MR Angiography
Techniques & Applications

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Vascular Imaging

- Arterial flow void
- Flow enhancement
- Gadolinium enhancement
Vascular Flow Voids
History: 35-year-old male with intermittent diplopia due to a sixth nerve palsy
Vascular Encasement
**MR Flow Void**

**Arterial Flow**

- **90 RF**
- **180 RF**

**Signal**

**Voxel Flow**

- **No flow**
- **Flow = 1/3 voxel**
- **Flow = 2/3 voxel**
- **Flow = 1 voxel**

**Voxel Signal**
Flow Enhancement
Flow Enhancement

Venous Flow: Short TR-TE Spin-echo

No flow

Flow = 1/3 voxel / TR

Flow = 2/3 voxel / TR

Flow = 1 voxel / TR

Flow = 2/3 voxel / TR

Flow = 1 voxel / TR
Flow Enhancement

Arterial Flow: Gradient echo

RF

TR

RF
MR Angiography

Pulse Sequences

- 2D time of flight
- 3D time of flight
- 2D phase contrast
- 3D phase contrast
2D Time of Flight

- TR 20-25 msec, TE 4.0 msec
- Flip angle 45-60 degrees
- 1.5 mm sections
- Moving SAT band
- MIP algorithm
Normal 2D-TOF MRA
Segmented MIP
History: 23 y/o female with neck pain & vertigo following a snowboard accident
Dx: Bilateral vertebral artery dissection

4 months later
3D Time of Flight

- TR 9.0 msec, TE 2.0 msec
- Flip angle 15-25 degrees
- 6-8 cm volume, phase encode in 2 directions
- 0.6-1 mm sections
- Superior SAT band
- MIP algorithm
Normal 3D-TOF MRA

{Video clip}
3D vs. 2D Time of Flight

- Higher signal-to-noise
- Shorter imaging times
- Less intravoxel dephasing
- Smoother vessel contours
- More saturation effects
3D TOF at 3T
History: 47 y/o man with von-Hippel-Lindau disease & new left arm weakness
Dx: Infarct & MCA stenosis
History: 40 y/o man with episodes of left sided weakness.
Dx: Cerebral arteritis
2D Phase Contrast

- TR 25 msec, TE 6-7 msec
- Flip angle 15-20 degrees
- 2-4 cm slab
- VENC factor
- Single projection image
Phase Contrast MR Angiography

Velocity Encoding

Gradient | 1st Excitation
---|---

Gradient | 2nd Excitation

Time

T
3D Phase Contrast

- TR 25 msec, TE 6-7 msec
- Flip angle 15-20 degrees
- 6-8 cm volume
- 0.6-1 mm section
- VENC factor
- MIP algorithm
PC vs. TOF Angiography

- Less saturation effects
- Not affected by thrombus
- Velocity / flow information
- Long imaging times
- Arterial VENC misses slow flow
Phase Contrast
Flow Direction
TOF vs. PC

2D-TOF

3D-PC
PC: Pseudo-occlusion

3D-PC

TOF

Q-209-12
Imaging Slow Flow

- Thin-section 2D TOF
- Longer TR
- Lower flip angle
- Lower VENC factor
- Gd enhancement
Intravoxel Dephasing & Signal Loss
Intravoxel Spin Dispersion

Strategies To Minimize

- Smaller voxel size
- Shorter TE
- Flow compensation
- Gd-enhanced MRA
Gd-Enhanced MRA

- 3D gradient-echo sequence
- TR 4.5 msec, TE 1.5 msec
- High bandwidth & fractional echo
- Flip angle 25 degrees
- Matrix 173 x 256, FOV 187 x 250
- Coronal volume 7 cm with 64 partitions
- 20 ml Gd injected @ 2ml/sec
- Acquisition time 21 sec
Timing Bolus Acquisition
Normal Gd-enhanced MRA

{Click for video}
History: 83 y/o woman with slurred speech
Dx: Gd-MRA, multiple stenoses

{Video clip}
History: 49 y/o man with neck pain following an MVA
Dx: Vertebral dissection

{Video clip}
History: 51 y/o man with right-sided facial dysesthesias & ataxia
Dx: Lateral medullary syndrome & right vertebral occlusion
Vulnerable or High-Risk Atherosclerotic Plaque

Imaging Criteria

- Thin fibrous cap
- Large lipid-necrotic core
- Fissured plaque
- Stenosis > 90%
- Intraplaque hemorrhage
- Other factors: Inflammation, endothelial dysfunction, platelet aggregation
History: 48 y/o women with trauma to the neck
Venous / Sinus Occlusion

Causes

- Hypercoagulable state
- Pregnancy
- Sepsis
- Dehydration
- Paranasal sinus infection
- Neoplastic invasion
2D TOF MR Venography

- TR 21 msec
- TE 4-6 msec
- Flip angle 60°
- 1.5 mm sagittal or coronal sections
- Axial SAT band below skull base
- MIP algorithm

{Video clip}
History: Newborn girl with seizures & decreased alertness
Dx: Hemorrhagic infarct with thrombosis of deep venous system, straight sinus & right transverse sinus

Day 7
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2 cm to right
History: 40 y/o woman with polycystic kidneys, renal failure, acute visual deficits & seizures
Dx: Hypertensive encephalopathy

2D PC Slabs
History: 32 y/o woman with headache, confusion & weakness
Dx: Thrombosis of superior sagittal sinus, left transverse sinus & deep venous system

Confusion & weakness
Meningioma
History: 60 y/o female with ataxia following trauma and concussion
Dx: MCA aneurysm
History: 66 y/o male with dizziness and possible basilar insufficiency
Dx: ACA aneurysm
History: A 62 y/o female with headaches for 3 weeks & a new 3rd nerve palsy
Dx: Acom & Pcom Aneurysms
History: 37 y/o woman with migraine headaches for many years
Dx: 2 mm AComm aneurysm
MR Angiography

Aneurysms

- High risk patients
- 3D time-of-flight
- A screening procedure ONLY
- View source, collapse & MIP images
- 86-95% sensitivity for aneurysms
  5 mm or larger
History: 80 y/o man with hypertension, slurred speech & unsteady gait

{Video clip}
History: 63 y.o. man with episode of aphasia & right sided weakness.
Dx:
History: 52 y/o woman with chronic seizures
Dx: AVM
History: 73 y.o. man with visual field deficits
Visual deficits
{Page 2}
Dx: AVM & basilar tip aneurysm
MR Angiography

Problems & Pitfalls

- Turbulence / nonlaminar flow
- Slow flow / near complete occlusion
- Flow stasis & recirculation
- Thrombus
- Limited resolution

Solution = Gd-enhanced MRA