Dynamic MR Lymphangiography

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Acknowledgement:

- Dr. Sheena Pimpalwar, MD
- Interventional Radiologist,
- EB Singleton Department of Radiology, Texas Children’s Hospital, Houston, TX
Disclosures

- Financial: None

- Will discuss off-label use of gadolinium contrast agents for MR lymphangiography
Dynamic MR Lymphangiography (d-MRL)

- Combining intra-nodal injection of contrast and MR imaging allows:
  - Rapid 3D visualization of the central conducting lymphatics (CCL)
  - Reliable visualization of the thoracic duct and cisterna chyli
  - Dynamic visualization of contrast transit
  - Lack of venous contamination
  - Improved characterization of lymphatic abnormalities
Outline

- Planning and Patient Selection
- Technique and Image Acquisition
- Interpretation
Outline

• Planning and Patient Selection
• Technique and Image Acquisition
• Interpretation
indications

• Most common indications
  • Chylothorax
  • Chylopericardium
  • Chylosus ascites
  • Protein losing enteropathy
  • Plastic bronchitis
Patient selection

- Children as young as 3 months
  - Less <1 year increased risk of failed study
- Right to left cardiac shunt *not* a contraindication
- General anesthesia
  - Needle position and breath holds
- Inpatient and outpatient
- Combined Interventional and CV radiology procedure
Outline

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Case Example 1

- 20 year old female
- Gastroschisis
- SPEN tumor of pancreas
  - *Status post Whipple procedure with protein losing enteropathy*
- Evaluate central lymphatics for chylolymphatic reflux
Normal d-MRL
Technique

- Formal consultation with Interventional Radiology physician
- Discuss procedure with patient and family
- Ultrasound of inguinal region
- Assess feasibility of lymph node injection
- Place on posterior coil on magnet table, and prep/drape
Technique

- Ultrasound guided placement of 22-25 gauge needle into inguinal lymph node medulla
  - Single capsule puncture
  - Bilateral if possible
  - Long subcutaneous tract
- Test injection to confirm positioning
  - Lymph node slightly swells
  - No fluid extravasation
- No securing to the skin
Technique

- Connected to long tubing which has been primed with gadolinium mixture
  - 0.1 mmol/kg gadolinium dose (Magnevist, Dotarem)
  - 1:1 (older) or 1:2 (younger) dilution with saline
  - Saline chaser
Technique

- Volume as important as concentration
  - >10 y/o: 8 – 10 ml each side
  - <10 y/o: 5 -7 ml each side
  - 1.5 x 2.0 gadolinium dosing and greater dilution, if needed
Technique

- Plastic shield placed over abdomen followed by anterior coil
  - Protects sterile field
  - Lifts weight of coil off patient
- Torso phased array coil
  - 55 cm field of view to cover from lower neck to groin
Technique
Technique:

- MRL protocol comprised of the following sequences:
  - Breath held 3D THRIVE (VIBE/LAVA) sequence as a mask prior to contrast administration
  - Repeat THRIVE every 2 minutes until contrast visualized in the retroperitoneal lymphatics
    - *Increase frequency to every minute to study transit from the retroperitoneal lymphatics to the cisterna chyli/thoracic duct*
  - STIR sequences optional
## THRIVE Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR/TE:</td>
<td>4/1.9 msec</td>
</tr>
<tr>
<td>Flip angle:</td>
<td>10°</td>
</tr>
<tr>
<td>FOV:</td>
<td>40-52 cm</td>
</tr>
<tr>
<td>Fat suppression:</td>
<td>Spectral adiabatic inversion</td>
</tr>
<tr>
<td>Voxel size (acquired)</td>
<td>1–1.3 x 1–1.3 x 2–2.6 mm³</td>
</tr>
<tr>
<td>Voxel size (reconstructed)</td>
<td>0.65–1 x 0.65–1 x 1–1.3 mm³</td>
</tr>
<tr>
<td>Parallel Imaging Factor</td>
<td>2x1 or 2x3</td>
</tr>
</tbody>
</table>

- Image acquisition duration: 20-30 seconds per dynamic

- Krishnamurthy R et al. Radiology, 274(3), 2015
Normal appearance of the CCL on d-MRL

Time in minutes from the start of intranodal injection

Outline

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- Interpretation
Case 2:

- 4 year old female
- Hydrops fetalis and severe edema at birth
- Recurrent chylous ascites, bilateral pleural effusions, and protein losing enteropathy
- MRL to evaluate integrity of the central conducting lymphatics and to screen for pulmonary, retroperitoneal or intestinal lymphatic anomaly
Case 2: d-MRL
Nomenclature of d-MRL

- Recruitment
  - Normal, from pressure injection into node

- Termination
  - Non-visualization of a large channel due to occlusion, disruption, absent development, or lack of filling

- Collateral flow
  - Diversion around obstruction / occlusion via normal channels in expected direction of flow

- Abnormal development
  - Abnormal collection of dilated, serpiginous lymphatic channels

- Reflux
  - Direction of flow away from expected direction of drainage into normal or abnormal channels

- Extravasation/leakage
  - Pooling of contrast within anatomical space (pleural or pericardial cavity) or interstitium
Case 2: Interpretation

- Contrast passes through normal retroperitoneal lymphatics into the cisterna chyli
- Recruitment versus collateral flow into lymphatic channels along gonadal vein
Case 2: Interpretation

- Main central lymphatic channel extends to level of carina
  - Termination of thoracic duct in lower chest
  - Collateral channels in right paratracheal space, drain to cervical collaterals to reach left venous angle, and into right cervical nodes
    - Transient reflux of contrast into right perihilar region that clears
CASE 2: Management

- Findings compatible with a generalized lymphatic anomaly
- Patient treated with sirolimus and furosemide
- No target for interventional therapy at this time
- Sirolimus therapy
  - Improvement in edema
  - Cessation of diuretic therapy
Case 3:

- 13 year old female
- History of recurrent chylopericardium and chylothorax
- Numerous other conditions including interstitial lung disease, pulmonary AVM, lytic bone lesions, and renal/splenic cysts
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- History of recurrent chylopericardium and chylothorax
- Numerous other conditions including interstitial lung disease, pulmonary AVM, lytic bone lesions, and renal/splenic cysts
Case 3: Time resolved MRA for AVM
Case 3: Management

- Sirolimus
- Placement of a Denver shunt
- Coiling of left lower lobe AVM
- Significant Improvement in respiratory symptoms and quality of life
Case 3: Management

• Patient expired 2 years later secondary to acute pulmonary embolism

• Autopsy demonstrated proliferation of muscularized, dilated lymphatic channels through the mediastinum, pericardium, lung, and pleura
Case 4

- 6 year old girl with progressive swelling of the left flank and perineum
  - Progressive
  - Cutaneous vesicles
  - Leaking lymphatic fluid

One year
Case 4: Imaging

- 6 year old girl with progressive swelling of the left flank and perineum
  - Diffuse osseous lesions
  - Diffuse signal abnormality in abdominal and pelvic wall extending into perineum
Case 4: Sclerotherapy unsuccessful
Case 4: d-MRL
Case 4: Findings

- Needles are located within node with no evidence of extravasation
- New onset distention of subcutaneous lymphatic channels
Following Denver shunt placement from SQ space to peritoneal space
Case 4: Management

- Continued on sirolimus and interferon therapy
- Denver shunt placement
- Resolution of lymphatic leak from left flank/perineum
  - Marked lifestyle improvement, able to attend school
- No sclerotherapy!
Case 5

- 29 year old woman
  - Swelling of left extremity at 14 years
  - Severe lymphedema by 22
    - Lymphorrhea
  - Multiple surgical incisions, sclerotherapy, and radiotherapy at outside institution
Case 5: dMRL

- *Right* inguinal lymph node accessed
- Extensive retroperitoneal lymphatic abnormality
Case 5: Management

- Sclerotherapy discontinued
- No role for further interventional therapy
  - Aggressive lymphatic massage
  - Surgical debulking for fibrotic cutaneous masses
  - Consideration of lymphovenous anastomosis
Case 6

- 11 year old male
  - Heterotaxy syndrome with single right ventricle and TAPVC status post Fontan procedure
  - Recurrent plastic bronchitis and pleural effusions
Case 6
Case 6 Management

- No interventional therapy offered
- Underwent heart transplant for failing Fontan
- Complete resolution of plastic bronchitis after transplant
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  • Rapid 3D visualization of central conducting lymphatics
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Dynamic MR Lymphangiography (d-MRL)

- Improved characterization of abnormalities of the CCL than previous modalities
- Development of nomenclature
- Differentiation of generalized lymphatic anomaly from lymphatic malformation
- Potential for mesenteric and extremity nodal access
- Indications for interventional versus medical therapy
- Identification of targets for interventions