
</tbody>
</table>

Urologic Trauma, EAU Guidelines 2014

Iatrogenic Ureteral Trauma

• Improvement in surgical experience, technique and instrumentation have led to a general decreasing trend over last 20 years (Johnson et al 2004).
  – Although: Incidence of ureteral injuries higher in Laparoscopic vs. Open colectomies (7/4469 vs 7/1060) (Nandini et al 2012)

• Major risk factors include pathologic processes that alter the normal anatomy:
  – Advanced malignancy, prior sx, radiation, diverticulitis, endometriosis, major hemorrhage
  – However: Most cases have no identifiable risk factors
Grading of Ureteral Injuries

Mechanisms of Injury

• Iatrogenic injuries can be classified based on mechanism

  – Laceration: Transection or partial laceration (grade II/III)
    • Intra-op repair is preferred to avoid post operative morbidity
    • Type of repair is dependent upon location of injury
  – Ligation:
    • Clamp or tie should be removed and stent placed for 4-6 weeks
    • Close f/u with CT Urogram to detect resultant ureteral stricture.
      • If stricture left undetected – asymptomatic (or silent) renal atrophy can occur with subsequent loss of renal units
Mechanisms of Injury Continued

– Devascularization:
  • Normal, healthy ureter usually very resistant to devascularization due to extensive collateral blood supply
  • More commonly seen months following radiation therapy or vascular surgical procedures
  • Extensive measures may be needed if contralateral kidney is compromised necessitating the need to preserve ipsilateral kidney function

– Energy:
  • Urothelial injuries from cauterity can often present early post-operatively with a fistula/urinoma or late with stricture formation
  • Steps to reduce incidence include avoiding monopolar cautery, being aware of proximity and reducing energy settings in vital areas.

Anatomy and Blood Supply of the Ureter

Blood Supply:
• Upper ureter – mainly from renal/gonadal arteries
• Mid portion – Aorta and iliac vessel branches
• Lower part – Sup/Inf vesicle, vaginal, middle rectal and uterine arteries
Prevention/Early identification of Ureteral Injuries

- Visualization of the ureter is key!
- In APRs and sigmoidectomies, the ureter may preferentially adhere to descending colon when mobilized rather than staying on psoas
- Careful dissection on plane above ureter to maintain integrity
- Peristalsis from gentle pressure on ureter: Kelly Sign

Table 1. Indication for procedures

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Group 1 (%)</th>
<th>Group 2 (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crohn’s disease</td>
<td>26 (30)</td>
<td>14 (15)</td>
<td>40 (24)</td>
</tr>
<tr>
<td>Diverticulitis</td>
<td>25 (27)</td>
<td>7 (7)</td>
<td>32 (20)</td>
</tr>
<tr>
<td>Neoplasia</td>
<td>11 (17)</td>
<td>61 (84)</td>
<td>72 (44)</td>
</tr>
<tr>
<td>Others</td>
<td>5 (6)</td>
<td>13 (14)</td>
<td>18 (12)</td>
</tr>
<tr>
<td>Total</td>
<td>67 (100)</td>
<td>86 (100)</td>
<td>153 (100)</td>
</tr>
</tbody>
</table>

Table 2. Postoperative morbidity

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Group 1 (%)</th>
<th>Group 2 (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right colectomy</td>
<td>0.08 (0)</td>
<td>263 (3.2)</td>
<td>NS</td>
</tr>
<tr>
<td>Left colectomy</td>
<td>109 (2.6)</td>
<td>532 (15.6)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Total</td>
<td>167 (1.5)</td>
<td>795 (5.3)</td>
<td>NS</td>
</tr>
<tr>
<td>General complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right colectomy</td>
<td>308 (10.7)</td>
<td>1463 (22.2)</td>
<td>NS</td>
</tr>
<tr>
<td>Left colectomy</td>
<td>739 (17.9)</td>
<td>1032 (31.3)</td>
<td>NS</td>
</tr>
<tr>
<td>Total</td>
<td>1047 (14.9)</td>
<td>2495 (25.3)</td>
<td>NS</td>
</tr>
</tbody>
</table>

Ramos et al 2014

The Utility of Perioperative Ureteral Catheterization

Nam Y, Wexner S. 2002

- 162 patients
- Laparoscopic segmental left or right colectomy
- 67 had bilateral ureteral catheters placed by staff Urologists, 95 patients proceeded without
- Mean time for placement: 11 min (making overall anesthesia time slightly longer in cath group)
- No morbidity differences between groups (others have reported self limiting hematuria of ~ 2.5 days)
- Authors note catheterized ureters were easier to identify in hostile abdomens
Diagnosis of Ureteral Injuries

- Approximately 50% of iatrogenic ureteral injuries are discovered and repaired at the time of injury
- The remaining 50% (delayed diagnosis) may remain undetected for days to months after the initial injury
- Delayed diagnosis of ureteral injuries often results in more extensive and complex repair options and increases the morbidity of the repair operation.
- High index of suspicion must be maintained accounting for mechanism of trauma or type of surgery performed and risk factors of the patient

Diagnosis of iatrogenic Ureteral Injuries

- Intra-operative assessment: Fully visualize the ureter at the site of suspected injury.
- May note discoloration, contusion or hematoma.
- Vermiculation does not rule out a ureteral injury.
- Indigo carmine/methylene blue can be injected and viewed in both the surgical field and via UOs through cystoscopy.
- A retrograde pyelogram and ureteral stent can be placed at time of injury
Endourologic mechanisms of Injury: The Scabbard Avulsion

- Complete Ureteral Avulsion: Extensive degloving injury first described in 1967 – aggressive stone manipulation with a basket (Hart et al.)
- Incidence of all ureteral injury during URS: 0 – 3.75 (Gleavlete et al 2006)
- Risk factors: Strictures, Prior radiation, Prior ESWL/URS, stone impaction, surgeon inexperience
- A devastated ureter will require a complex repair

Delayed diagnosis of the missed ureteral injury

- Clinical signs are generally non-specific:
  - Abdominal or flank pain
  - Chemical peritonitis if associated peritoneal injury and leak
  - Fevers/chills
  - Urinary incontinence
  - Hematuria
    - Rare, but if present enhances the specificity of further investigations
- A high clinical suspicion must be maintained in the presence of these signs to direct appropriate further investigations.
  - A ureteral injury may be only considered lower on DDx
  - Crucial to inform our radiology colleagues of a complete history so they may help in guiding appropriate imaging investigations.
Diagnostic Algorithm to investigate a suspected iatrogenic Ureteric Injury

Modalities of Radiologic Diagnosis: Pearls and Pitfalls

• **Ultrasound**
  - Advantages: non-invasive, no radiation exposure, widely available
  - Disadvantages: efficacy is unclear – highly sensitive for Hydro but only ~20% of IUI demonstrate hydro at presentation (Mensah et al 2008). If suspicion is high – go to CT

• **CT Urography**
  - High spatial resolution examination of kidneys, ureters and bladder
  - Thin section imaging in excretion phase following IV contrast
  - Ureteric injuries require delayed phases (12 to 120min depending on renal function, hydro etc.)
  - Excellent for detecting and localizing small defects in ureter, urinomas and abscess
  - Allows assessment of any separation of prox and distal ureter
**CT Urography**

Radiographic Features:

1. Contrast Medium Leak
2. Hydronephrosis/Hydroureter
3. Abnormal Ureteric enhancement

Benefits Over Intravenous Urogram:

1. 3 dimensional information important for operative planning
2. May identify other causes of patients symptoms not related to leak

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**Retrograde Pyelography**

- Reference standard for ureteric imaging
- Although invasive it has the distinct advantage of being diagnostic and therapeutic — allowing for JJ stent insertion at time of procedure.
- Risk of further iatrogenic injury
- Ureter must be able to be crossed if stent is to be deployed
- Poorly sensitive for devascularization injuries
A Case of Ureterovaginal Fistula

- 49 yr F post op from hysterectomy for myomatous uterus
- Presents w/ fevers, chills and UI per vagina
- Unrecognized injury at time of surgery - urinoma develops and dissects down through vaginal suture line
- US confirms hydronephrosis and delayed phase CT urogram localizes extravasating urine in RL pelvis
- Antegrade nephrostogram then NT + stenting fail → Pt underwent open repair.

Ureteral injury incurred during Aorto-Fem bypass... delayed recognition

- 68 yr M, recent aorto-right femoral bypass presents POD 12 with RQ abdo and flank pain.
- CT for acute appendicitis...
  - New Right Hydro, prolonged contrast filling into collecting system
- Rescanned for delayed phase at 2 hrs post – contrast extravasation from R proximal ureter, dissecting into retroperitoneal fascial planes
- If conservative management with stenting fails in this situation, what do we do?
Ureteral Injury during laparoscopic Colostomy

- 70 yr F, Hx of Colon Ca resection and formation of colostomy laparoscopically
- Presents POD7 with abdo pain, fevers and chills – CT with delayed images obtained
- Several small pelvic collections +/- air, all have opacified with oral and IV contrast. Is this still a ureteral injury?
- Diagnosis must be established by antegrade pyelography
  - Confirms urine leak from distal R ureter.

Ureteral injury during stent placement

- 42 yr F with leukemia and GvH disease
- Severe unilateral dilated R collecting system
- Stent place to relieve obstruction and preserve renal function
- CT confirms stent to be in good position however:
- Delayed images show posterior proximal ureteral perforation
- Options:
  - Conservative – reposition stent across perf for maximal drainage vs. Perc NT with exchange for IN/EXT
  - What if conservative mx fails, what options do we have?
Management Options by Site of Injury

<table>
<thead>
<tr>
<th>Site of injury</th>
<th>Reconstruction options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper ureter</td>
<td>Ureteroureterostomy</td>
</tr>
<tr>
<td></td>
<td>Transureteroureterostomy</td>
</tr>
<tr>
<td></td>
<td>Ureterocalicostomy</td>
</tr>
<tr>
<td>Mid ureter</td>
<td>Ureteroureterostomy</td>
</tr>
<tr>
<td></td>
<td>Transureteroureterostomy</td>
</tr>
<tr>
<td></td>
<td>Ureteral reimplantation</td>
</tr>
<tr>
<td></td>
<td>and a Boari flap</td>
</tr>
<tr>
<td>Lower ureter</td>
<td>Ureteral reimplantation</td>
</tr>
<tr>
<td></td>
<td>Ureteral reimplantation</td>
</tr>
<tr>
<td></td>
<td>with a psoas hitch</td>
</tr>
<tr>
<td>Complete</td>
<td>Ileal interposition graft</td>
</tr>
<tr>
<td></td>
<td>Autotransplantation</td>
</tr>
</tbody>
</table>

EAU Guidelines on Ureteral Injuries 2014

Endourologic Management of Iatrogenic ureteral ligation

[Images of medical procedures and X-rays related to endourology and ureteral management]
Ureteroureterostomy

- **Indications:**
  - Short defects of upper and middle ureter from contusion/avulsion
  - Laparoscopic/Robotic/Open

- **Principles of repair:**
  - Mobilize widely, sparing adventia
  - Debride liberally
  - Spatulate, tension free, watertight repair over stent
  - RP drain, close peritoneum over

- **Outcomes:**
  - Very good success rate (as high as 90%, Carlton et al 1971)

- **Complications:**
  - Acute: Leak (10-24%), abscess/fistula
  - Chronic: stenosis (more rare)

---

Transureteroureterostomy

- **Mid/distal ureteral injuries:**
  - Rarely used but high success rates in adults
  - Planned/Delayed repair when psoas hitch/boari flap impossible

- **Principles of repair**
  - Establishing appropriate length to bring ureter across midline
  - End to side anastomosis, watertight, tension free, over stent

- **Outcomes**

- **Complications**
  - Same as UU
  - Difficult to perform URS through bladder
  - Risk of damage to contralateral Ureter

L → R TUU, ureter passed over the IMA to avoid fibrosis or kinking btw artery and aorta
The Psoas Hitch and Boari Flap

**Psoas Bladder Hitch**
- 95-100% success rates for lower 1/3 injuries (Ahn and Loughlin 2001)
- Complications: persistent leak, heals well with adequate drainage and time

**Boari Flap repair**
- Injuries to lower 2/3 w/ long ureteral defects
- Bladder pedicle swung cephalad and tubularized, tunneled/refluxing anastamosis
- Not commonly performed in acute setting

---

Ileal Transposition

**Indications:**
- Long segment of ureter destroyed.
- Often a "last resort" procedure esp. when PH/BF/TUU are technically not feasible

**Pre/post-operative considerations:**
- Ensure adequate renal function
  - MAG3
  - Pre op NT
  - Ante/retrograde pre op imaging
- Can be combined with PH/BF +/- mobilization of kidney to shorten ileal segment used
  - Cystogram POD14
  - Antegrade nephrostogram POD 14-28

**Outcomes:**
- Anastamotic stricture: 3%
- Fistula: 6% (Armatys 2009)

**Complications:**
- Stay tuned...
Renal Autotransplantation

- Indicated in cases with a solitary kidney, extensive ureteral destruction or complete avulsion (scabbard) not amenable to reconstruction of the ureter

- Transplanted into iliac fossa with vascular anastomosis and pyelovesicostomy

The Good, The Bad and The Ugly

RECENT CASES HERE AT HOME
The psoas hitch for left distal ureteral reimplantation (The Good)

- DH 59 yr F

- PMHx: obesity, smoker, RA, HTN, OSA, tubal ligation, R foot surgery, Malignant melanoma, Hx of perforated gastric ulcer, Cholecystectomy

- Ref 2012 to Dr. Chew for symptomatic 7mm LLP stone in context of prev stones req ESWL/URS.

- ESWL unable to fragment stone – booked for URS

- Small perf during URS but stented

DH continued

- Presents to EM afebrile but with L flank pain and malaise

- CT KUB shows L HUN, ? Distal stricture

- Relook URS reveals only tight intravesicle ureter which can pass 10 Fr ureteral catheter

- Persistent L Hydro on US and Mag scan shows only 37% function on L

- HUN thought to be secondary to distal stricture and decision is made to perform ureteric resection and psoas hitch

- Eventual HUN resolution staving off further decrease in renal function
From URS to Ileal transposition (The Bad)

- TM 63 yo M
- 10X8 mm R UPJ stone – URS perf in Vernon. Unsuccessful re-alignment in Kelowna. Transferred to VGH to re-align. Unsuccessful URS complicated by two further perforations (L4-5 and a lost segment from UPJ to iliac crest ~ 15 cm damage). NT repositioned and left in.

- Discussion with pt and fam re: options – ileal ureter > Simple Nx > autotransplant

- Initially booked for Simple Nx, then wants Auto Transplant (unable to do given length of defect). Settles on ileal transposition.

TM continued

- Ileal Transposition performed on Jan 30/15
- POD4 – unstable, exquisitely tender abdo – diffuse peritonitis – CT scan anastomotic leak at bowel reconstruction site. Urgent OR (Feb 3rd) – noted fecal spillage. Repaired anastomosis and abdo left open to VAC. Relook Feb 6th: no leak – abdo closed

- Prolonged ICU stay (ventilated, pressors, piptazo/vanco/fluc)

- Feb 11th – cystogram – no leak

- Feb 27th Cysto stent removal

- Bedlined back to Vernon early March
Proximal Ureteric stricture to Autotransplant (The Ugly)

- DC 73 yr old M
- Complex Medical Hx: COPD, CKD, TB, Anemia, UGIB, DM2, Isch CM (Bypass), Aftb, HTN, BPH, GERD, MRSA sepsis, fungemia sepsis...
- Sept 2010 – Underwent PCNL/Antegrade/ Retrograde URS for 14mm Impacted prox L stone and part of guidewire – unsuccessful removal of all components, noted 4-5 cm unpassable segment. NT left.
- Feb 2011 – successful Lap Donor Nx and Auto Transplant

DC continued

- No resolution of symptoms post stent insertion – Jan 2012 Urgent R Simple Nx for Source control. Post op Atrial clot – heparinized -> post op bleed
- Taken back to OR – 2L Hematoma evacuated from retroperitoneum and pleural cavity (unable to close) -> Chest tube.
- Minimal change clinically – ID/Nephro recommend Transplant Nx – not performed (high risk of death). NT inserted instead
- New AoCKD (Jan 2013) elected to watch with serial US, foley inserted, resolution of hydro, started on tamsulosin...
Ureteral Injuries: Conclusions

• Although relatively rare, ureteral injuries may be associated with significant morbidity

• If recognized intra-operatively and the extent of the injury is minimal, primary repair through end to end anastomosis is preferred if possible

• In the post-operative period (days to weeks), a high index of suspicion for ureteral injury must be maintained in patients who have undergone high risk procedures and re-present with non-specific symptoms. Appropriate radiological investigations will guide management decisions

• For the unfortunate few, major operations (bearing their own morbidities) may need to be performed to preserve renal units

Acknowledgements

• Dr. Chew
• Dr. Metcalfe
• Dr. Tran
Diagnosing Ureteral Injuries

- High index of suspicion must be maintained accounting for mechanism of trauma or type of surgery performed and risk factors of the patient

- Ureteric injuries can be identified during primary laparotomy for external penetrating trauma if sufficiently examined during surgical survey

- Diagnosis is often delayed in laparoscopic high risk procedures and missed at time of surgery.