I. Pathophysiology of acute/chronic urinary tract obstruction

II. Management of various causes of obstruction compared to nephrostomy drainage

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Advanced Urology Course, MUA Building
Physiology: Urine Flow

• Normal urine flow due to 3 factors:
  – Pressure gradient from glomerulus to Bowman capsule
  – Peristalsis of renal pelvis and ureters
  – Effects of gravity

• Peristalsis
  – Coordinated renal pelvic and ureteric contraction
  – Primary drive: renal pelvic urine volume and pyeloureteric pacemaker (Cajal-like cells)

Mundy A, et al. The Scientific Basis of Urology, 2010
Pathophysiology – Acute Obstruction

• Urinary tract obstruction
  – ‘Stretch’ stimulus increases basal/active tension all along ureter
  – Increase spontaneous frequency of firing in pelvic segment
  – Sepsis dampens contractility

  Mundy A, et al. The Scientific Basis of Urology, 2010

• Increase in intraluminal pressure causes
  – Smooth muscle cells to increase contraction
  – Ureteral wall pressure rises
  – With time, smooth muscle contraction less forceful
  – Ureteral dilation increases

Pathophysiology of Urinary Tract Obstruction

• Determinants of outcome of urinary tract obstruction
  – Extent and severity of obstruction
  – Unilateral or bilateral
  – Persistence or relieved obstruction

\[ \text{GFR} = K_f \left( \text{PGC} - \text{PT} - \pi \text{GC} \right) \]

• Glomerular filtration rate (GFR)
• \( K_f \) (ultrafiltration coefficient)
  – Surface area, and permeability of capillary membrane
• PGC (glomerular capillary pressure)
  – Renal plasma flow and resistance of arterioles
  – Renal plasma flow depends on aortic pressure, renal venous pressure and vascular resistance
• PT (hydraulic pressure of tubules)
• GC (oncotic pressure)
  – Plasma proteins
# Renal Pelvic Pressure and Renal Blood Flow: Unilateral Ureteric Obstruction

### STAGES (timeline: after obstruction)

<table>
<thead>
<tr>
<th>STAGE</th>
<th>Timeline</th>
<th>Effects</th>
</tr>
</thead>
</table>
| ONE     | (GFR ~80% normal) | - Reduced GFR countered by a rise in RBF  
- Hyperaemic state  
- PGE2 and NO contribute to vasodilatation |
| TWO     | (GFR ~20% normal) | - PT and RBF decline in next 12-24 hours  
- Raised afferent arteriolar resistance  
- Shifts in blood flow from periphery to core kidney, glomeruli underperfused |
| THREE   | - 5 hours later | - Further drop in GFR due to reduced RBF  
- GFR sustained due to adaptive dilatation  
- Mediators of vasoconstriction include Thromboxane A2 (TXA2), Endothelin |

- Increased renal blood flow (1-2hrs)  
- Raised intratubular pressure (PT) and pressure in collecting system (PC)

- Lasting 3-4 hours  
- Sustained rise in PT and PC  
- Reduced renal blood flow (RBF)
Pathophysiology – Acute Obstruction
Acute Obstruction: Changes in Glomerular Arteriolar Tone

**Figure 2** Changes in glomerular arteriolar tone in UUO. Early after complete UUO, vasodilatory mediators such as nitric oxide and prostaglandin E2 cause afferent arteriolar dilatation which acts to maintain renal blood and glomerular ultrafiltration coefficient in spite of rises in intratubular hydrostatic pressure. As obstruction proceeds and an inflammatory response is established, increased release of vasoconstrictory substances (e.g., thromboxane A2 and endothelin-1) lead to constriction of both afferent and efferent arterioles, leading to reduced renal blood flow and a decrease in GFR.
**Bilateral Ureteric Obstruction/Solitary Kidney**

- **Early**
  - Modest rise in RBF (~90 min)
  - Nitric Oxide helps maintain renal haemodynamics

- **Late**
  - Prolonged and profound reduction in RBF
    - Mediators: Endothelin, TXA2, Angiotensin II
  - Renal nerve stimulation (vasoconstriction) due to reno-renal reflex, reduces RBF
  - Blood flow shifted from inner to outer part of kidney
  - Sustained rise in ureteral pressure (≥ 24 hrs)
    - Substance that contribute to preglomerular vasodilatation and postglomerular vasoconstriction (eg. ANP) IS NOT eliminated by a normal kidney
  - Raised in intravascular volume
    - Reduced sensitivity of tubulo-glomerular feedback (ANP)
Acute Obstruction: Uni- or Bi-lateral/(Single) Kidney

Figure 40-2. Summary of the functional changes during and following ureteral obstruction. Symbols and abbreviations indicate ↑, increases and decreases; ~, little change; angII, angiotensin II; ANP, atrial natriuretic peptide; AQP, aquaporin; ECV, extracellular volume; ET, endothelin; FE, fractional excretion; NO, nitric oxide; PGC, glomerular capillary hydraulic pressure; Ppr, proximal tubular hydraulic pressure; PGE2, prostaglandin E2; Rae, afferent arteriolar resistance; Ref, efferent arteriolar resistance; RBF, renal blood flow; TG feedback, tubuloglomerular feedback; TXA2, thromboxane A2.
Acute Obstruction: Other Pathophysiological Effects

- Egress of urine from kidney
- Electrolytes handling
- Urine concentrating ability
- Tubular cell death via apoptosis
- Fibrosis
Acute Obstruction: Urine Egress

- Egress of urine from kidney
  - Into calyceal fornix (pyelosinus) : acute obstruction
  - Into venous system (pyelovenous) : chronic
  - Into lymphatics (pyelolymphatics) : obstruction
Acute Obstruction: Electrolytes Handling

• Control of extracellular volume
  – Counter transport of Na+/K+ at basolateral membrane of tubular cells in nephrons
  – Catalysed by Na-K-ATPase

• In obstruction
  – Hypoxia (renal underperfusion) limits active transport
  – Reduced expression of apical Na+ antiporters and catalytic units at basolateral membrane (Na-K-ATPase)
  – Reduced GFR reduces K+ excretion
  – Slight reduction Na+ transporter esp. contralateral kidney
  – Renin-Angiotensin-Aldosterone system effects seem ‘blunted’ for ‘salt and water retention’
Acute Obstruction: Urine Concentrating Ability

• Distal Tubular Acidification
  – Depends on apical sodium coupled antiport esp. at distal tubule (Na+/H+ ports cause urine acidification
  – In obstruction, expression of antiports reduced, and sodium absorptive capability reduced

• Baroreceptors/Osmoreceptors
  – In obstruction, receptor cell function impaired
  – Failure to reabsorb urea from filtrate
    • Type A & B urea transporters down-regulated
    • Collapse in cortico-medullary gradient
Pathophysiology: Chronic Obstruction

• Tubular Cell Death
  – Cell death is via apoptosis
  – Mediated by cysteiny1 aspartate-specific proteinases (caspases, esp. 3 and 8)
  – Two apoptotic pathways
    • Intrinsic: via TNF-α
    • Extrinsic: via mitochondrial release of pro-apoptotic proteins eg. cytochrome c

• Fibrosis
  – Obstruction increases synthesis of Tissue Inhibitor MetalloProteinases (TIMPs) which reduce MMP activity
  – This causes increased production of extra-cellular matrix
  – Process mediated by TGF-β, angiotensin II, NFκβ, TNF-α
Figure 40-3. Summary of major pathways leading to tubulointerstitial fibrosis and tubular apoptosis as a consequence of ureteral obstruction. Membrane proteins and regulators are discussed in the text. ang II, angiotensin II; HGF, human growth factor; HSPs, heat shock proteins; IGF, insulin-like growth factor; JAK/STAT, Janus kinase/signal transducers and activators of transcription; mØ, macrophages; MAP, mitogen-activated protein; NF-κB, nuclear factor κB; TGF, transforming growth factor; TNF, tumor necrosis factor; TNFR1, tumor necrosis factor receptor 1.
Urinary Tract Obstruction
Management

• **Choice of drainage**
  – Site of obstruction (lower or upper urinary tract)
    • Indwelling ureteral stents vs percutaneous nephrostomy (upper urinary tract)
    • Urethral/Suprapubic catheter vs (bilateral) percutaneous nephrostomy (lower urinary tract)
  – Aetiology of obstruction
  – Laterality (uni- or bi-lateral)

• **Immediate renal drainage for obstruction required if:**
  – Symptomatic
  – +/- fever complicated by infection
  – Bilaterality
  – Risk of renal failure
## Ureteral obstruction: Indwelling ureteral stent

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
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</thead>
<tbody>
<tr>
<td>- Obviate need for external collection device</td>
<td>- Stent morbidities</td>
</tr>
<tr>
<td>- Suitable for coagulopathic or thrombocytopenic patient</td>
<td>- Greater exposure to radiation</td>
</tr>
<tr>
<td></td>
<td>- Not so effective for extrinsic ureteral obstruction (eg. malignancy)</td>
</tr>
<tr>
<td></td>
<td>- Stent failure</td>
</tr>
</tbody>
</table>
Problems with Stenting

<table>
<thead>
<tr>
<th>Stent Morbidity</th>
<th>Stent Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection of symptoms and signs attributed to the presence of ureteric stent</td>
<td>Non-functioning ureteral stent due to:</td>
</tr>
<tr>
<td>1. Irritative bladder symptoms +/- haematuria</td>
<td>- Malignant external compression</td>
</tr>
<tr>
<td>2. Stent fracture</td>
<td>- metastatic cancer requiring chemotherapy or radiation</td>
</tr>
<tr>
<td>3. Stent encrustations</td>
<td>- renal insufficiency</td>
</tr>
<tr>
<td>4. Stent migration</td>
<td>- encrustations</td>
</tr>
<tr>
<td>5. Forgotten stent</td>
<td>- pregnancy</td>
</tr>
<tr>
<td></td>
<td>- urinary tract infection</td>
</tr>
<tr>
<td></td>
<td>- urine stasis</td>
</tr>
<tr>
<td></td>
<td>- dehydration</td>
</tr>
<tr>
<td></td>
<td>- prolonged dwell time</td>
</tr>
</tbody>
</table>
## Ureteral Obstruction: Percutaneous nephrostomy

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Can be done under ultrasound guidance, hence suitable for pregnancy</td>
<td>- Requires external collection device</td>
</tr>
<tr>
<td>- pyonephrosis</td>
<td>- Risk of nephrostomy tube dislodgement</td>
</tr>
<tr>
<td>- can estimate differential renal function</td>
<td></td>
</tr>
<tr>
<td>- bailout for failed stenting</td>
<td></td>
</tr>
<tr>
<td>- adjunct to ureteric stent</td>
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</tbody>
</table>
In ureteral obstruction, which is the choice for urinary diversion?
Ureteral Obstruction

• Optimal method of urgent decompression of the collecting system for obstruction and infection due to ureteral calculi. 

• N = 42 patients, randomised to percutaneous nephrostomy (PCN) and antegrade ureteric stenting (AUS)

• Outcomes:
  – In obstructive ureteral calculi, both PCN and AUS are effective
  – No difference in resolution of fever or normalisation of WBC
  – PCN has slightly prolonged hospital stay, but not statistically significant
• N = 135 patients, retrospective. Ureteral obstruction with sepsis.

• Outcomes:
  – Both PCN and ureteric stenting are equally effective.
  – PCN : likely in larger stones and more critically ill.
  – Stone location does not influence choice of intervention.
Ureteric stents vs percutaneous nephrostomy for initial urinary drainage in children with obstructive anuria and acute renal failure due to ureteric calculi: a prospective, randomised study


N = 90 stable children, age ≤ 12 years

Conclusion

We recommend the use of JJ stents for initial urinary drainage for stones that will be subsequently treated with chemolytic dissolution or ESWL, as this will lower the total number of subsequent interventions needed to clear the stones. This is also true for stones destined for ureteroscopy (URS), as JJ-stent insertion will facilitate subsequent URS due to previous ureteric stenting. Mild hydronephrosis will prolong the operative time for PCN-tube insertion and may increase the incidence of insertion failure. We recommend the use of PCN tube if the stone size is >2 cm, as there was a greater risk of possible iatrogenic ureteric injury during stenting with these larger ureteric stones in addition to prolongation of operative time with an increased incidence of failure.
• Obstructive uropathy in advanced cancer indicates poor prognosis – median survival 120-140 days
• No clear evidence urinary diversion improves quality of life but validated prognostic tool show longer survival in good-risk patients.
• Percutaneous nephrostomies and ureteric stents should be first method of diversion.
• Compression-resistant metallic stents promising for long-term drainage but costly and UTI causes blockade:
  – Expandable : Memokath
  – Non-expandable : Resonance
• Parallel stenting has a better short-term outcome than exchange stent (72% v 100% will block in 3 months)
• If stents fail, supravesical diversions can be attempted, selectively.
What are the effects of ureteral stenting on stone transit and ureteric motility?

• JJ stents:
  – Cause ureteric dilatation
  – Reduce peristalsis
  – Impaired stone passage

• Antegrade percutaneous nephrostomy:
  – Preserves peristalsis
  – Facilitates stone passage

Questionnaire to Radiologists and Endourologists
- Low response rate 19.3%
- Disagreement in malignant obstruction. 50% urologists thought of decompression
- Urologists prefer PCN and more likely to stent in benign, uncomplicated conditions
- Differing opinion: intrinsic (ability) and extrinsic factors (on-call interventionalist)

Treatment Outcomes for Infected Upper Urinary Tract Stones in the United States.
Sammon JD, et al. European Urology, Volume 64, Issue 1, July 2013, Pages 85-92
- Between 1999 and 2009, increasing infected uroliths
- Women 2x more likely
- In emergent decompression, trend of performing less PCN observed. Reasons:
  - Associated with sepsis and severe sepsis
  - Higher mortality
  - Longer hospital stay
  - Higher hospitalisation charges
Physiology of a Ureteric Stent

• Flow of urine
  – Through peri-stent > central hollow lumen

• Passive dilatation
  – Facilitates passage of debris
  – Primes the ureter for future instrumentation procedures

• Peristalsis
  – Initially increased with stent in situ
  – With time, frequency and amplitude decrease

An Ideal Ureteric Stent

- Ease of insertion
- Ease of removal
- Inert and biocompatible
- Resistant to encrustation
- Resistant to migration
- Highly radio-opaque
- Affordable
- Biodurable
- Optimal flow characteristics
Ureteric Stent: Components

- Markers
- Proximal end, curled
- Multi Holes
- Distal end with string attached
- Wire guide
- Stent pusher
Anatomy of a Ureteric Stent (I)

- Structure: cylindrical tube + multiple side holes
- Mechanism to limit stent movement
  - Double pigtail
    - Double-J
    - Dual durometer (softer distal curl, rigid proximal curl),
    - Tail shape changes (loop tail, eg. Polaris™)

- Length correlates to a patient’s height:
  - 5 to 12 inches (12 – 30 cm) but average adult 24 or 26cm
  - Xyphoid process to pubis distance (X – P) or shoulder acromion process to wrist head of ulnar (S – W)
  - Children: stent length = age (years) + 10

Yachia D. Curr Opin Urol 2008
Anatomy of a Ureteric Stent (II)

• Diameter 0.06 to 0.2 inches (1.5 – 6 mm or 4 to 7 Fr)
  *Fr = 1/3 diameter (mm)

• STRING attached
  – Distal stent; for self removal
  – String versus no string = no difference in Quality of Life
Ureteric Stent Characteristics: Material

- **Silicone-based**: inert (best biocompatibility), flexible, elastic, tolerable but collapsible, with low tensile strength
- **Polyethylene**: unstable in urinary environment, early stent fracture
- Polyurethane (pure): rigid, corrosive, lithogenic
- **Composite** material eg. Percuflex material (Boston Sc):
  - Olephinic block co-polymer, softens and become flexible at room Temp
  - Soft and smooth surface but collapsible
  - But encrustation similar to conventional stent

Metallic Ureteral Stent

- **Features and Function**
  - Increased radial force to maintain ureteral patency
  - Better than standard stents to resist external compression
  - Fewer stent changes required – MAIN ADVANTAGE, less morbidity
  - Primary patency rate 17-30% to 50% in 1 year
  - The use in benign ureteral stricture – undefined

- **Types**
  - Self-expanding and Balloon expandable
    - Short stents, not meant for change/removal; now defunct
  - Covered (Resonance)
    - Non-expandable, non-magnetic nickel-cobalt-chromium-molybdenum
    - Lumenless, solid spiral design
    - Overall obstruction rate 37%
  - Thermo-expandable (Memokath 051)
    - Nickel-titanium material, success rate 87%
    - Conformational change with temperature, uncoiled with cold saline (< 10°C) instillation
    - Less pain and urinary symptoms, stent migration rate 45%

Ureteric Stent Characteristics: Coating

- Coating
  - Prevents encrustation, biofilm formation, improves patient discomfort/tolerance
  
  - **Hydrogel**: hydrophilic polymer traps water, reducing friction coefficient, reducing encrustations and improving bio-compatibility
  
  - **Heparin**: a form of glycosaminoglycan, high negative charge density, prevents crystallisation
  
  - Others: hyaluronic acid, silver-nitrate, ofloxacin

Ureteric Stent Characteristics: Future

• Future stents
  – Drug-eluting stents
    • Putative benefits: drugs prevent encrustation, bacterial colonisation, biofilm formation
    • Triclosan®: anti-inflammatory agent, potent antibacterial. Can reduce bacterial colonisation on stent but not stone encrustation.


– Biodegradable polymer stents
  • Temporary ureteral drainage stents (TUDS), Boston Sc
  • Proprietary polymeric material
  • Phase I study – safe; Phase II – effective drainage, patient satisfaction

Nephrostomy Tube

• Utility
  – Ureteral stent unable to provide adequate upper tract drainage
  – Better urine flow than internal stents
  – Overcome stent deficiencies such as:
    • Low- and high-pressure vesicoureteric reflux
    • May not drain with external compression
    • Elevated intrapelvic pressure
    • Reduced/absent ureteric peristalsis
    • Collagen deposition and muscular hypertrophy in ureter
Nephrostomy Tube: Design

• Types
  – Councill catheters
  – Modified Foley
  – Pezzer and Malecot
    • Larger bore
  – Re-entry
    • Permit nephrostomy drainage
    • Allows access to ureter
  – Smith and Hulbert percutaneous endopyelotomy
    • Variable diameter, tapering end (into pigtail)
Nephrostomy Tube Use: Indications

• Short-term
  – Failed retrograde ureteric stenting
  – High-grade bilateral ureteric obstruction/single kidney
  – Urinary tract sepsis with obstruction

• Long-term
  – Palliative care in malignant extensive obstruction
Nephrostomy Tube: Complications

• Overall, complication rate is 8.8 – 10%
• Access Procedure-related
  – Haematuria
    • Need for blood transfusion (3.2%)
  – Clot colic
  – Pulmonary injuries
  – Adjacent organ injury

• Tube-related
  – Sepsis (1.3 to 2.2%)
  – Arteriovenous fistula
Guide wires-Principles

• Radio-opaque adjunct to provide access to a particular area of the urinary tract and also as a guide/track to pass catheters, stents and sheaths.

• The property varies with respect to length, diameter, composition, tip flexibility, surface coating and shaft rigidity.

• Ideal guide wire requires little force to flex in response to resistance encountered in its path, while requiring a large force to perforate through tissue.

Holden T, Pedro RN, Monga M. Indian J Urol 2008
Guide Wire Size: Length and Diameter

- Size refers to diameter measured in inches
- The diameters and lengths range from 0.018 to 0.038 inch and 145 to 280cm respectively.
- Most common size are 0.035 inches or 2.7 Ch and 0.038 inches or 2.9 Ch.
- Smaller wires for paediatric age group eg size 0.025 inch and 70cm length
Guide Wire Tip: Design

- Straight or angled, maybe coated with hydrophilic polymer
- Straight is usually adequate for most cases
- An angled tip is useful for negotiating an impacted stone or for placing the guide wire in specific situations.
- A J-shaped tip can negotiate an impacted stone (it can suddenly flick past the stone, in a situation where a straight guide wire may inadvertently perforate the ureter and thus create a false passage).
Guide Wire Tip: Rigidity

- The tip of all guide wires are soft and therefore flexible, which reduces but does not completely eliminate the risk of ureteric perforation.
- Length of the floppy tip may vary, e.g., 8 cm instead of 3 cm tip.
Guide Wire: Surface Coating

• Most guide wires are coated with PTFE – polytetrafluoroethylene
  – low coefficient of friction
  – easy passage of the guidewire through the ureter and of instruments over them

• Some coated with polymer are very slippery when wet. Some are coated just at the tip, whilst others are coated along the entire length.
• Stiff guide wires are easier to manipulate than floppy ones and help to straighten a tortuous ureter.

• Very malleable wires can be very useful in bypassing an impacted stone just like the J-tipped wires.
Guide Wire: Composition

• Basic composition consists of an inner core that determines shaft rigidity and an outer covering responsible for low resistance passage through the ureter.

• The outer surface, designed to reduce friction during passage is typically coated with either PTFE-jacketed tightly coiled stainless steel spring or a hydrophilic polymer.
# Flexible Guide Wires

<table>
<thead>
<tr>
<th>Guide Wire Type</th>
<th>Characteristics</th>
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</table>
| BENTSON (Boston Sc) | • PTFE-coated, stainless steel wire  
|                  | • Floppy-tipped                                      |
| ROAD RUNNER (Cook) | • Hyrophilic polymer coating  
|                  | • Nitinol core                                       |
|                  | • Platinum-tipped                                    |
| TERUMO           | • Hydrophilic coating                                |
|                  | • Nitinol-alloy core                                 |
|                  | • Polyurethane jacket with Tungsten                  |
| Amplatz Stiff/Superstiff (Boston Sc) | • PTFE coating  
|                  | • stainless-steel core                               |
|                  | • gradual core taper                                 |
|                  | • tip of flat wire construction + spring coil        |
Conventional Guide Wires: Bentson, Road Runner, Amplatz

Bentson Wire

Road Runner

Amplatz Superstiff
Terumo Glide Technology™
hydrophilic coating
- Unmatched lubricity consistently gets you where you need to go

Core-to-tip design
- Provides optimal torque control for superior navigation

Polyurethane jacket with tungsten
- Provides enhanced radiopacity of entire Terumo Glidewire

Terumo nitinol alloy core
- Resists kinking for easier, faster navigation through even the most tortuous vessels
- Restores shape to manufactured state for multiple use in single procedure
General features: Flexible Wires

- Flexible guide wires
  - permit passage through tortuous ureter
  - permit passage through impacted ureteral calculi
  - have insufficient stiffness for passage of catheters and stents (may slip out)
  - have Nitinol core allows maximal deflection without kinking
  - have Platinum tip allows high visualisation
  - have hydrophilic coating that attracts and holds water to allow low-friction surface
Comparison of guide wires in urology. Which, When and Why?


- Among guide wires used for access:
  - PTFE wire (Roadrunner, Cook) with 15cm flexible tip requires least amount of force to deflect the tip

- Among 3cm flexible tip wire, Bentson guide wire (Boston Sc) had the most flexible tip. PTFE-coated Bard wire had the stiffest flexible tip.

- Boston Scientific Glidewire requires least among of force to pull from a tortuous pathway, and this wire required the greatest force to puncture (aluminium foil). Amplatz super stiff best for passing instruments.
General Features: Stiff Wire

• Extra stiff wires (eg Amplatz stiff, Super stiff, extra stiff; Boston Sc) with a stainless steel core add increased shaft rigidity (resistance to kinking) and are commonly used for passage of ureteral access sheaths, catheters and coaxial or balloon ureteral dilators.

• Gradual core taper creates an atraumatic distal segment for safe advancement.
New Generation Guide Wires

• Hybrid wires (eg Sensor wire by Boston Scientific) has three features:
  – Smooth hydrophilic distal tip
  – Kink-resistant body (nitinol core with PTFE coating)
  – Flexible proximal tip for back-loading of wire through the working channel of ureteroscope


• Hybrid wire is not as stiff as Amplatz wire to provide wire for ureteral access sheaths and large stents

Systematic evaluation of hybrid guidewires: shaft stiffness, lubricity, and tip configuration


- Hybrid guide wires U-nite (Bard) and Sensor (Boston Sc) compared with Amplatz Superstiff (Boston Sc) for stiffness
  - Amplatz stiffest wire, suitable for placement of ureteral access sheath or larger stents
- Hybrid wires compared with 2 hydrophilic wires: NiCore (Bard) and RadiFocus (Boston Sc) for hydrophilic tip
  - Boston Sc wire tips less stiff than Bard, requiring 48% less force to bend when encountering resistance.
  - U-nite highest lubricity.
  - RadiFocus required the greatest puncture force.
Guide Wire: Complications

- Ureteral puncture during manipulation
- Kinking of guide wire
- Peeling off the sheath of the guide wire, which when left behind can be a nidus for further stone formation
- Dislodged guide wire during manipulation especially in extra-hydrophillic wires
- Fractured guide wires
Bladder outlet obstruction

• Emergent
  – Urethral catheterisation
  – If failed, suprapubic drainage

• Elective
  – Urethral stent
  – Prostatic stent
Urethral Catheter: Material and Coating

• Material
  – Rubber and Latex: for short-term
  – Silicone: latex-allergy, long-term in-dwelling, better tolerated by urethral mucosa, less encrustation, larger diameters

• Coating
  – Reduce urethral trauma and infection risks
  – Hydrophilic coat: less discomfort, less UTI rates and lower risk of urethral stricture
  – Antiseptic coat: not enough evidence for its usefulness to prevent infection
  – Viable bacterial coat: rationale is for nonpathogenic bacteria overpowering pathogenic ones.
Urethral Catheter: Size

- Size
  - French (F) or Charriere (Ch) gauge. 1F = 1 Ch = 1/3 mm
  - Factors in choosing size:
    - Indication, Age, and Type of Fluid drained

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Catheter Size (Fr)</th>
</tr>
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<tbody>
<tr>
<td>&lt; 5</td>
<td>5-8</td>
</tr>
<tr>
<td>5-10</td>
<td>8-10</td>
</tr>
<tr>
<td>10-14</td>
<td>10</td>
</tr>
<tr>
<td>&gt;14</td>
<td>10-14</td>
</tr>
</tbody>
</table>
Urethral Catheter: Configuration (I)

• **Types/Configuration**
  
  – **Non-self retaining straight (Robinson)**
    - Straight rubber tube with rounded tip and drainage ports along the side
    - Short-term use, for intermittent self-catheterisation
    - If left in-dwelling, must be secured to glans penis
  
  – **Straight Self-retaining (Foley catheter, 2-way catheter)**
    - Inflation channel (capacity of inflated balloon as stated, inflating medium - water for irrigation)
    - Drainage channel
  
  – **3-way catheter**
    - Additional bi-directional channel for bladder instillation and drainage
    - Useful for?? BOO associated with solid or potentially solid particles forming
Urethral Catheter: Configuration (II)

– Coude’ catheter (curved at the tip, “elbow”)
  • To pass through strictured or hypertrophied bladder neck, avoid false passage
  • Stiffer than Robinson catheter
  • With/without retention balloon

– Councill catheter
  • To bypass urethral stricture or false passage
  • Similar to Foley but has an opening at the end to allow use with screw-tip stylet that can be attached to a filliform
  • It does not dilate a stricture
Types of Urethral Catheter

**Figure 7-1.** Three-way, two-way, and single-lumen catheters.

**Figure 7-2.** From top to bottom: coudé tip, two-way Foley, three-way Foley, and Nelaton.
# Urethral Catheter: Types and Uses

## Features of Ureteral Catheters

<table>
<thead>
<tr>
<th>FORM OF TIP</th>
<th>SIDE HOLE</th>
<th>RETAINING MECHANISM</th>
<th>NAME</th>
<th>USES (ADVANTAGES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight</td>
<td>Single or multiple</td>
<td>None</td>
<td>Robinson</td>
<td>One-time drainage, instillation or irrigation in children, females, and most males</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nelaton</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Jaques</td>
<td></td>
</tr>
<tr>
<td>Balloon</td>
<td></td>
<td></td>
<td>Foley</td>
<td>Continuous drainage or irrigation in children, females, and most males</td>
</tr>
<tr>
<td>Balloon/retention plug</td>
<td></td>
<td></td>
<td>Madduri</td>
<td>Used for urethrography, allows proximal and distal occlusion and contrast instillation in the intermediate section</td>
</tr>
<tr>
<td>2 or 4 wings</td>
<td></td>
<td></td>
<td>Malecot</td>
<td>Continuous drainage or irrigation in children, females, and most males (less prone to retaining mechanism failure and increased lumen diameter because no channel is necessary for device activation)</td>
</tr>
<tr>
<td>Umbrella</td>
<td></td>
<td></td>
<td>Pezzer</td>
<td>Continuous drainage or irrigation in children, females, and most males (less prone to retaining mechanism failure and increased lumen diameter because no channel is necessary for device activation)</td>
</tr>
<tr>
<td>Curved</td>
<td>Balloon</td>
<td></td>
<td>Coudé</td>
<td>Continuous drainage or irrigation (ease of insertion males with enlarged prostate midlobe or high bladder neck)</td>
</tr>
<tr>
<td>End hole</td>
<td></td>
<td></td>
<td>Council</td>
<td>Continuous drainage or irrigation in children, females, and most males (end hole permits insertion or exchange over a previously placed guidewire)</td>
</tr>
<tr>
<td>Whistle tip</td>
<td></td>
<td></td>
<td></td>
<td>Has a large diameter end hole occupying half of its beveled tip, for increased drainage/instillation capacity</td>
</tr>
</tbody>
</table>
Types of indwelling urethral catheters for short-term catheterisation in hospitalised adults.


- Objectives: compare effectiveness of different indwelling urethral catheters in reducing UTI (CA-UTI) and impact assessment

- Findings:
  - 26 trials ~12,400 patients
  - Silver alloy-coated catheters not associated with statistically significant reduction in CAUTI, but more expensive.
  - Nitrofurazone-impregnated catheters reduced risk of symptomatic CAUTI and bacteriuria, but magnitude low.
  - More expensive, more discomfort
  - Silicon is more superior than latex-based in terms of urethral reactions.
• Objectives: To determine which type of indwelling urinary catheter is best to use for long-term bladder drainage in adults.

• Findings:
  – Long term defined as > 30 days
  – 3 trials ~102 patients
  – One trial did suggest hydrogel-coated latex catheter rather than silicone, may be better tolerated
  – All trials were small to reach practical conclusions
Suprapubic Catheterisation (I) in Bladder Outlet Obstruction

• **Indications**
  – Urethral access not possible
  – Urethral access contraindicated (‘blood per meatus’, multiple attempts at catheterisation)

• **Techniques**
  – Percutaneous
    • Trochar method: blind puncture into urinary bladder
    • Seldinger method: wire-guided entry
  – Open
    • Contraindication for percutaneous technique: uncorrected coagulopathy, previous lower abdominal surgery, or pelvic irradiation
  – Adjunct
    • Transabdominal Ultrasound
    • Cystoscopy manoeuvre: displacement of bladder dome
Suprapubic Catheterisation (II)

• Equipments

<table>
<thead>
<tr>
<th>Percutaneous Access</th>
<th>Open Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sharp stylet/trochar</td>
<td>• Scalpel</td>
</tr>
<tr>
<td>• Catheter with peel-away sheath OR</td>
<td>• Entry into anterior rectus sheath</td>
</tr>
<tr>
<td>• 18G hollow needle with syringe</td>
<td>• Space of Retzius developed</td>
</tr>
<tr>
<td>• Guidewire</td>
<td>• Stay sutures (Silk 1/0, a pair)</td>
</tr>
<tr>
<td>• Coaxial dilator</td>
<td>• Electrocautery (all layers of bladder)</td>
</tr>
<tr>
<td>• Councilll catheter (16- to 18-Fr)</td>
<td>• Catheter</td>
</tr>
<tr>
<td></td>
<td>• Anchoring sutures and device</td>
</tr>
</tbody>
</table>
Suprapubic Catheterisation (III)

- Complications
  - Initial
    - Haematuria
    - Perivesical fluid collection
    - Surrounding organ injury
  - Long-term
    - Blockage
    - Encrustation
    - Dislodgement
    - Skin site infection
    - Symptomatic UTI
    - Urethral neoplasm
    - Stone formation
In-dwelling foreign body in urinary tract: Biofilm

- Catheter-associated bacteriuria usually asymptomatic.
- Catheterised patient more likely to receive antibiotics, spend more time in hospital, and 3 times more likely to die.
- About 80% nosocomial UTI due to preceding urologic instrumentation
- About 50% with long-term indwelling catheter will experience complications of bacterial biofilms.

- Pathogenesis
  - As contaminated urine passes through catheter lumen, cells attach to surface and bathed with warm flowing nutrients
  - Pathogen: urease-producing (Proteus mirabilis, Providencia, Morganella). Pathogens coat the surface of catheter like a film.
  - Nature of biofilm: mucoid or crystalline

Why are catheterised patients vulnerable to biofilm formation?

• Violation of defence system
  – Disruption of regular **filling and emptying** of bladder
  – Tip of catheter and balloon **erode** mucosal lining
  – **Pressure** exerted by catheter disrupts blood flow to urethral surface and block **periurethral gland**.
  – Disruption of hydrophilic **mucin** layer secreted from urothelial cells

Biofilm Formation

• Uropathogens adhere to conditioning biofilm (proteins, electrolytes, and other organic molecules) on a prosthesis within minutes of placement
• Substance adhere and alter surface of biomaterial, providing receptor sites for bacterial adherence

• Irreversible attachment via bacterial polysaccharides
• Colonisation by slow migration, spreading, packing, rolling and adhesion of pathogens

• Established biofilm (groups of microbes surrounded by interstitial space fluid)
• Bacteria immobilisation and embedded

Biofilms and Antimicrobials

• Three layers of biofilms
  – Linking film that attaches to the surface of a tissue or biomaterial
  – A base film of compact microbes
  – A surface film on outer side of which planktonic organisms arise and spread

• Protection of biofilm cells (communities) from adverse environmental exposition
  – Confers resistance to antibiotics and antiseptics
  – Only prosthesis removal can cure an established device-related infection

Pathophysiology of Biofilm-Encrustation

- **Surface attachment** of Proteus via hair-like surface projections
- **Irregular luminal surface of catheter** (manufacturing defects) with embedded diatom skeletons are attractive for Proteus attachment (especially at the catheter eyelets)
- Bacterial **colonisation**, ammonia formed, urine **pH rises** inducing **crystallisation** of magnesium and calcium salts
- **Crystalline** material deposited (struvite and apatite)
- Crystals and biofilm **block** catheters, compounded by narrowed central channel of catheter.
- Change of catheter – on deflation of balloon crystalline debris shed, microcrystals of apatite form a foundation layer on surface of new catheter followed by colonisation

Conclusions

- In managing urinary tract obstruction, patho-physiological effects depend on how much renal reserve is available, causative factor and duration of obstruction.

- In relieving obstruction, treatment is influenced by the urgency, location and aetiology.

- The most effective, least traumatic and most durable method should be selected to unobstruct the patient.

- When managing obstruction, the patient is put at risk of biofilm formation on the indwelling device in the urinary tract which can lead to urinary tract infection.
THANK YOU