FLUORO PROTOCOL

Kamal Singh
Record fluoro beam time in chart
Record which fluoro room utilized
Needed for sentinel event
  • Sentinel event is dose > 1500 rad to field
Fluoro components
General tips on Fluoro dose reduction

- Typical entrance skin exposure rate of 2R/min (max ESE 10R/min regulated by FDA) vs boost-mode* (up to 20R/min allowed by FDA)
- Fluoro mode (allows LIH which can be stored) vs spot image mode
- Time/distance
- Wear lead apron which reduces exposure by 80% (2 piece has less strain on shoulders): 0.5mm lead attenuates 90% of scattered radiation
- Wear dosimeter (outside apron on collar)—may wear ring badge
- Collimate image
- Use LIH (last image hold)
- Keep II close to patient (reduce OID) and reduce air gap
- For c-arm, keep x-ray tube (aka primary beam) away from you, under the table, and as far away from patient as possible with greatest source to patient distance. Keep detector or II close to patient as possible.
- Change projections to avoid high cumulative local skin dose (1.5-4x higher dose)
- Avoid overuse to magnification or high fluoro rate (use intermittent pulsed fluoro instead of continuous fluoro)
  - Pulse mode Frame rate of 3.7/s, 7.5/s, 15/s, 30/s (cath lab uses 15/s)—reducing frame rate from 30/s to 15/s reduces dose by 25%
- Avoid cine mode (10-20x higher doses)
- Keep beam-on time to minimum
- Keep hands out of primary beam (also avoid lead or high density material in beam path which results in ABS)
- Use ceiling mounted lead shield, mobile floor shield, lateral shield, and table curtain as suitable
- Use 5min exposure time audible alarm
- Vary entrance site of radiation by changing angles if prolonged exposure is anticipated
- To better see catheter tip consider low kVp and high mAs
Fluoro dose reduction for kids

“Lower-dose intermittent pulsed fluoroscopy with last image hold”

- Pulsed fluoro (instead of continuous)
- Decrease pulse rate (≤5/s) and pulse width (<33ms)
- Decrease voltage (kVp)
- Remove anti-scatter grid for pts <50lbs (i.e. ≤5yo)
- Collimate well
- Avoid magnification (use largest FOV)
- Bring II closer to patient (decrease source to skin distance SSD)
- For c-arm, keep tube under the patient (with max source to patient distance)
- Last image hold (aka fluoro save) – radiation generally 10 times lower
2Gy threshold for skin injury

<table>
<thead>
<tr>
<th>Injury</th>
<th>Threshold Dose to Skin (Sv)</th>
<th>Weeks to Onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early transient erythema</td>
<td>2</td>
<td>&lt;&lt;1</td>
</tr>
<tr>
<td>Temporary epilation</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Main erythema</td>
<td>6</td>
<td>1.5</td>
</tr>
<tr>
<td>Permanent epilation</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Dry desquamation</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Invasive fibrosis</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Dermal atrophy</td>
<td>11</td>
<td>&gt;14</td>
</tr>
<tr>
<td>Telangiectasis</td>
<td>12</td>
<td>&gt;52</td>
</tr>
<tr>
<td>Moist desquamation</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Late erythema</td>
<td>15</td>
<td>6-10</td>
</tr>
<tr>
<td>Dermal necrosis</td>
<td>18</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Secondary ulceration</td>
<td>20</td>
<td>&gt;6</td>
</tr>
</tbody>
</table>
### Characteristics of radiation injury

<table>
<thead>
<tr>
<th>Effect</th>
<th>Threshold (Gy)</th>
<th>Single-dose Onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early transient erythema</td>
<td>2</td>
<td>Hours</td>
</tr>
<tr>
<td>Main Erythema</td>
<td>6</td>
<td>~10 d</td>
</tr>
<tr>
<td>Temporary hair loss</td>
<td>3</td>
<td>~3 wk</td>
</tr>
<tr>
<td>Permanent hair loss</td>
<td>7</td>
<td>~3 wk</td>
</tr>
<tr>
<td>Dry desquamation</td>
<td>14</td>
<td>~4 wk</td>
</tr>
<tr>
<td>Moist desquamation</td>
<td>18</td>
<td>~4 wk</td>
</tr>
<tr>
<td>Secondary ulceration</td>
<td>24</td>
<td>&gt;6 wk</td>
</tr>
<tr>
<td>Late erythema</td>
<td>15</td>
<td>~6 – 10 wk</td>
</tr>
<tr>
<td>Ischemic dermal necrosis</td>
<td>18</td>
<td>&gt;10 wk</td>
</tr>
<tr>
<td>Dermal atrophy (1st phase)</td>
<td>10</td>
<td>&gt;14 wk</td>
</tr>
<tr>
<td>Dermal atrophy (2nd phase)</td>
<td>10</td>
<td>&gt;1 yr</td>
</tr>
<tr>
<td>Induration (Invasive Fibrosis)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Telangiectasia</td>
<td>10</td>
<td>&gt;1 yr</td>
</tr>
<tr>
<td>Late dermal necrosis</td>
<td>&gt;12?</td>
<td>&gt;1 yr</td>
</tr>
<tr>
<td>Skin cancer</td>
<td>not known</td>
<td>&gt;5 yr</td>
</tr>
</tbody>
</table>
Skin injury

- Threshold 2Gy
- Onset of skin rx depends upon dose
  - Prompt (<2wks)
  - Early (2-8wks)
  - Midterm (6-52wks)
  - Longterm (>40weeks)
- Transient erythema (reddening of skin) is developed as a prompt effect and epilation (loss or removal of hair) may be present as an early effect
- All effects are expected to heal in the midterm, leaving no observable effects in the long term (>40 weeks)
- Skin reactions for doses up to 10Gy are usually graded as grade 1 according to the NCI classification (grade 1-4 with 4 being the most severe)
Grade I

Grade II

Grade III (moist desquamation)

Grade IV (necrosis needs grafting)
5-10 Gy Erythema in 10 days

10-15 Gy Desquamation in 4-8 weeks

Greater than 15 Gy Moist desquamation in 4-8 weeks

Desquamation

Necrosis needing graft
1. I see $\text{Gy-cm}^2$ and $\text{mGy}$ on the monitor of my angiography machine. What do these represent?

These are two measured dosimetric quantities that can be used to estimate the radiation risks. $\text{Gy-cm}^2$ is used for estimating stochastic risk to patients while $\text{mGy}$ relates to tissue reaction. $\text{Gy-cm}^2$ is a unit historically known as dose-area product (DAP) and currently named kerma-area product (KAP). The official notation recommended in ICRU report 74 is $P_{KA}$. [ICRU, 2005] KAP represents the product of the dose (in $\text{mGy}$, $\text{cGy}$, or $\text{Gy}$) at the center of a certain plane of the X-ray beam (e.g., the surface of the patient) multiplied by the area of the X-ray field at that plane (in $\text{cm}^2$ or $\text{m}^2$). Generally, KAP is expressed as $\text{Gy-cm}^2$, $\text{cGy-cm}^2$, $\text{mGy-cm}^2$, $\mu\text{Gy-cm}^2$. The IEC has recently standardized this to $\text{Gy-cm}^2$ [IEC, 2010]. KAP provides a good index for estimating stochastic risk but is not directly useful for estimating tissue reactions. Skin injury is related to the peak skin dose (PSD). There is no currently available real-time method to measure or calculate PSD. The dose at a defined reference point can be measured ($\text{Gy}$, $\text{cGy}$, $\text{mGy}$) and used to estimate PSD. For an iso-centric interventional fluoroscope, the reference point is located 15 cm from the isocenter toward the X-ray tube [IEC, 2010]. The reference point moves with the gantry in such systems. Appropriate estimates of skin dose must account for gantry motion, patient size, and patient location relative to the gantry.

2. How is KAP (DAP) measured and how can it be used to estimate effective dose?

KAP is frequently measured using a transparent ionization chamber mounted in the X-ray tube assembly between the collimators and the patient. In most fluoroscopic machines, the KAP chamber is hidden by the tube-housing cover. Some fluoroscopy machines calculate KAP using generator and collimator settings. KAP does not depend on the distance of the measuring plane from the X-ray source because dose decreases according to the inverse square law and the area of the field increases with the square of the distance. This keeps the KAP value constant at any distance. KAP represents the total energy incident on the patient. KAP is combined with a coefficient depending on the irradiated portion of the body and protocol (irradiated organs) to estimate effective dose ($E$). The coefficients range from 0.028 to 0.29 (mSv/Gy-$\text{cm}^2$). They are derived from Monte-Carlo simulations using anthropomorphic digital phantoms. A summary of these coefficients adapted from NCRP report 160 [NCRP, 2009] is shown in the following table.
4. What are the quantities that relate radiation risk to the skin and how are they measured?

The best quantity to assess the risk to skin is peak skin dose (PSD). The X-ray tube and gantry moves and therefore irradiates different portions of the skin during most interventional procedures. PSD can be directly measured using radiochromic films or a matrix of thermoluminescent dosimeters (TLDs). Unfortunately, this data is usually available only after the procedure is completed. Metal-oxide semiconductor field-effect transistor (MOSFET) detectors provide real-time information but are difficult to place at the correct location in advance. They can also influence radiation output and/or interfere with the visibility of critical anatomy. Modern fluoroscopy machines indicate the cumulative air kerma (CAK) at the reference point during the procedure as well as gantry angles and table positions. CAK in many (but not all cases) overestimates PSD. It is clinically useful as a real-time safety indicator. Efforts are underway to combine CAK and geometry with patient size to obtain real-time maps of skin dose distributions.

5. How are the dose indices for fluoroscopy connected to patient skin dose and effective dose?

PSD is by definition equal to the maximum dose absorbed anywhere on the skin surface of the patient and is therefore directly related to the possibility and intensity of skin injury. According to current data, minimum prompt skin reactions may occur in sensitive patients within hours after an acute PSD exceeding 2 Gy [BALTER et al., 2010]. Medically important reactions occur in average patients several weeks later at PSDs exceeding 5 Gy.

If the reference point happens to be on the patient’s skin, and the beam does not move during the procedure, the PSD is the CAK multiplied by a backscatter factor. As noted above, in most cases, more complex calculations are needed to account for beam motion, patient position, and field overlap.

KAP can be used to estimate CAK. If the field size at the level of the reference point is 100 cm², a KAP reading of 200 mGy·cm⁻² is observed after one minute of fluoroscopy. The corresponding CAK rate is 2 mGy/min. The same KAP could be observed with a larger field such as 400 cm². Under these conditions, the CAK rate is 0.5 mGy/min. Assuming that the same organs are irradiated in both cases, the total energy imparted to the patient, and the effective dose is approximately the same for both cases. However, the PSD will be a factor of four smaller for the larger field.

X-ray beam intensity is controlled by the automatic brightness control system to accommodate differences in patient thickness, projection angles, detector settings, and source to detector distance. Therefore PSD values based on KAP must be used with caution in most circumstances. Newer systems provide CAK at the reference point, incremental KAP, and geometry at an individual irradiation level in a radiation dose structured report [BALTER, 2008]. When such reports are available in real time they will be used to produce skin dose maps [JOHNSON et al., 2011].
<table>
<thead>
<tr>
<th>Groups/Subgroups</th>
<th>Examinations</th>
<th>Dose Conversion Coefficient (DCCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary studies</td>
<td>Cystometry, Cystography, Excretory urography, micturating cysto-urethrogram, Urethrography</td>
<td>0.18</td>
</tr>
<tr>
<td>Endoscopic retrograde \choangiopancreatography (ERCP)</td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>Arthrograms</td>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>Orthopedic procedures</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Vertebroplasty</td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Obstetrics and gynecology procedure</td>
<td>Pelvimetry</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>Hysterosalpingogram</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>Noncardiac diagnostic procedures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripheral vascular</td>
<td>Arteriography (all types)</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Peripheral phlebography/venography</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Carotid and cerebral angiography</td>
<td>0.087</td>
</tr>
<tr>
<td>Renal</td>
<td>Antegrade pyelography, Retrograde pyelography</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Renal angiogram, Abdominal aortography</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Thoracic angiography, arch angiography</td>
<td>0.12</td>
</tr>
<tr>
<td>Other peripheral</td>
<td>Cervical spine</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>Thoracic spine</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>Lumbar spine</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>Pulmonary angiography, Vena cavaogram</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>Noncardiac interventional vascular procedures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percutaneous transluminal angioplasty (PTA)</td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>Stent placement</td>
<td>Renal/Visceral PTA with stent, Iliac PTA with stent, Bile duct, dilation and Stenting</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Carotid stent</td>
<td>0.087</td>
</tr>
<tr>
<td>Inferior vena cava filters</td>
<td>Filter placement only, Hepatic</td>
<td>0.25</td>
</tr>
<tr>
<td>Embolization</td>
<td>Chemoembolization, Pelvic arterial Embolization, Pelvic vein embolization: ovarian vein, Other tumor embolization, Embolization</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Pulmonary angiography with filter, Bronchial artery embolization</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>Thrombolytic therapy</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Transjugular intrahepatic portosystemic shunt (TIPS)</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Cardiac procedures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnostic coronary angiography</td>
<td></td>
<td>0.12</td>
</tr>
<tr>
<td>Interventional procedures</td>
<td>Angioplasty</td>
<td>0.20-0.25</td>
</tr>
<tr>
<td></td>
<td>Percutaneous transluminal coronary angioplasty</td>
<td>0.19-0.23</td>
</tr>
<tr>
<td></td>
<td>Embolization</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Cardiac radiofrequency ablation</td>
<td>0.1-0.23</td>
</tr>
</tbody>
</table>
Contrast types

- Iodinated
  - Ionic (no longer used)
  - Non-ionic
    - Low osmolar
      - Monomers
        - Isovue-370 (used at DGMC) -- 1.6cc/kg (max 140cc)
        - Omnipoque-350 (used at DGMC)
    - Dimers (less osmolar than monomers)
      - Ultravist-300
      - Visipaque (iso-osmolar) -- 1.9cc/kg (max 140cc), goal=600mg Iodine
    - Isovue M (from myelogram)
  - Hi osmolar
    - Conray (IVP)
    - Cystoconray II (VCUG)
Common used contrast media

<table>
<thead>
<tr>
<th>Type</th>
<th>Composition w/v %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-ionic monomer</td>
<td></td>
</tr>
<tr>
<td>Iopamidol</td>
<td>61.2%</td>
</tr>
<tr>
<td>Iohexol</td>
<td>64.6%</td>
</tr>
<tr>
<td>Ioversol</td>
<td>63.6%</td>
</tr>
<tr>
<td>Iopromide</td>
<td>62.3%</td>
</tr>
<tr>
<td>Non-ionic dimer</td>
<td></td>
</tr>
<tr>
<td>Lotrolan</td>
<td>64.1%</td>
</tr>
<tr>
<td>Iodixanol</td>
<td>65.2%</td>
</tr>
</tbody>
</table>

- Iopamidol = Isovue
- Iohexol = Omnopaque
- Ioversol = Optiray
- Iopromide = Ultravist (dimer)
- Iodixanol = Visipaque (dimer)
Contrast types

- **GI**
  - **Barium**
    - EZ Paque (“thin barium” for SBFT and single contrast UGI; keep refrigerated)
    - EZ HD (“thick barium” for double contrast UGI; add 50cc water)
    - EnteroH (for Enteroclysis along w/ methylcellulose “Entrocel”)
    - Liquid Polibar Plus (BE)
    - Readi-Cat II (diluted barium for CT scan; 2.1% w/v) \(\leftarrow\) for patient with allergy to iodine!!
  - **Gastrografin/Gastroview** (water-soluble ionic)
    - HOCM (diatrizoate like Hypaque/Gatroview/Gastrografin)
    - LOCM (iohexol or Omipaque)—less aspiration risk, also use if pt has contrast rxn, poorly absorbed by GI tract, has neutral taste (FDA approved for oral use)
    - 1% (CT) \(\leftarrow\) need to dilute for CT
    - 37% (Fluoro) \(\leftarrow\) use un-diluted for Fluoro
    - EZ Paste (esophagus CT)
  - **Other**
    - Omnipaque 350 (water-soluble non-ionic LOCM) \(\leftarrow\) for patients with aspiration risk!!
    - EZ-Gas II (effervescent granules)
    - Bar-Test (13mm barium pill)
- Sinograffin (HSG)
- Gadolinium (MRI)
Gastrografin vs Gastroview

- **Gastroview** (Mallinckrodt)
  - Diatrizoate Meglumine and Diatrizoate Sodium solution
  - Water soluble **Ionic HOCM** iodinated contrast
  - 30cc bottle (single use): mix 30cc in 1L water
  - Lemon-vanilla flavored
  - 367mg Iodine/cc (11g Iodine in 30cc bottle)
  - For oral and rectal contrast
  - Protect from light (store at room temp)

- **Gastrografin** (Bracco)
  - Similar to Gastroview
  - 370mg Iodine/cc (11g Iodine in 30cc bottle)

- **Omnipaque 350** (for GI fluoro)
  - Water soluble **Non-ionic LOCM** iodinated contrast
  - Non-ionic (unlike Gastroview and Gastrografin)
  - Better taste
  - Omnipaque 350 (350mg Iodine/cc) for GI fluoro
  - Diluted Omnipaque 240 for pediatrics and Omnipaque 240/300 for adults PO for CT scan: mix 50cc in 1L of water
When to give PO water-soluble contrast instead of barium for GI fluoro

- **PO water soluble contrast**
  - Gastroview
  - Gastrograffin
  - Omnipaque 350

- **When to give**
  - Leak study (including fistulogram, sinus tract, abscess etc)—b/c barium can cause in mediastinitis and peritonitis
  - Confirm percutaneous tube placement (like G-tube etc; if suspect NGT may be in lung give barium instead)
  - SBO (therapeutic)←not omnipaque
  - Prior allergic-type rxn to barium (very rare)
  - Peds fluoro studies

- **When not to give**
  - High risk for aspiration (use Omnipaque 350 instead)
  - Undiluted PO for CT scan (must dilute)
  - Never give Gastroview or Gastrograffin IV
Omnipaque (iohexol) by GE

- **Intrathecal**
  - Omnipaque 180 (peds)
  - Omnipaque 180/240/300 (adults)
  - Note: Omnipaque 140 and 350 are not for intra-thecal use!
- **IV (for CT)**
  - Omnipaque 240/300 (peds)
  - Omnipaque 240/300/350 (adults)
- **PO (for Fluoro)**
  - Omnipaque 350 (GI)
  - Omnipaque 240/300/350 (arthrogram)
  - Omnipaque 240/300 (HSG)
- **PO (diluted for CT)**
  - Omnipaque 240/300 (peds CT)
  - Omnipaque 300 (adults CT)
  - 50cc in 1L of water → drink 1 cup every 20 min starting 2 hrs before (drink last cup right before scan)
Barium for CT scan

- **Readi-Cat 2**
- 2.1% w/v (2.0% w/w)
- 450ml bottle (ready to drink; comes in different flavors)
- **CT (SB) 30-60min protocol**
  - 1-2 bottles
  - 30min protocol: 300cc 30min before → 125cc right before
  - 60min protocol: 225cc 60min before → 225cc 30min before → 225 right before
- **CT (SB+LB) 90min protocol**
  - 2 bottles
  - 90min protocol: 450cc 90min before → 300cc 30min before → 150cc right before
<table>
<thead>
<tr>
<th>Product</th>
<th>Class</th>
<th>% Iodine conc</th>
<th>Iodine (mg/ml)</th>
<th>Osmolality (mOsm/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visipaque-320</td>
<td>Non-ionic IV</td>
<td>32</td>
<td>320</td>
<td>290</td>
</tr>
<tr>
<td>Isovue-370</td>
<td>“</td>
<td>37</td>
<td>370</td>
<td>796</td>
</tr>
<tr>
<td>Ultravist-300</td>
<td>“</td>
<td>30</td>
<td>300</td>
<td>607</td>
</tr>
<tr>
<td>Gastrografin/Gastroview</td>
<td>Ionic PO (HOCM)</td>
<td>36.7/36.7</td>
<td>367/367</td>
<td>1940/2000</td>
</tr>
<tr>
<td>Omnipaque-350</td>
<td>Non-ionic PO (LOCM)</td>
<td>35</td>
<td>350</td>
<td>844</td>
</tr>
<tr>
<td>Cysto-conray II</td>
<td>Ionic urologic</td>
<td>8.1</td>
<td>81</td>
<td>400</td>
</tr>
<tr>
<td>Isovue-M 300</td>
<td>Intrathecal</td>
<td>30</td>
<td>300</td>
<td>616</td>
</tr>
<tr>
<td>Sinografin</td>
<td>HSG</td>
<td>38</td>
<td>380</td>
<td></td>
</tr>
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<table>
<thead>
<tr>
<th>Product</th>
<th>Barium sulfate</th>
<th>% w/v</th>
</tr>
</thead>
<tbody>
<tr>
<td>EZ paque</td>
<td>Thin barium</td>
<td>45-65%</td>
</tr>
<tr>
<td>EZ HD</td>
<td>Thick barium</td>
<td>250%</td>
</tr>
<tr>
<td>Liquid Polibar plus</td>
<td>Barium enema</td>
<td>105%</td>
</tr>
<tr>
<td>EZ paste</td>
<td>Esopho-cat</td>
<td>100%</td>
</tr>
<tr>
<td>Readi-cat 2</td>
<td>Barium for CT scan</td>
<td>2.1%</td>
</tr>
<tr>
<td>Bar-test</td>
<td>13mm pill</td>
<td></td>
</tr>
<tr>
<td>EZ Gas II</td>
<td>Effervescent granules</td>
<td></td>
</tr>
</tbody>
</table>
## Properties of Radiographic Contrast Media

<table>
<thead>
<tr>
<th>Product</th>
<th>Chemical Structure</th>
<th>Ionicity</th>
<th>Osmolality Class</th>
<th>Osmolality (mOsm/kg H₂O)</th>
<th>Iodine (mg/I)</th>
<th>Viscosity at 25°C</th>
<th>Viscosity at 37°C</th>
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### Properties of Radiographic Contrast Media

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<th>Product</th>
<th>Chemical Structure</th>
<th>Ionicity</th>
<th>Osmolality Class</th>
<th>Osmolality (mOsm/kg H₂O)</th>
<th>Iodine (mg/L)</th>
<th>Viscosity at 25°C</th>
<th>Viscosity at 37°C</th>
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*Measured at 20°C; References 31–37
* PROTOCOLS
BE prep

- 2 days prior to test
  - Clear liquid diet only
  - Clear broth, juices, coffee, carbonated bev, jello, popcicles (no milk)

- Day before test
  - Continue clear liquid diet
  - 1, 3, 7, 10pm drink 8oz water
  - At 4pm mix and drink *phospho-soda (Fleets) laxative* w/ 4oz water and followed w/ 8oz water
    - ALTERNATIVE= *Golytely* if age>55, renal dz, high risk for volume depletion, meds affecting intraglomerular hymeodynamics (NSAIDs, diuretics, ACE-I, ARB, aldo blocker) to avoid acute phosphate nephropathy (fill plastic container containing Golytely powder with water and flavoring such as kool-aid and drink 1 glass q15min until all gone; may take Phenergan for nausea)
  - At 7pm take 4 Dulcolax (biscodyl) tabs w/ 8oz water

- On day of test
  - Drink at least 8oz water/coffee/juices
  - No breakfast (no broth)
  - 1hr before exam insert *suppository* (hold BM for 15min to allow full suppository absorption)

- After test
  - Drink plenty of water x48hrs
DCBE

1. scout KUB for adequacy of bowel prep and r/o free air
2. test equipment (balloon etc) and ask about prior appendectomy
3. place patient in left lateral decub position
4. do DRE to exclude rectal mass
5. insert tube and inflate balloon (may tape bottom to secure tube)
6. gravity-assisted filling (Liquid Polibar Plus)
7. take single-contrast images of early rectal filling
8. slowly let barium in and alternate with barium and air puff—follow barium until it reaches past the splenic flexure (avoid overfilling esp if patient has a long/redundant sigmoid) and then stop barium flow by clamping the tube
9. roll patient supine and slightly RPO
10. gently insufflate 6-8 times (this will advance barium column)
11. consider placing patient in right lateral decub (or upright) once contrast gets past hepatic flexure to aid filling of cecum (remember: a normal appendix may or may not fill)
12. drop barium bag to floor, unclamp the tube, and drain out as much barium as possible (note: air will also leak out into the bag)
13. may have to insufflate additional 3-4 times to distend the rectum
14. take left lateral (make sure both hips are overlapping) and PA (prone) images of rectum
15. take right lateral and LPO images of the sigmoid (also consider upright 45deg right image if redundant sigmoid)
16. take AP (supine) image of the descending colon
16. take upright images of the flexures (LPO for hepatic and RPO for splenic) and AP image of the mid transverse colon
17. take AP (supine) and LPO images of the cecum (also consider prone)
18. additional spot images to be performed by techs (R/L lateral decub, AP KUB, RPO, LPO, AP axial sigmoid 30deg cephalic, PA axial sigmoid 30deg caudad, Lat rectum w/ tip out)—some also do post-evacuation supine

Glucagon 0.5-1.0mg IV can be considered in patients w/ symptomatic colonic spasm (contraindications: diabetic, pheochromocytoma, insulinoma)
DCBE tray

- Surgilube
- Two 4x4 gauze
- Double gloves
- Roll of tape
- Clamp/hemostat
- Insuffalator
- BE bag w/ tubing
- 500-750cc Liquid Polibar Plus
- Two blue towels

SINGLE CONTRAST BARIUM: 1000-1500cc gastroview/water mix
DCBE overheads

Cassette size and techniques:

- KUB scout 14x17
- R lat decub 14x17 (90kVp @80mAs)
- L lat decub 14x17 (90kVp @80mAs)
- AP KUB 14x17 (90kVp @40mAs)
- RPO 14x17 (95kVp @45mAs)
- LPO 14x17 (95kVp @45mAs)
- AP axial sigmoid (30deg cephalic) 10x12 (90kVp @45mAs)
- PA axial sigmoid (30deg caudal) 10x12 (90kVp @45mAs)
- Lat rectum (tip out) 10x12 (180-210mAs)
Peds BE

- **Prep**
  - No bowel prep needed (esp to r/o Hirschsprung’s)
  - Nothing per rectum (including rectal exam or suppository) x24hrs
  - IVF (b/c enema will dehydrate pt)

- Pediatric green straight tip (placed while left lateral decub)
  - Don’t use balloon (esp for Hirschsprung’s)—tape the bottom

- Don’t use barium—results in fluid shift

- Diluted single contrast ½ strength (50/50) water-soluble Gastrograffin or Gastroview (some use non-diluted CystoConray)

- Remember to get left lateral early-filling rectum image (most sensitive for Hirschsprung’s—caveat=rectum may relax w/ time and can be false negative)

- Post-evacuation image w/ catheter out
Intussusception reduction

- **Pneumatic reduction**
  - r/o free air prior to study
  - 16-18F foley with balloon and Sheil kit
  - 80-120mmHg
  - Must reflux into TI
  - 18G needle for emergent pneumoperitoneum decompression

- **Enema reduction**
  - Diluted 1/2 strength (50/50) Gastrograffin or Gastroview (some use Hypaque)
  - 3 feet above table w/ gravity
  - 3 attempts for 3min each
UGI

- NPO
- Assess for need to include detail pharyngeal eval or SBFT
- Upright RPO (facing you)
- Effervescent granules EZ-Gas II (put granules into 5cc water cup and “chug”)
- Instruct against burping (instead “swallow”)
- Thick barium (EZ-HD with 50cc water) “drink as fast as possible”
- Multiple eso shots (also do AP view at GE jct which helps detect HH)
- Put patient in supine or left lat position and lay table flat
- Supine and prone “side-to-side roll” to mix (turn patient away from you to avoid right lateral position)
- Assess for proper coating of gastric mucosa
- AP and LPO views of stomach
- R Lat shot of fundus (alternative=“atom bomb” upright view)
- Coned-down LPO view of duo bulb (alternative=Rao with compression)
- Do recumbent thin barium imaging with straw (Rao)—”take a big sip and swallow” watch single swallow to evaluate motility
- May give water to clear eso→Supine valsalva, straight leg, trendelenburg maneuvers to elicit reflux
- AP view of entire abdomen
- Upright 13mm pill (Bar-Test barium sulfate pill)
- Pharyngeal imaging:
  - AP and Lat imaging
  - 6-8/s timed swallow imaging (bolus in mouth and hold until countdown then swallow)
  - Gargle→say “e’s”, “aah’s”, and “puff cheeks”
Pediatric UGI

- R/o HPS (uncommon <1wk or >3mos) and malrotation/volvulus
- Ask about projective vomiting (HPS) or bilious vomiting (malrotation)
- Scout image to r/o double bubble (ddx=duo atresia/stenosis or annular pancreas)
- With hold feed (NPO 2-4hrs)
- Start with left lateral decub
- 2-8oz “Thin” barium (EZ-paque) via bottle/nipple
- Supine AP stomach (let gastric fundus fill)
- Consider quick right lateral position to facilitate emptying
- When contrast in 2nd portion (descending) of duo, right lateral image to confirm retroperitoneal location of duo (along the spine)
- Return supine for AP imaging of Ligament of Trietz (should be at the level of pylorus and to the left of the L1 pedicle)
- Also get right lateral image of the Ligament of Trietz
- Document any reflux (crying increases intrathoracic pressure and negates GERD)
SBFT

- NPO
- Scout KUB
- Two 8oz cup of thin barium (EZ-Paque)—drink w/in 5min
- Obtain sequential overhead PA views at 15-20min interval until reaches cecum
- Normal transit time 30min to 3hrs
- Spot views of jejunum and ileum w/ compression (balloon paddle)
- LPO views of ileocecal junction (alternative: RPO)
- Advise to drink fluid x48hrs after exam
SBFT with gastrograftin for SBO

- The administration of WSCA (water soluble contrast agent) proved to be effective in several randomized studies and meta-analysis. Three recent meta-analyses demonstrated that the presence of contrast in the colon within 4-24 h is predictive of ASBO (acute SBO) resolution. Moreover, WSCA decreased the need for surgery and reduced the length of hospital stay.

- The appearance of contrast in the colon within 4-24 h after administration had a sensitivity of 96% and specificity of 98% in predicting resolution of SBO

Systematic review and meta-analysis of the diagnostic and therapeutic role of water-soluble contrast agent in adhesive small bowel obstruction.
Branco BC
Enteroclysis

- The most sensitive of the small bowel examinations
- Colon prep with dulcolax, NPO
- Premedicate with Reglan 20 mg PO - Increases peristalsis
- Anesthetic spray for nose and throat - Insert 12 Fr maglinte catheter nasal route through a guidewire
- Sedation may be needed in some cases
- Place cath distal to the ligament of Treitz., inflate balloon w 20cc of air - prevents reflux, aspiration
- Double contrast → 500cc of barium sulfate susp (50% w/v) followed by 2000cc of methylcellulose (500cc diluted with 1500cc of water)
Modified enteroclysis

- Scout
- Ask which nostril is patent and preferred
- Supine with chin slightly down
- Fill nostril with viscous Xylocaine jelly
- Setup 8fr Frederick Miller 120cm nasojejunal feeding tube by placing guidewire (slightly retract guidewire from tip to allow atrumatic passage)
- If any coughing, consider placing pt in right lateral position and then advance under fluoro guidance while visualizing pharynx
- If tube loops in stomach, may consider following:
  - Consider injecting air to distend stomach
  - Retract guidewire, advance tube, re-engage guidewire and advance to straighten out any curves
  - Rotate tube as necessary
- Prefer tube tip distal to ligaments of trietz (duo-jej jct) or within distal duo
- Take out guidewire (don’t discard) and secure tube to nose with paper tape
- Attach provided christmas tree connector and a short tubing (similar to arthrogram) for attaching 60cc syringe
- Push 5 60cc syringes (300cc) of thin barium and wait until contrast crosses midline (consider intermittent fluoro w/ last image hold) at fast as possible (although not so fast that contrast refluxes into stomach)
- Then push 2 60cc syringes of air and start taking images→avoid putting too much air to avoid air lock (which will prevent contrast progress distally)
- Alternate syringe of air then contrast (usually 4-5 syringes ~300cc more) until contrast gets to TI
- Use balloon paddle for compression-aided visualization of all bowel loops
- Record transit time from LOT to cecum
Leak study

- Give water to make sure patient won’t aspirate
- Start w/ water-soluble contrast first
gastrograffin/gastroview (50/50 dilution)
  - Visipaque or Isovue or Omnipaque (non-diluted) are safe less
    osmolar alternatives if high-risk patients (with prior contrast rxn
    or risk for aspiration)
- Then use “thin” barium (EZ-paque)
- If needed can try “thick” barium (EZ-HD)
- Avoid barium if risk for perforation
- Avoid gastrograffin/gastroview if risk for aspiration
- Image drain to see if any secondary sign of leak
Feeding tube (Dobhoff) placement

- 10mg Reglan (Metoclopramide) IV over 30-60sec (if no contra-ind)
  - Relaxes pylorus and increases SB peristalsis
- Lubricate tip w/ Lidocaine gel
- Consider flushing tube before inserting wire stiffner
  - Retract stiffner several cm to allow flexibility
  - May use guidewire instead of stiffner (remember to lubricate w/ water)
- Place tube via nostril w/ neck flexed
- Inject air into stomach if no sig air present (100cc air using 60cc syringe)
- If tip faces pylorus, continue advancing
- If loops or coils w/in stomach—2 options
  - Pull tube back (without adjusting stiffner) and twerk and re-advance
  - If keep coiling, consider pulling back stiffner→ advancing the tube→force the stiffner in to push the tube distally (alternative: place patient in left lateral decub)
- Left lateral decub position also helps get tube past pylorus
- Inject barium or water-soluble contrast
Video swallow study

- MBSS=modified barium swallow study
- Performed by speech-language pathologist
- Initial phase of swallowing is oral manipulations that happen prior to the actual intentional initiation of swallowing
  - An individual opens his or her mouth to admit the portion of food or liquid, which we shall call a “bolus”, to be swallowed
  - Completion of this stage requires good intra-oral (within the mouth) sensation, good function and range of motion of the tongue, and good strength and range of the jaw for chewing
- During the pharyngeal phase of swallowing the tongue squeezes the food against the posterior pharyngeal wall, the larynx and airway elevate, the epiglottis retroflexes (inverts), the UES opens
- With respect to the oral and pharyngeal phases, the esophageal phase is longer in duration
- Use a representative sample of p.o. textures and consistencies in order to reach valid conclusions about the state of a patient’s swallowing (usually, a chewable food item such as cracker or cookie is selected, along with a pureed or pudding)
- Treatment strategies fall under three broad categories:
  - dietary manipulations/adaptations
  - active strategies
  - and postural changes
Video swallow study

- A patient may be asked to hold his or her breath immediately before swallowing, so as to make the swallow more effortful and increase the neuromuscular effort; limit the size of the bolus the patient swallows; or alternate from solid boluses to liquid boluses.
- Lastly, with postural modifications, the patient may be asked to “tuck your chin”, which causes the airway to be drawn under the base of the tongue, which acts somewhat like an umbrella to shield it from spilled liquids or food.
- Patients may be asked to turn their head either to the left or right because with a unilateral stroke, weakness will sometimes manifest in the pharyngeal constrictors on the affected side (patients may thus have pharyngeal pooling or residual only on that one side and turning his or her head to the affected side will help eliminate that pooling by compressing or closing off the recesses).
- The phenomenon of premature spillage, in which food or liquid boluses spill and enter the hypopharynx prematurely before the initiation of the swallow may be due to impaired sensation and control of the tongue or delayed initiation of the swallowing reflex.
- General rule of thumb is that the patient should generate a swallow within a second of being asked to. If the swallow does not trigger in this time, the food or liquid most likely has already spilled prematurely into the hypopharynx. A protective reflex called the LAR (laryngeal adductory reflex) will trigger in normal patients if spilled material touches sensory receptors at the rim of the laryngeal vestibule. This reflex promotes an immediate airway closure followed by a swallow.
- MBSS is considered the “gold standard” examination for oral and pharyngeal dysphagia but a newer complimentary instrumental endoscopic examination called FEES (Fiberoptic Endoscopic Evaluation of Swallowing) has been gaining acceptance.
- FEES has the advantages of being free from radiation, so studies using FEES are able to be sustained for longer time intervals—in this way, clinicians can more easily tell if a patient is impacted by fatigue.
- Disadvantage of FEES is that aspiration may not be noted as reliably, since the white out phenomenon at the height of the swallow reflex is often when aspiration occurs.
HSG

- Hysterosalpingography should not be performed during (per package insert for sinografin)
  - menstrual period or pregnancy
  - when infection of the external genitalia or genital tract is present (like PID)
  - not be attempted within 30 days following curettage or conization
  - within six months following the termination of pregnancy
- Performed 7-10 after start of menses (patient advised to not have sexual intercourse)
- Take motrin or tylenol 30min b/f exam for cramping
- Patient asked to bring feminine pad for spotting after exam
- Confirm neg B-HCG on all patients prior to study
- Obtain written consent (risks: cramping/bleeding x48hrs, infx, perforation, unsuccessful procedure)
- If doing u/s after HSG, wait 2wks

Prepare kit:
- 5F Gynecath catheter w/ 2cc balloon
- 10cc Sinograffin (warm)
- Betadine swabs
- Plastic speculum w/ lite
- Bleed catheter to avoid air bubbles and ensure integrity of balloon
- Locate cervix with physical exam
- Place speculum (with surgi-lube)
- Wipe cervix with betadine
- Place catheter using sterile technique (may need dilator prior to instrumentation)
- Inflate balloon w/ 2cc air (ensure catheter is secured)
- Remove speculum and position patient under camera
- Gently inject contrast (keep tip of syringe down to avoid injecting air bubbles) and obtain static images in AP and oblique projections
- At end of study, deflate balloon and image inferior uterine cavity
- Remove catheter
HSG
HSG tray

- Sheet
- Stirrups
- HSG catheter
- Sterile lubricant
- 10cc sterile syringe
- 18G needle (sterile)
- Gloves
- Two bottles of Sinografin (warm)
- Betadine bottle
- Plastic speculum with light
Essure evaluation with HSG

- Bilateral Essure inserts are seen on scout image. Adequate filling of endometrial canal and distention of cornua without filling defect. There is no contrast filling of bilateral fallopian tubes or intraperitoneal spill. The essure inserts are appropriately located with distal ends within distal fallopian tubes and proximal ends near cornua.
ESSURE® CONFIRMATION TEST

RADIOGRAPHIC MARKERS

There are 4 radiographic markers on the device to help confirm satisfactory insert location and tubal occlusion:

1. Proximal end of outer coil
2. Proximal marker of inner coil
3. Distal marker of outer coil
4. Distal end of inner coil ("bail tip")

Length of inner coil = 30 mm
SCOUT FILM
Scout film is the first image captured, before injecting the contrast. Capture an image of the uterus and fallopian tubes. The Essure inserts should be clearly seen; note the lie and curvature of the inserts. During evaluation, note the 4 radiographic markers on each insert.

MINIMAL FILL
Capture an image of the uterus after a small amount of contrast infusion. No contrast should be leaking from the cervix if an adequate seal is maintained. The uterine cavity should start to opacify. Contrast may not have reached the uterine cornua. If the uterine cavity silhouette is not seen in a nearly A/P projection, adjust the fluoroscopy beam and/or the patient.

PARTIAL FILL
Capture an image of the uterus when it is nearly full of contrast or opacified. The cornua may not yet have been adequately distended. Proximal portions of the Essure inserts may not yet be obscured by the advancing contrast.

TOTAL FILL
Capture an image of the uterus when the uterine cavity is completely filled to patient tolerance or the cornua has reached maximal distension, whichever comes first. Ideally, contrast should reach the proximal end of the inserts.

Note: You may need to gently increase contrast volume in the uterine cavity to obtain a satisfactory image.

MAGNIFICATION OF THE UTERINE CORNUA
Once the uterine cornua are filled to maximum distension, obtain magnified views of both right and left cornua with the distal ends of the insert in view.

Note: Assessment of the location of the inserts on Essure Confirmation Test is not the same as noted on hysteroscopy. Therefore, a correctly placed insert may appear to be more distal on the Essure Confirmation Test than noted at the time of hysteroscopy.
SATISFACTORY LOCATION

A satisfactory location is defined as the distal end of the inner coil being within the fallopian tube with <50% of the inner coil trailing into the uterine cavity, OR the proximal marker of the inner coil being ≤30 mm into the tube from where contrast fills the uterine cornua.

Note the normal curvature and symmetrical appearance of both inserts.
UNSATISFACTORY LOCATION

There are 4 types of unsatisfactory location: proximal location of the insert, expulsion of the insert, distal location of the insert, and perforation or peritoneal location of the insert.

1. PROXIMAL LOCATION OF THE INSERT
   Proximal location is defined as ≥50% of the inner coil is trailing into the uterine cavity.
   
   How to manage:
   Advise patient not to rely on Essure; continue alternative contraception or consider incisional sterilization.

2. EXPULSION OF THE INSERT
   One or both inserts are not present in the radiographic image.
   
   How to manage:
   Advise patient not to rely on Essure. If corresponding tube is patent, counsel patient on repeat Essure placement procedure. If corresponding tube is occluded, counsel patient about potential false-positive Essure Confirmation Test results. Also counsel patient on incisional sterilization or remaining on alternative contraception.

3. DISTAL LOCATION OF THE INSERT
   Distal location is defined as the insert is in the tube, but the proximal end of the inner coil is >30 mm from the cornua.
   
   How to manage:
   Advise patient not to rely on Essure. If tube is patent, counsel patient on repeat Essure placement procedure. If tube is occluded, advise patient on potential false-positive Essure Confirmation Test results. Also counsel patient on incisional sterilization or remaining on alternative contraception.
PERFORATION OR PERITONEAL LOCATION OF THE INSERT

When perforation occurs, the insert has punctured the uterine cavity. Peritoneal location means the insert is within the peritoneal cavity through a uterine perforation.

How to manage:

Advise patient not to rely on Essure for contraception. If tube is patent, counsel patient on repeat placement procedure. If tube is occluded, advise patient on potential for false-positive diagnosis of occlusion. Also counsel patient on incisional sterilization or remaining on alternative contraception.
IVP (at DGMC)

- aka excretory urography
- NPO with fluid hydration; Check Cr; Void prior to exam
- Scout KUB 65-75kVp w/ high MA [and scout tomograms to ascertain level and technique]
- 100cc Ultravist IV (monitor for contrast rxn)→use 50cc if patient only has one kidney
- No tomograms (or zonograms)
- NEPHROGRAPHIC 2min (some say 1-3min) coned-down kidneys [or nephrotomograms]
  - Assess for symmetric nephrograms and renal size/location
- 5min KUB (should see collecting system activity; if persistent nephrograms w/o excretion→immediately assess patient for hypotension, possible contrast rxn, or CIN)
  - Some use compression (across upper pelvis at level of ASIS) at this time
  - No compression if hx of stone, abdominal surgery, AAA (may do prone or trendelenburg instead), severe abd pain, renal tx, or see obstruction at 5min
  - Assess for blunting of fornices or filling defects within calyces or renal pelvis
- PYELOGRAPHIC 6min coned-down kidneys [some do this 5min after compression]
- 7 and 8min oblique (15-30deg LPO/RPO) KUB
- 10min KUB [some do this immediate after release of compression]
  - If don’t see entire ureter, consider prone imaging, trendelenburg, and/or fluoro
- Determine if OK to do post-void
- Post-void upright KUB
IVP images

- Scout KUB
  - Centered on iliac crest (14x17)
  - Closely monitor 1st 5-10min for contrast rxn

- 2min
  - Coned down kidneys (10x12)
  - Top at xyphoid; bottom at iliac crest

- 5min
  - KUB

- 6-8min
  - 6min Coned down kidney
  - 7min 30deg RPO KUB
  - 8min 30deg LPO KUB

- 10min
  - KUB (may do prone KUB if ureter not visualized or consider fluoro)

- Post-void
  - Upright KUB (include bladder)
IVP

- **Zonogram**
  - Thicker slice
  - Short amplitude button (2.5)

- **Tomogram**
  - Thinner slice (use 20deg arc)
  - 3 images separated by 1-2cm
  - $[\text{AP abd dia in cm / 2}] - 2\text{cm}$
  - Use 11-13
  - Long amplitude button (30)
Normal IVP

- Renal length ~3-4 L-spine vert bodies (upper pole slightly above 12th rib)
- <1cm size variation between kidneys (left larger than right by 0.5cm; kidneys slightly larger in women)
  - Significant if right kidney ≥1.5cm larger than left
  - Significant if left kidney ≥2.0cm larger than right
- R kidneys generally lower than L
- Vertical axis of kidneys parallel to psoas muscle
- Parenchymal thickness 3.0-3.5cm in polar and 2.0-2.5cm in interpolar
- Minor calyces ~7-14 (some say 10-25)
- Compound papilla may be seen in polar regions (simple with acutely angulated forniceal margins usually seen in interpolar)
Normal IVP

- Ureter separated >5cm
- Ureter dia <8mm
- Ureter located <1cm from transverse process and not medial to ipsi pedicle
- Medial deviation=ureter overlies ipsi pedicle
- Lateral deviation=ureter lies >1cm lateral to ipsi transverse process tip
- At L3 ureter passes ventral to psoas muscle crossing from lateral to medial
- At point of iliac vascular crossover, there is minimal deviation of ureter
- Once within anatomic pelvic, it parallels the inner margin of iliac bone
- There may be impression on ureter by gonadal veins in female
- Post-void collapsed bladder mucosal ridges <3mm in width
IVP eval

- Should see renal parenchyma w/in 1-3min (nephrographic phase)
  - Symmetry, size, location
- Should see collecting system activity with receding nephrographic activity on 5min KUB (persistent nephrogram suggests contrast rxn)
- Tomograms for renal contour distortion (mass evaluation)
  - Mass causes “double contour”
- Mentally draw “interpapillary line” (arc shaped line connecting papillary tips) to assess renal cortical thickness
  - Parenchymal thickness increased with mass and decreased with infx/inflammm/infarction
- Compression compresses ureters against sacral ala allow visualization of prox to mid ureters→imaging immediately after release allows visualization of distal ureters
- Gravity maneuvers like prone imaging or trendelenburg also help to opacify ureters
- At 10min, the pyelographic phase should be dominant (hardly any nephrographic)
- By 15-30min, bladder should be adequately filled
- Obstruction may result in: subtle rounding of fornicae margins→loss of papillary impression due to blunting→caliceal clubbing
IVP eval

- Material within papilla:
  - Papillary blush (no resolvable tubular structures; decreases in prominence on later images esp after release of compression) → b9 tubular ectasia (linear striations in virtually all papilla; don’t fill on retrograde pyelogram) → medullary sponge (calcs w/in papillary tips which appear to “enlarge” with contrast)
  - Papillary necrosis

- Contrast material outpouching from collecting system: abortive calyx or calyceal diverticulum

- Persistent standing-column of contrast within ureter on several images: distal obstruction or non-obstructive ureteral ileus

- Ureteral defects: luminal, mural, or extrinsic

- May do fluoro spot images if do not visualize distal ureters

- 0.5mg/kg Lasix IV over 30sec → image 5, 10, 15, 20min to assess for normal washout
VCUG

- Indicated if “recurrent febrile UTI” or “1st febrile UTI with abnl ultrasound”
- Inquire if kid is potty trained
- Calculate bladder volume (age in yrs + 2) * 30cc
- Remember to use pulse-fluoro and do last image hold
- 5 or 8 Fr feeding tube (secure with tape); 10F for adult
- Clean catch urine in specimen cup for urinalysis
- Scout AP
- Cystoconray II via gravity
- Early filling AP (for ureterocele)
- Late filling AP
- Bilat obliques
- In infant, when top of bladder gets to iliac wing, the bladder is full!
- Look for toe curling
- When voiding
  - Remove catheter in males and do oblique (turn baby boys away from you so they don’t pee on you) imaging to exclude PUV
  - Never remove catheter in females (let them pee around the catheter)
- Post-void imaging over kidneys
- Grade I-V for VUR
VCUG tray

- Urinal
- 8F catheter for peds (10F for adults)
- Xylocaine jelly
- Gloves
- Betadiene swabs
- Bottle of cystoconray II
- Urine specimen cup and plastic bag w/ label
- IV tubing
- Catheter adapter for adults
- Paper tape
- Chux
Retrograde urethrogram (RUG)

- Prepare external meatus in sterile fashion
- Lubrication not rec for results in sliding of balloon
- Flush cath prior to use
- Place 10-16F foley cath
- Inflate balloon w/ 1-1.5cc NS or air w/in fossa navicularis of penile urethra
- Supine 45deg oblique
- Penis should be placed laterally over the proximal thigh with moderate traction (use gauze at glans penis for traction)
- 20–30cc of 60% iodinated contrast material (cysto-conray II in 60cc syringe) is injected under fluoroscopic guidance so that the anterior urethra is filled
- Slow gentle pressure may overcome any initial spasm preventing filling beyond external sphincter (at urogenital dia; membranous urethra)
- Spot images obtained after confirmation of contrast into bladder
- Smooth indentation at bulbous urethra is normal
- Filling of cowper glands may mimic extravasation
- Opacification of the prostatic ducts, Cowper ducts, and periurethral Littré glands is often, but not necessarily, associated with urethral inflammatory and stricture disease
- Opacification of the corpora and draining veins may represent intravasation of contrast
RUG tray

- 60cc syringe
- Cystoconray II bottle
- 10F foley catheter
- 5cc syringe for balloon
- Xylocaine jelly
- Catheter adapter (christmas tree)
- Chux
- Basin (urinal)
- Betadiene swabs
*LP & MYELOGRAM
Indications for myelogram

IV. INDICATIONS FOR MYEOGRAPHY

A. Presurgical assessment of degenerative disc disease, spondylopathy and spinal stenosis (when adequate CT or MRI cannot be done).

B. Assessment of acute myelopathy to confirm suspected cord compression prior to decompression or radiotherapy (when MRI is unavailable).

C. Assessment of chronic myelopathy (when MRI is unavailable).

D. Assessment of nondiscogenic radiculopathy.

E. Location of source of CSF leak or dural tear.

F. Confirmation of nerve root avulsion.

G. Confirmation of arachnoiditis.

H. Confirmation and evaluation of arachnoid cysts.

I. Confirmation of dural AV fistula prior to angiography (if necessary).

CT and MRI have replaced myelography as the examination of choice for most of the above indications. Inability to do an MRI examination because of patient size or patient contraindication to the MRI study or extensive orthopedic hardware at area of interest should be the main reasons for myelography in centres where there is adequate availability of MRI.

V. RELATIVE CONTRAINDICATIONS FOR MYEOGRAPHY

A. Either known significant intracranial process with mass effect or neurological signs in keeping with unilateral intracranial mass. Preprocedure CT head may be needed before proceeding with myelography under this circumstance.
Indications for LP

- Suspect CNS infx
- Suspect SAH
- Therapeutic reduction of CSF pressure
Make sure Neurology has attempted already
Inquire if patient is consentable (or will need family to consent)
Obtain consent (N/V, vertigo, contrast rxn, infx/meningitis, bleeding, muscle spasm, numbness/tingling, HA, paralysis, seizures, death, unsuccessful tap)
Inquire about contrast allergy
Check coags (INR≤1.5 and platelets≥50k)
Make sure patient is not beyond fluoro table wt limit (usually ~400lbs)
ASA and Plavix are ok but no blood thinners or anticoagulation (heparin, coumadin, pradaxa, xarelto etc) x1wk prior to study
Prefer NPO at least 2-4hr prior to study
Well hydrated to avoid spinal HA
Avoid meds that lower seizure threshold (phenothiazines, antipsychotics, CNS stimulants, lithium, reserpine, isoniazid, monoamine oxidase inhibitors) x24-48hrs prior to exam and 1-2d following myelogram
Make sure CSF labs already ordered
May be admitted 4-6hrs after myelogram
Needs ride home after exam
Ensure CT schedule open 1hr after study
Baseline LE strength and sensation physical exam (document)
May also do eye exam for papilledema
Wear gloves and masks
Contraindications

- Increased ICP (check any prior CT head for obstructive hydrocephalus, not NPH)—myelogram increases ICP
  - Papilledema, midline shift, posterior fossa or spinal cord mass
  - Exception is pseudotumor cerebri
- Coagulopathy (may check PT, PTT, and INR)—risk of epidural hematoma
- Recent lumbar puncture <1wk
- Contrast allergy
- Generalized septicemia (risk for meningitis)
- Seizure (patient may be pre-medicated)
- Pregnancy
Meds that lower seizure threshold

- Phenothiazines (chlorpromazine [Thorazine], prochlorperazine [Compazine], perphenazine [Etrafon, Trilafon], thioridazine [Mellaril])
- Antipsychotics (thiothixene [Navane], haloperidol [Haldol], droperidol [Fentanyl])
- Tricyclic antidepressants (amitriptyline [Elavil], desipramine [Norparmin], imipramine [Tofranil], nortryptyline [Pamelor], doxepin [Sinequan])
- CNS stimulants (methylphenidate [Ritalin], ephedrine, pseudoephedrine)
- Monoamine oxidase inhibitors (tranylcypromine [Parnate], procarbazine [Matulane])
- Others (lithium, reserpine, isoniazid)
2 basic approaches

- **Midsagittal** (less painful and more safe)
  - L2-3 or L3-4 interspinous approach thru interspinous ligament
  - Center spinous process btwn pedicles
  - Palpate interspinous depression and mark the site
  - Anethesize to level of interspinous lig
  - Start by aiming for top of spinous process (i.e. L3 spinous process) located below the targeted interspace (L2-3)
  - Keep notch down (towards patients feet) or toward patient’s flank since needle goes against direction of bevel and advance cranially 10-30deg to reach the target
  - May need to use both hands to advance needle when get deep (one hand at hub and other guiding needle near the skin)
  - As you get closer to dura (check needle placement on lateral) freq remove stylet to look for CSF flow (may or may not feel pop as you go thru dura)
  - If CSF flow is minimal, push the needle further 1-2mm deep
  - To aide flow of CSF, keep bevel up or down (not sideways) and tilt head up
2 basic approaches

- **Parasagittal**
  - L2-3 or L3-4 interlaminar approach
  - May turn knee outwards on side of approach or angle camera 15deg ipsi oblique
  - Aim for underside of the lamina
  - Mark the skin (usually 2-5cm off midline)
  - Advance needle vertically ("target sign") towards midline
  - Bevel parallel to nerve roots → resistance of lig flavum followed by dura mater ("second pop") → may periodically remove stylet to check for flow of CSF
  - Inject under fluoro guidance to avoid epidural or subdural injection (consider lateral view to see contrast fall aways from needle tip in a linear line along the dependent or ventral sac) → epidural or subdural injections are recognized by contrast around the needle tip along dorsal part of sac
Myelogram

- Review prior CT/MRI (avoid areas of spinal stenosis or prior laminectomy)
- Prone w/ head up 10deg
- Pillow under abdomen to reverse lumbar lordosis
- Conus medularis ends at L1 or L2 (use 2-3 or L3-4)
- Lumbar puncture kit
  - 22G (3.5-4.5in length) spinal needle w/ stylet
  - 1% Lidocaine for local anesthesia
- May withdraw CSF for testing if requested
- Intrathecal (subarachnoid) contrast agents
  - Only non-ionic water-soluble contrast
  - Ensure no bubbles in tubing
  - Max 3g total iodine for adult patient
  - 10cc Isovue-M 300 for thoracic/cervical/lumbar+cervical myelogram
  - 12cc Isovue-M 240 or 17cc Isovue-M 180 for lumbar only myelogram
  - Remember contrast will be retained in tubing
  - Make sure you are opacifying the subarachnoid space (should see nerve roots) not subdural space
  - Place stylet back before you pull out the needle
- Perform images (see next slide)
- Perform CT w/in 1hr of myelogram
LP

- **Manometer (see next slide for details):**
  - To measure opening pressure, the patient must be in lateral position
  - Attach manometer (glass tube) using 3 way stop-cock and note the height of the fluid column (there will be resp variation→take max reading)
  - CSF in manometer should be placed into tube #1
- **4 plastic tubes (1-4):**
  - 10 drops each (~2-3cc each for total of 12cc)
  - #1=glucose, protein, protein electrophoresis
  - #2=gram stain, C&S, bacterial/viral culture
  - #3=cell count and diff
  - #4=reserve for any special tests (if MS, call lab to come draw blood for MS at this time)
- Ask patient to cough or bear down to aid flow of CSF
- May also have assistant press of patient’s abdomen for valsalva maneuver
- Bloody (traumatic) tap usually due to microtrauma of spinal venous plexus
  - If persistent blood in CSF and no hx of intracranial hemorrhage, consider withdrawing needle and re-tapping at different level
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>15-45 mg/dl</td>
</tr>
<tr>
<td>Glucose</td>
<td>50-80 mg/dl</td>
</tr>
<tr>
<td>WBC</td>
<td>&lt; 5 mm$^3$</td>
</tr>
<tr>
<td>RBC</td>
<td>0-5</td>
</tr>
<tr>
<td>Opening pressure</td>
<td>5-20 cm</td>
</tr>
<tr>
<td>Clarity, color</td>
<td>Clear and colorless</td>
</tr>
</tbody>
</table>
LP opening pressure

- A true CSF opening pressure must be measured with the patient in lateral decubitus position so that the entire CSF column is at the same horizontal level (not possible in the prone position).
- Set up the manometer before starting the procedure.
  - Have the 3-way stopcock valve set to be open from the needle attachment port to the manometer.
- Place the patient in the lateral position and place the spinal needle at L2-3 using a midsagittal (interspinous) approach (to keep the needle level with the CSF).
- When in the thecal sac and see flow of CSF, attach the stopcock to the needle.
- Wait for the CSF to stop rising in the manometer (this takes a few breaths of the patient).
- Measure the pressure in cm of water (i.e. not mm Hg).
  - The pressure varies with the cardiac cycle.
  - Use the max pressure over the cycle.
  - Abnormal is >18 cm water.
- If CSF is to be collected, open the stopcock to allow the CSF in the manometer to flow into tube #1.
Myelogram images

- Make sure caudal sac is filled prior to imaging
  - If difficulty opacifying, have patient head up 45deg or sit up with legs hanging off the bed
- AP prone table flat
- AP prone table head up 60-80deg wait 1-5min
- 45deg oblique views patient prone
  - Some do RPO and LPO upright 45deg obliques
- Lateral views with patient in lateral decub position (also do flexion/extension views esp if hardware)
  - Some do upright lateral WB spot film (boost kV to 90)
- X-table lateral prone and 7x17 overhead views (head up 10-30deg) by tech
Thoracic myelogram

- Bring table from head up to neutral level with patient in prone position to aid in cranial progression of contrast
- May place patient on side to aid continue movement of contrast up
- Slowly lower the table head down
- Patient is placed supine to trap contrast in thoracic kyphosis
- Obtain images in AP, oblique, and lateral views
Cervical myelogram

- With patient in prone position, head is hyperextended (chin out) on the neck to create lordotic “trough” and the table is then gradually and slowly tilted head down until contrast flows cranially.
- Chin is supported in a chin rest to avoid rapid ascent of contrast into the intracranial basal cisterns.
- AP, oblique, and x-table lateral views.
- Also consider Swimmer’s view (one hand up and one down).
Post-myelogram orders

1. Strict Bed rest x4-6 hrs with head of bed up 30-45 deg
2. After that, bathroom privileges with attendant
3. Encourage PO fluids
4. Regular diet
5. Pain reliever of choice PRN headache
6. Discharge after 4 hrs (If outpatient)
7. No phenothiazines, TCA, or Tigan for 48hrs after study

Also, the patient should be told that if there are any signs of meningitis (severe headache with stiff neck, fever) within 48 hours they should contact their doctor or go to the emergency room.
CT myelogram

- Keep prone and HOB at 30deg and transfer to CT (do CT w/in 1hr)
- Log roll 360 deg to supine (this will also aid mixing of contrast) prior to imaging
- Image from T12 thru S1 (or mid sacrum)
- 3mm pedicle to pedicle parallel to disc level (at least 3 levels L3-4, L4-5, L5-S1)
- Then turn supine onto CT table and image at 3mm in bone window
LP dictation

- Risks, benefits, and potential complications explained and a informed written consent
- Patient placed on prone position on fluoroscopy table
- Back prepped and draped in usual sterile fashion
- Local anesthesia with 1% lidocaine
- L2-3 or L3-4 interspace was localized
- Under fluoro guidance, a 22G spinal needle was advanced in the right paramidline interlaminar space into the thecal space with a single pass
- Approx 12cc of clear CSF was passively obtained and sent to lab for analysis
- Opening pressure was measured to be 11cm of water
- Stylet was replaced and the spinal needle was removed
- Patient was placed in left lat decub position midway thru CSF collection to help continue CSF flow
- No immediate post-procedure complications
- Impression: successful LP
Myelogram

- Post-procedure orders
  - Lay flat x4hrs post-procedure to avoid spinal HA (may keep HOB up at 15-30deg if no HA)
  - Bed rest x24hr
  - Check vitals q1hr x4hr with LE neurovascular check
  - Anti-emetic PRN
  - IV or PO hydration x24hr
  - Tylenol (no NSAIDs) and ice pack to forehead PRN for HA (caffeine also helps)
  - Instruct patient for signs of meningitis (HA, fever, stiff neck)
Spinal headache

- Post-spinal puncture headache in 10-30%
- Usually begins 24-48 hrs after procedure
- Usually frontal or retro-orbital and occipital (throbbing)
- Postural i.e. improves with supine position
- Self-limited (up to 7d)
- Treatment:
  - Supine position
  - Fluid hydration
  - Responds to analgesics and caffeine
  - Severe cases can be treated with epidural blood patch (usually performed by anesthesiologist if HA persists >2 days)
Spinal HA

- Severe postural headache aggravated by Valsalva maneuver
  - Worse when patient sitting up; better when lying down
  - Typically located in the frontal or occipital region (rarely unilateral)
  - Pressure, pounding, worse on movement of head
  - Onset usually within 24hrs of procedure (but may be delayed)
  - 90% develop within 3d
  - Associated findings: Visual or auditory sx, N/V, neck stiffness, visual sx (diplopia, photophobia, blurry vision), vertigo, hearing loss, occasionally CN palsy
  - Resolves in 1-2 days with rest and fluids (more common in patients with migraines)

- Treatment
  - Flat and strict bedrest
  - IV hydration
  - Analgesics (prefer Tylenol)
  - Avoid NSAIDs or opioids
  - Caffeine 300 mg PO (short-term relief by causing mild vasoconstriction)
  - Vitals, Neuro, and Temp checks
  - May need blood patch if HA persists >48hrs by anesthesiologist (10-20cc autologous blood epidural plug) 90% success w/ 1st patch and 98% success w/ 2nd patch

- Mimicker: meningitis which is not a postural HA
<table>
<thead>
<tr>
<th></th>
<th>NORMAL</th>
<th>BACTERIAL MENINGITIS</th>
<th>VIRAL MENINGITIS</th>
<th>TUBERCULOUS MENINGITIS</th>
<th>FUNFAL MENINGITIS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>APPEARANCE</strong></td>
<td>Clear/Colourless</td>
<td>Turbid</td>
<td>Clear</td>
<td>Fibrin Web</td>
<td>Fibrin Web</td>
</tr>
<tr>
<td><strong>PRESSURE (mmH2O)</strong></td>
<td>&lt;180</td>
<td>Elevated</td>
<td>Normal</td>
<td>Variable</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>WBC COUNT (mm³)</strong></td>
<td>0 - 5</td>
<td>&gt;1000</td>
<td>10 - 100</td>
<td>10 - 100</td>
<td>10 - 100</td>
</tr>
<tr>
<td><strong>DIFFERENTIAL COUNT</strong></td>
<td>-</td>
<td>PMNs</td>
<td>Lymphocytes</td>
<td>Lymphocytes</td>
<td>Lymphocytes</td>
</tr>
<tr>
<td>(Predominance)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PROTEIN (mg/dl)</strong></td>
<td>15 - 50</td>
<td>Mild/Markedly Elevated</td>
<td>Normal/Elevated</td>
<td>Markedly Elevated</td>
<td>Elevated</td>
</tr>
<tr>
<td><strong>GLUCOSE (mg/dl)</strong></td>
<td>45 - 100</td>
<td>Mild-Markedly Low</td>
<td>Normal</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>GRAM STAIN</strong></td>
<td>-</td>
<td>Positive</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
</tbody>
</table>
“yellowish” suggests SAH
**NM study**

- Useful to inject a little intra-thecal non-ionic (isovue-M 300) contrast prior to administering the radionuclide to verify that you are indeed in the thecal sac
- A needle is placed into the lumbar thecal sac
- **R/O CSF leak** → CSF is usually collected because of the risk of meningitis
- **Normal Pressure Hydrocephalus (NPH)** → ask the clinician ahead of time if they would like an opening pressure
- 0.5mCi of Indium-111-DTPA (Note that the syringe containing the radiopharmaceutical is not sterile)
- All items that touched the radiopharmaceutical need to be disposed of in a special radioactive disposal container (syringe, needle, etc)
- On the rare occasion that a CT cisternogram and RN cisternogram are done simultaneously, prefer that the radiopharmaceutical is injected before the iodinated contrast so that it has a little longer to circulate before scanning (do CT before nuc med imaging)