Workshop - CTA Runoffs: Upper & Lower Extremity

Lower Extremity

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peripheral CTA; learning objectives

- Feasibility & Barriers
- Technical Principles
  - Image acquisition
  - Contrast agent injection
- Image display strategies
- Vascular Anatomy
- Clinical Applications
feasibility & barriers

• (not so) New Multidetector Scanners
  – Best with ≥64 rows
• High Temporal Resolution
  – scanners may be too fast
• High Spatial Resolution
• Injection Techniques (power & flexible)
• Multi-planar & 3D Visualization
  – imbedded in PACS or Imaging Lab
• Demand from Vascular Surgery
scanners & injectors
advantages of CTA

• Short exam time
• Availability
• High spatial resolution
• Calcium & Vessel wall characterization
• Non-vascular abnormalities
• Implantable devises
• Large patients, Claustrophobia
high spatial resolution calcium & vessel wall characterization
non-vascular abnormalities
implantable devices; metal artifact reduction algorithms
adversities

- IV contrast nephrotoxicity
  - hydration
- Small vessels most peripherally
- Advanced image processing
- Bone interference
- Common metal artifacts
- Radiation
calcification blooming & soft plaque
bone interference
metal artifacts
scanning technique

• Position
  – tape extremities
  – Lower extremities: feet inward
  – upper extremities: above head (preferred) – by patient’s side

• Scout
  – determine scanning range to assess inflow (proximal to common femoral a. or axillary a.) & outflow
    • abdomen w/ run-off – torso w/ run-off (arch to feet)
  – center

• Low-dose non-Contrast
  – limit to area of interest

• CTA

• 2nd scan (feet-to-knee immediately after cranio-cadual run)
  – leg (helpful 10%) - arm (fingers to elbow - less helpful)
positioning
2nd-run
2nd run – venous contamination
## Scanning Technique

### Upper Extremity Run-off
- **Arm Above Head**
  - NC: kVp 120, mA 80, NI 30, ASIR 30%
  - CTA: kVp 80, mA 300, NI 21.85, ASIR 30%
  - Delay: kVp 80, mA 250, NI 21.85, ASIR 30%

### Lower Extremity Run-off
- **Arm On Side**
  - NC: kVp 120, mA 200, NI 30, ASIR 30%
  - CTA: kVp 100, mA 600, NI 21.85, ASIR 30%
  - Delay: kVp 100, mA 250, NI 21.85, ASIR 30%
iv contrast injection

- **Contrast Medium**
  - 350 mg I/mL - 100 mL (130 in torso w/ runoff)

- **Injection Rate**
  - 4 mL/sec
  - 30 mL NS test – 100 mL Contrast – 40 mL NS flush
    - (Biphasic injection: 120 mL: 5 mL for 4 sec - 4 mL rest)

- **Scan Trigger (contrast transit time)**
  - Location: aorta at start of scan
  - Delay 10 sec (arch) -12 sec (T12) – 15 sec (bifurcation)
  - Interscan delay: 2.5 sec
  - Threshold: 200 HU ↑ (150 HU in torso w/runoff)
visualization techniques

• From Scanner to PACS
  – Axial (average density): 2.5mm x 2.5 mm images
  – Coronal and Sagittal (MIPs): 15 mm x 5 mm interval
    • Abdomen (torso) – Thighs – Legs (overlapping)
    • Upper arm – forearm – hand (optional)

• Scanner to Workstations
  – Source images: 0.625 mm x 0.625 mm

• Work Stations
  – Whole body MIPs & VRs with bone segmentation
  – Curved reforms with at least 2 perpendicular renderings or rotations around center axis
axial images 2.5 mm
thick slab MIPs 15 mm thick x 5 mm
thick slab mips 15 mm thick x 5 mm
thick slab mips 15 mm thick x 5 mm
thick slab mips  15 mm thick x 5 mm
thick slab mips  15 mm thick x 5 mm
work stations - imaging lab
work stations - imaging lab
curved planar reformations (CPR)

Lower Extremity CPR
• Aorta → celiac, SMA, renal a.
• Aorta → external iliac → common femoral a.
• Common femoral → popliteal a.
• Popliteal a → a tibial, p tibial, peroneal

Upper Extremity CPR
• Arch → subclavian → axillary → brachial
• Brachial → radial, ulnar, interosseous
curved planar reformations
curved planar reformations
curved planar reformations
curved planar reformations
<table>
<thead>
<tr>
<th>Description</th>
<th>Images</th>
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<tbody>
<tr>
<td>CTA ABD AND PELVIS</td>
<td>2 images</td>
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<tr>
<td>SCOUT RUN OFF</td>
<td>2 images</td>
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<tr>
<td>CTA ABD AND PELVIS</td>
<td>5 images</td>
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<td>C- RUN OFF LOW DO</td>
<td>269 images</td>
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<tr>
<td>CTA RUN OFF</td>
<td>762 images</td>
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<td>Screen Save</td>
<td>2 images</td>
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<td>Smart Prep Series</td>
<td>8 images</td>
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<td>3D MP</td>
<td>13 images</td>
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<td>3D VR</td>
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<td>3D CURVE TO LT EXT</td>
<td>20 images</td>
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<td>3D CURVE TO RT EXT</td>
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<td>RT ANT CURVE</td>
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<td>LT PER CURVE</td>
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<td>LT POS CURVE</td>
<td>20 images</td>
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<tr>
<td>cORONAL 15 x 5 MIPS</td>
<td>53 images</td>
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<td>SAG 15 x 5 MIPS</td>
<td>74 images</td>
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<td>cORONAL 15 x 5 MIPS</td>
<td>68 images</td>
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<td>90 images</td>
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<td>Dose Report</td>
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<td>LOW LEG ARTERIAL ...</td>
<td>25 images</td>
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<tr>
<td>LOW LEG 3D MIP ROT...</td>
<td>25 images</td>
</tr>
<tr>
<td>LOWER LEG VR</td>
<td>3 images</td>
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- **28 series**
- **1,894 images**
- **20 min room time**
- **20 min image processing**
Image display strategies

• Axial images
  – Quick overview
  – Extravascular abnormalities
  – Vessel, plaque analysis
• Whole body MIP & VR
  – Road map
• CPR
  – Vessel & plaque analysis
• Optional tools
  – Multipath CPR - Thin & thick slab MIPs & VRs - PACS viz tools - Plaque analysis tools - Metrics
whole thickness mips & vr – zoom in abnormality

cold R foot
whole thickness mips & vr – zoom in abnormality
plaque analysis
lesion analysis tools
pitfalls

• Calcified plaque (interactive window adjustment)
  – Blooming artifact – stenosis assessment
  – Medium & small size vessels assessment
• Over- or under- editing in image processing
• Stent & graft patency
• Metal artifacts (new algorithms strategies)
  – Orthopedic devices
  – Stents and coils
• Overshoot IV contrast
  – Fast scanning – slow flow
• Venous contamination
interactive window adjustment
Graft patency evaluation with cpr
new technical innovations

- Multi-energy applications
  - Iodine imaging
  - Subtraction techniques
- kV & mA modulations
- Metal reduction artifacts techniques
- Large volume sequential scanning
- Improved autosegmentation techniques
metal artifact reduction
dual energy – iodine reduction
dual energy – iodine reduction
dual energy – iodine reduction
dual energy – iodine reduction
vascular anatomy – lower extremity

Common Femoral a.

- Profunda
- Superficial Femoral a
- Popliteal a
- Tibioperoneal trunk
  - Posterior Tibial a
  - Peroneal a
  - Plantar a (medial, lateral)
- Anterior Tibial a.
- Dorsalis pedis a
vessel analysis

- Atherosclerotic steno-occlusive disease
  - Plaque composition
    - Calcified (degree) – soft – mixed - ulceration
  - Location & extend
    - Focal, short or long segment
  - Degree of stenosis
    - Minimal (<25%) – mild (<50%)
    - moderate (<70%) – severe (>70%) – occluded
  - Collaterals

- Vasculitis
  - Wall thickening
  - Inflammatory changes - stranding
clinical applications – lower extremity

- Atherosclerotic steno-occlusive disease
  - intermittent claudication – chronic critical ischemia
  - pre & post stent or graft evaluation & vasc mapping
- Aneurysm
- Embolism – blue toe
- Trauma and Orthopedic procedures
- AVM & other anomalies
- Non-atherosclerotic occlusive disease
  - Takayasu – Buerger dx
- Other
  - popl a. entrampent – adventitial cystic dx – vasculitides
lower extremity atherosclerotic dx

- **ABI (Ankle - Bbrachial Index)**
  - Systemic pressure index of < 0.9
    - 0.9-0.4: claudication; <0.4 rest pain

- **Leriche classification**
  - Type I: distal aorta & Common Iliac a.
  - Type II: aorto-iliac
  - Type III: aorto-iliac & femoro-popliteal

- **TASC II: (Trans-Atlantic inter-Society Consensus)** for the management of peripheral arterial disease
TASC II lesion classification; femoral-popliteal disease

- **Type A lesions**
  - 1 Stenosis $\leq 10$ cm
  - 1 Occlusion $\leq 5$ cm

- **Type B lesions**
  - >1 lesions each $\leq 5$ cm
  - 1 lesion ↑knee $\leq 15$ cm
  - Lesions in the absence of continuous tibial a.
  - Heavy Calc Occl $\leq 5$ cm
  - 1 popl stenosis

Norgen L et al *Eur J Vasc Endovasc Surg* 2007; 33
type A & B lesions
TASC II lesion classification; femoral-popliteal disease

- **Type C lesions**
  - >1 lesions sum >15 cm
  - Recurrent lesions post 2 interventions

- **Type D lesions**
  - Chronic occlusion CFA or SFA >20 cm
  - Chronic occlusion popliteal & proximal trifurcation

Norgen L et al. Eur J Vasc Endovasc Surg 2007; 33
type D lesion
graft(s) assessment and follow up
acute thrombosis - embolism
acute thrombosis - embolism
popliteal aneurysm
pseudoaneurysm
conclusions

• Peripheral CTA is extensively and increasingly used for upper and lower extremity vascular disease
  – imaging technique of choice for many vascular surgeons

• Helpful in vascular mapping, assess disease, treatment planning, post treatment monitoring

• Attention to acquisition technique is important.

• Availability of advanced visualization techniques has markedly enhanced utilization of exam.
Bibliography

• Fleischman DF, Hallett RL, Rubib GD. CT angiography of peripheral arterial disease. J Vasc Interv Radiol 2006; 17: 3-26
• Kock MCJM, Dijkshoorn ML, Pattynama PMT, Hunink MGM. Multidetector row computed tomography angiography of peripheral arterial disease. Eur Radiol 2007;17: 3208-3222
• Foley WD, Stonely T. CT Angiography of the lower extremities. Radiol Clin NA 2010;48: 367-396
• Norgren L, Hiatt WR, Dormandy JA et al. Inter-society consesus for management of peripheral arterial sisease (TASSC II). Eur J Vasc Endovasc Surg 2007;33: S1-S-75
• Hellinger JC Epelman M, Rubin GD. Upper extremity computed tomographic angiography: state of the art technique and applications. Radiol Clin NA 2010;48: 397-421