Automatic Selection of Mask and Arterial Phase Images

for Temporally-Resolved MR Digital Subtraction Angiography

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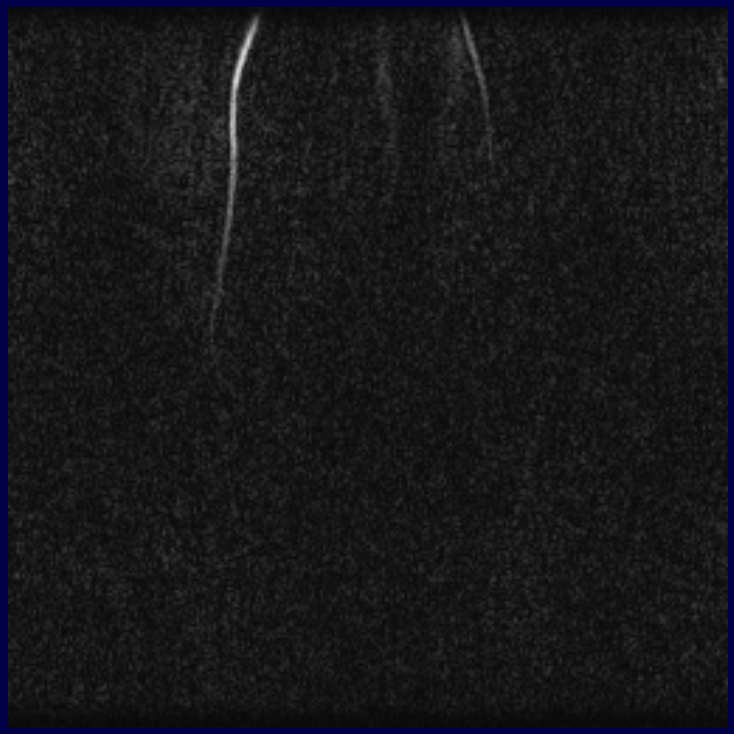

Department of Radiology
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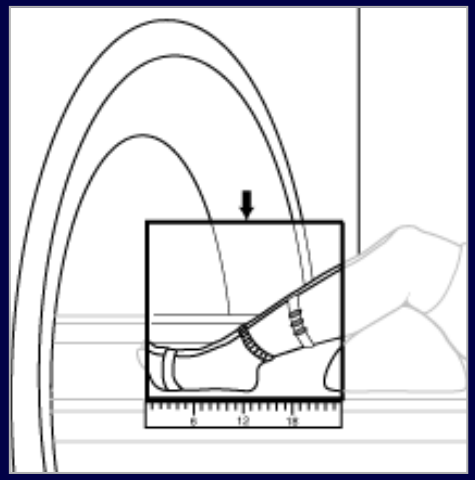
Cornell University

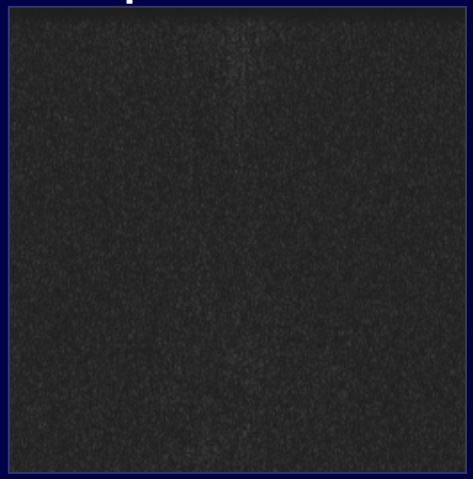
2D Projection MRA: 5 ml Gd



Coronal T1

Raw image

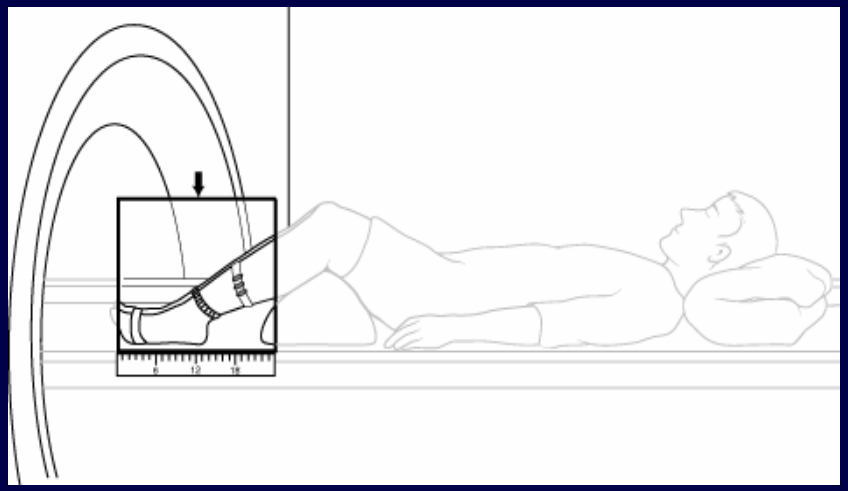
Complex subtraction



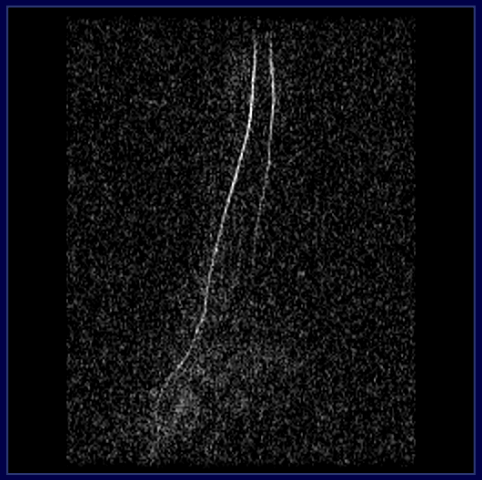
Left

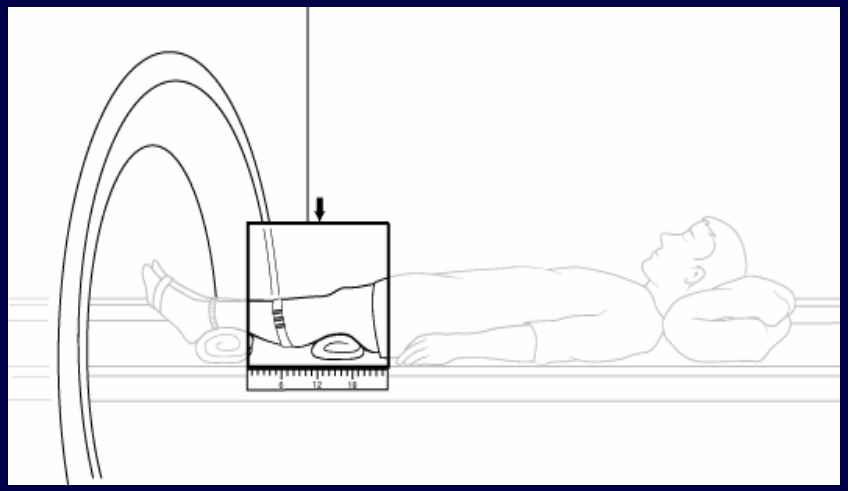
Right

2D Projection MRA: + complex subtraction

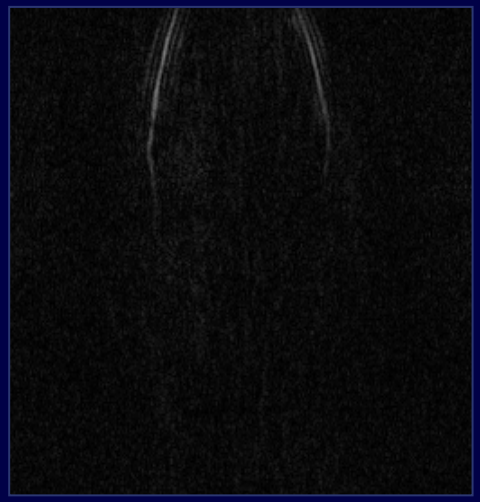


Ankles

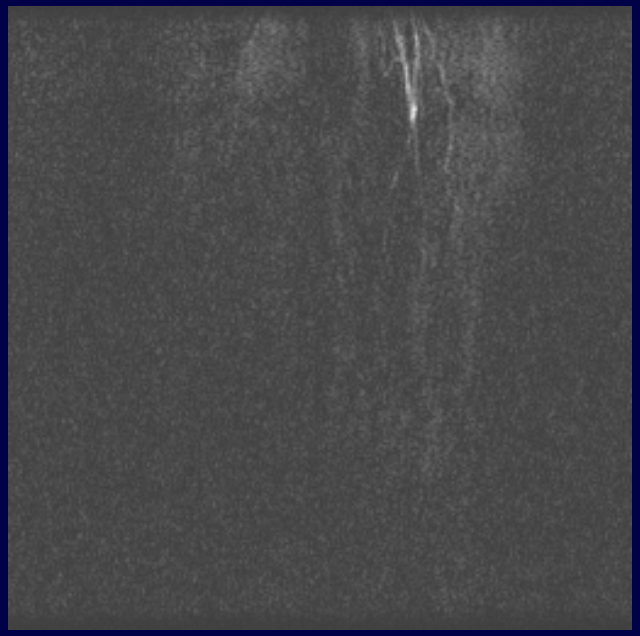




Knee



Time-resolved background-subtracted CEMRA



- Time-resolved image gives too many images
- Surgeon prefers one image that shows everything
- Our goal: Create a single best subtraction image by combining best mask and best arterial phase images

Coronal spoiled gradient echo sequence parameters

- TR/TE/flip angle = 10/2/60 degrees
- Slab thickness = 7-10 cm
- Field-of-view = 30cm
- Matrix = 256x192
- Bandwidth = 16 kHz
- The imaging time
  - 1.95 seconds per acquisition
  - repeat the acquisition 35 times
  - total of 67 seconds

Major challenges

- Identify the contrast bolus arrival
- Avoid motion corrupted images
- Tedious manual procedure


Untitled - idsa_v5
File View Help
FTP Connect
PFile Open
AutoDSA
Window/Level
Ready
NUM

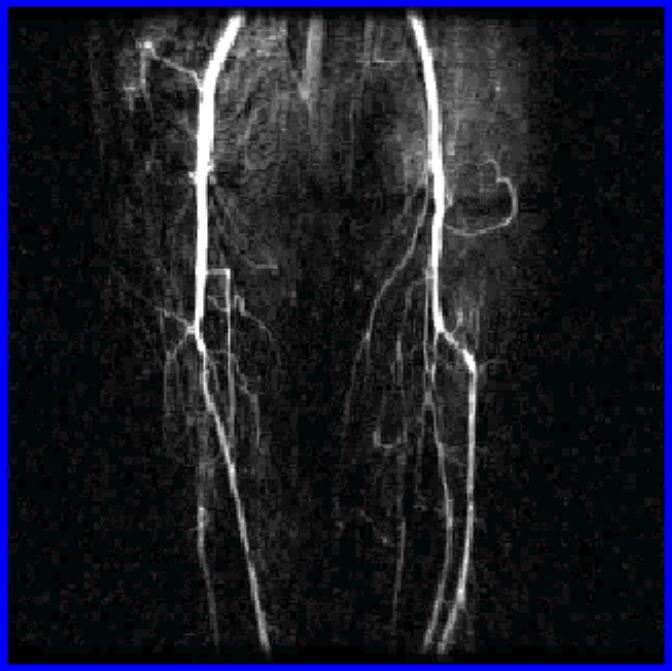
Major challenges

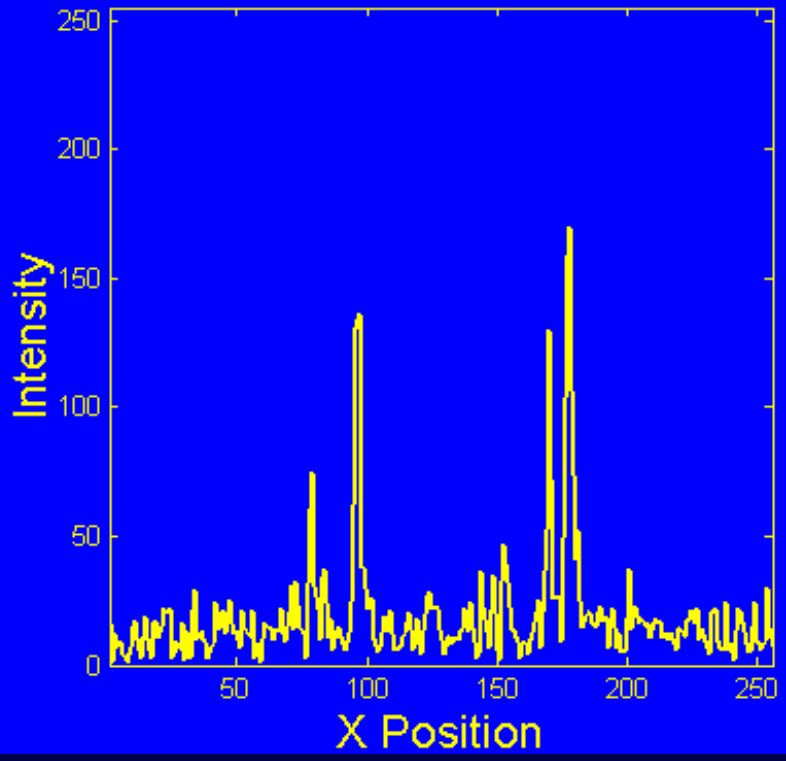
- Identify the contrast bolus arrival
- Avoid motion corrupted images
- Tedious manual procedure
- Issues
  - Quantify “image quality”
  - Select the mask and arterial phase images based on image quality

Subtracted Image Quality Evaluation

- Two basic criteria
  - Bright foreground (i.e. artery)
  - Dark background
- Quality = avg(Artery) – avg(Background)
- Problem: How to determine whether each pixel is in artery or background
- We need assumptions!
  - Artery is thin and vertically oriented
  - Artery width is typically 1-5 mm

Artery-Background Classification





Artery-Background Classification

- A pixel is in the artery
  - If the pixel ranks in brightness between 1st and 2nd of 128 pixels in the scan line.
- A pixel is in the background
  - If the pixel ranks in brightness between 11th and 128th of 128 pixels in the scan line.
- Unclassified
  - Otherwise

Select mask and arterial phase

Contrast arrival detection

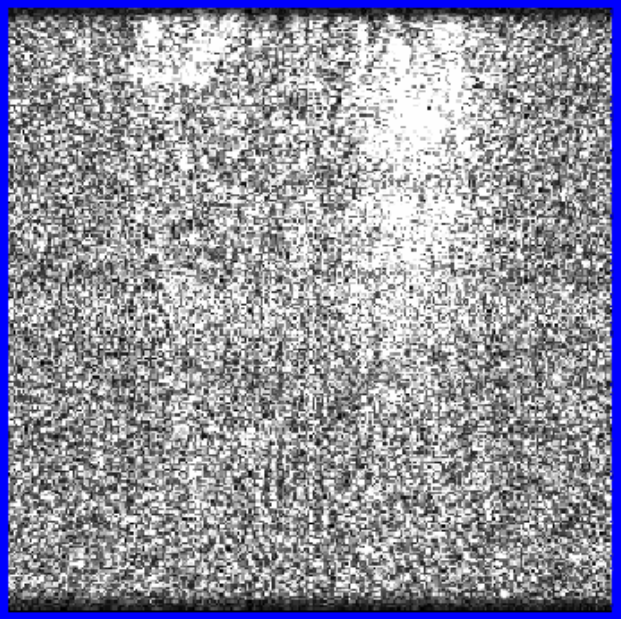
↓

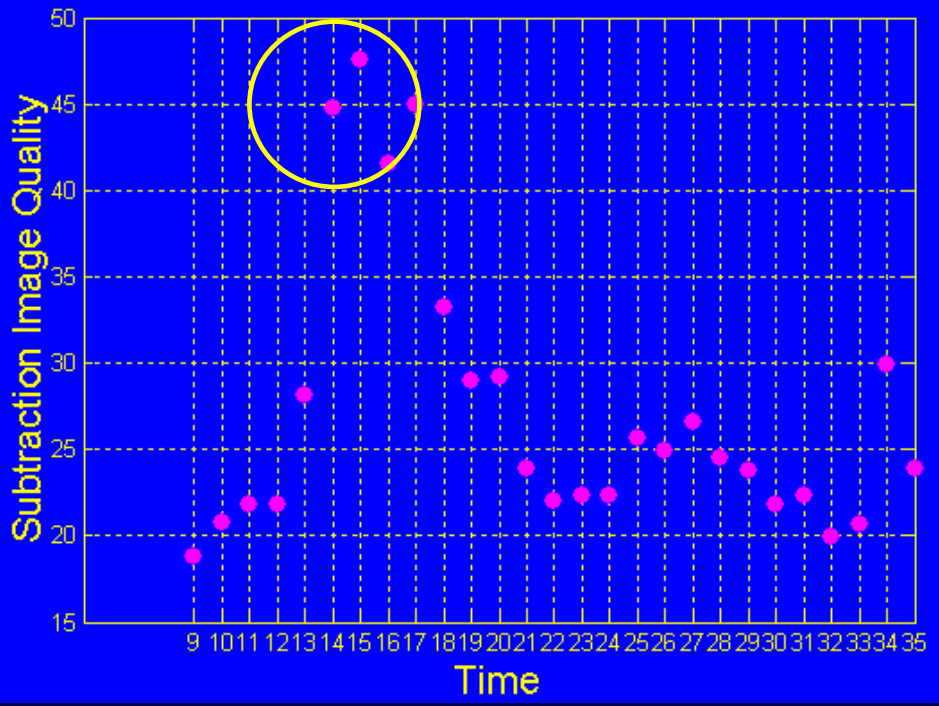
Best mask /
arterial phase pair selection

↓

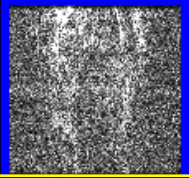
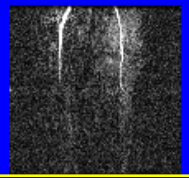
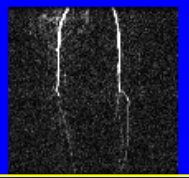
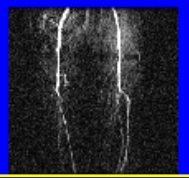
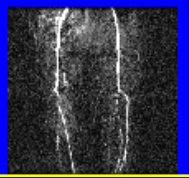
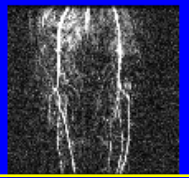
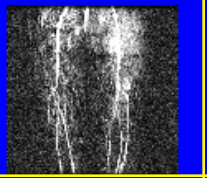
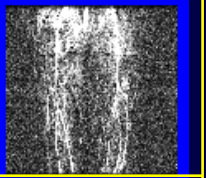
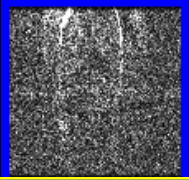
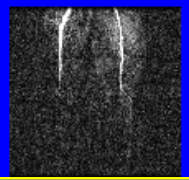
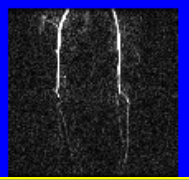
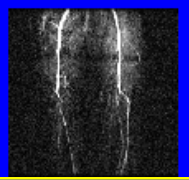
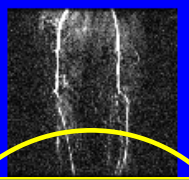
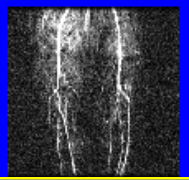
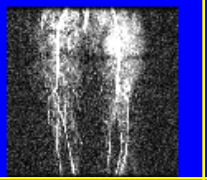
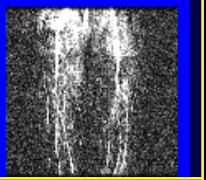
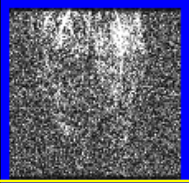
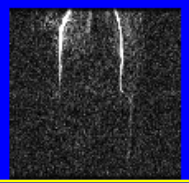
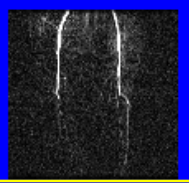
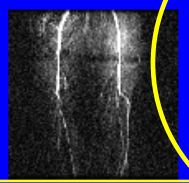
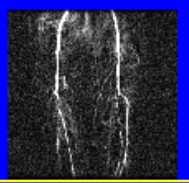
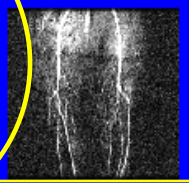
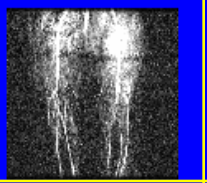
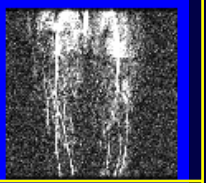
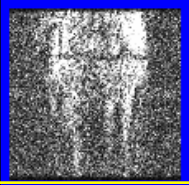
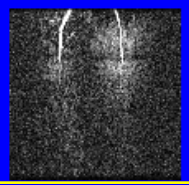
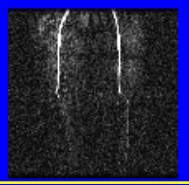
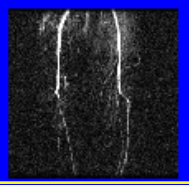
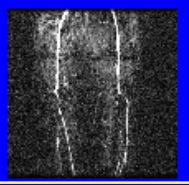
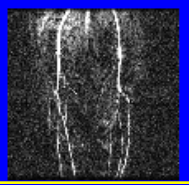
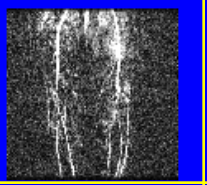
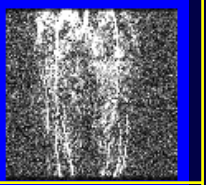
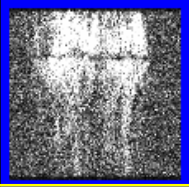
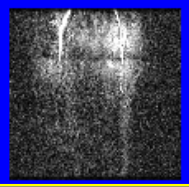
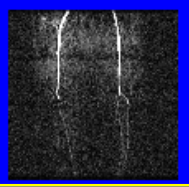
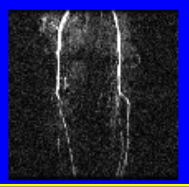
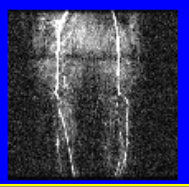
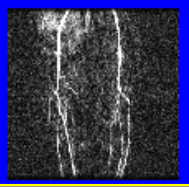
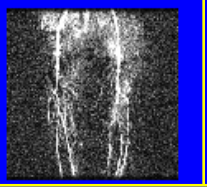
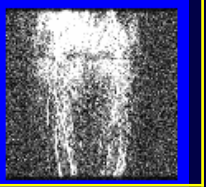
Best mask set /
arterial phase set selection

Contrast Arrival Detection

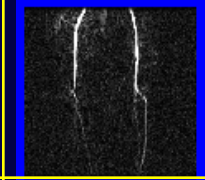
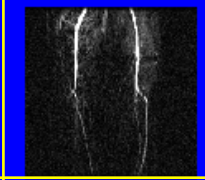
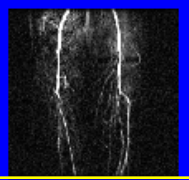
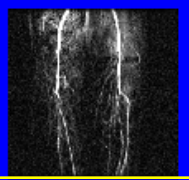
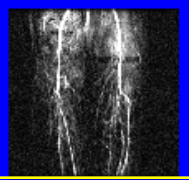
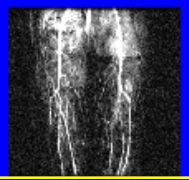
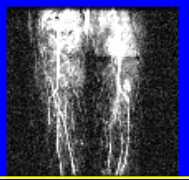
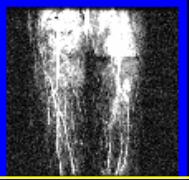
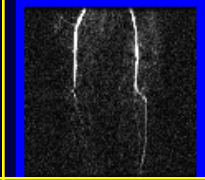
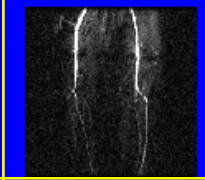
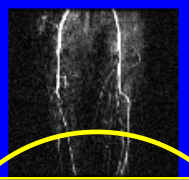
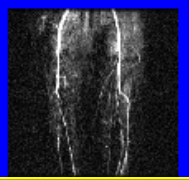
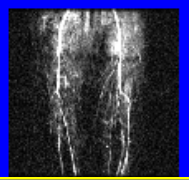
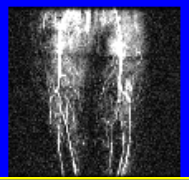
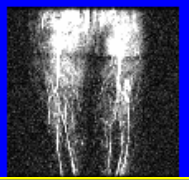
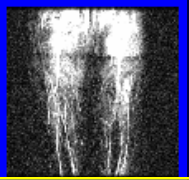
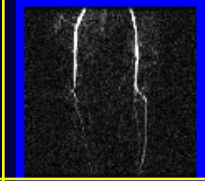
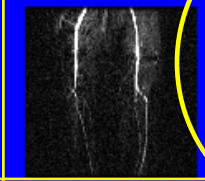
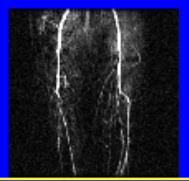
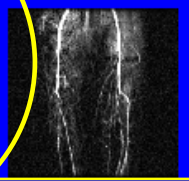
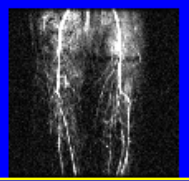
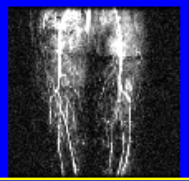
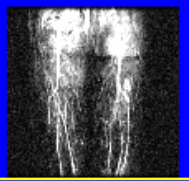
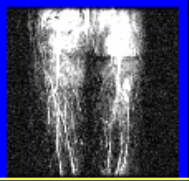
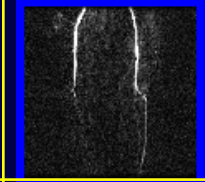
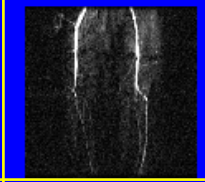
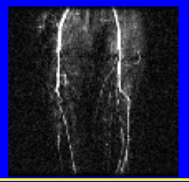
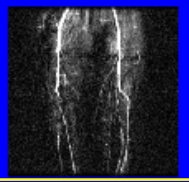
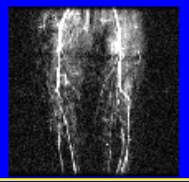
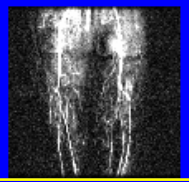
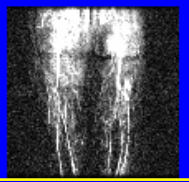
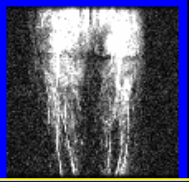
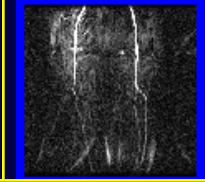
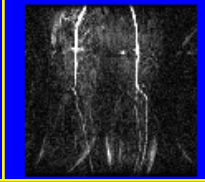
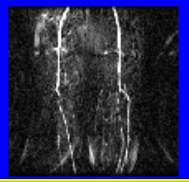
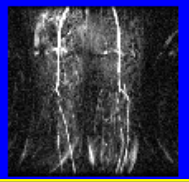
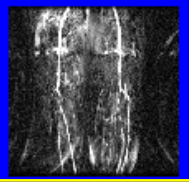
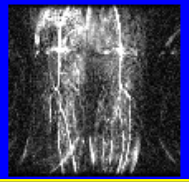
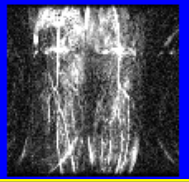
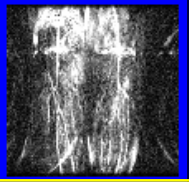


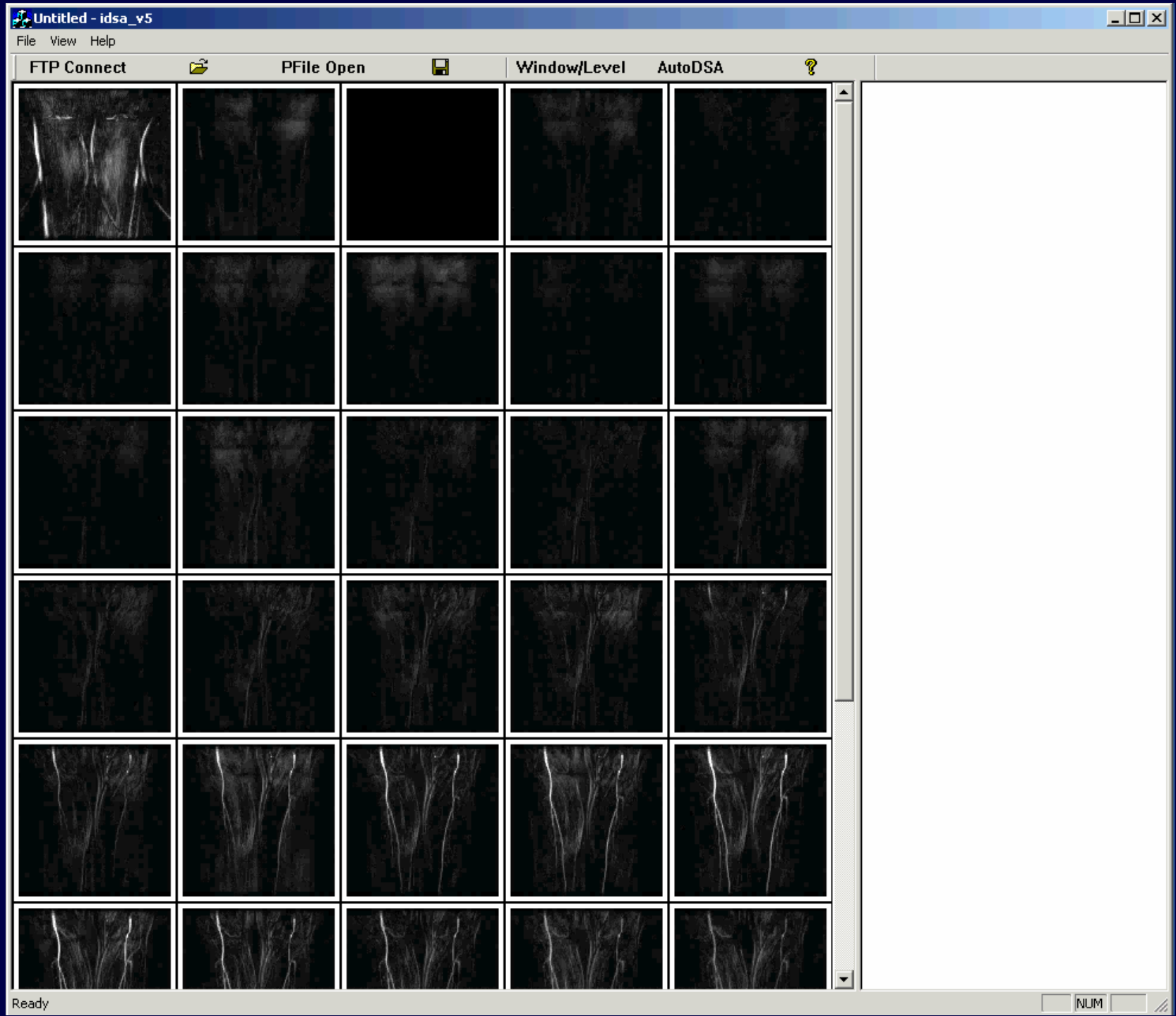


Best mask / arterial phase pair selection

	arterial 1	arterial 2	arterial 3	arterial 4	arterial 5	arterial 6	arterial 7	arterial 8
masks 5	30.99 	29.61 	35.59 	39.55 	42.90 	41.24 	37.44 	33.23 
masks 4	33.13 	29.57 	35.25 	38.17 	43.03 	40.37 	35.99 	35.04 
masks 3	32.00 	29.91 	34.39 	36.94 	43.71 	38.59 	35.95 	35.32 
masks 2	29.43 	28.89 	32.91 	38.82 	41.53 	41.41 	38.77 	30.89 
masks 1	26.94 	27.92 	32.55 	39.83 	39.58 	42.36 	37.82 	28.83 

Best mask set / arterial phase set selection

	arterials 1	arterials 2	arterials 3	arterials 4	arterials 5	arterials 6	arterials 7	arterials 8
masks 5	36.82 	38.29 	43.76 	43.31 	43.17 	41.06 	37.81 	36.17 
masks 4	35.54 	36.94 	42.50 	42.02 	42.04 	40.25 	36.92 	35.01 
masks 3	36.40 	38.10 	44.54 	43.33 	43.17 	41.30 	38.03 	36.27 
masks 2	35.54 	36.94 	42.50 	42.02 	42.04 	40.25 	36.92 	35.01 
masks 1	35.89 	38.18 	44.42 	42.68 	42.16 	39.19 	37.10 	35.21 


Untitled - idsa_v5
File
View
Help
FTP Connect
PFile Open
Window/Level
AutoDSA
Ready
NUM

Patients

- Period: Sep 11, 2000 to Nov 25, 2000
- Demography
  - 26 males aged 24 – 87 (mean 70) years
  - 19 females aged 33 – 85 (mean 68) years.
- The primary indications
  - claudication (n=23)
  - limb threatening ischemia (n=11)
  - aneurysm (n=7)
  - post-bypass graft (n=3)
  - dissection (n=1).
- Approved by our Institutional Review Board.

Image evaluation

- Blind test by two radiologists (MRP, HE)
  - Auto >> Manual
  - Auto > Manual
  - Auto ≅ Manual
  - Auto < Manual
  - Auto << Manual

- Statistical analysis
  - Paired signed-rank Wilcoxon test

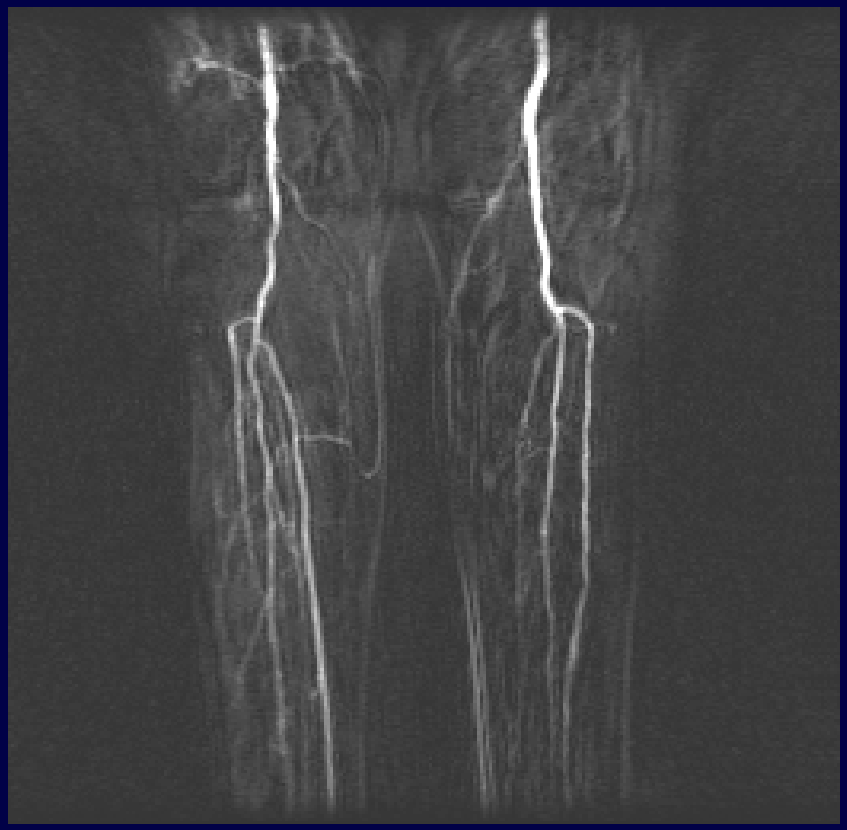
Image Quality Comparison

	Radiologist 1	Radiologist 2	Total
Auto >> Manual	3	3	6
Auto > Manual	25	11	36
Auto ≅ Manual	2	9	11
Auto < Manual	11	17	28
Auto << Manual	4	5	9
p value	0.1533	0.2043	0.9081

Automatic wins

Automatic

Manual

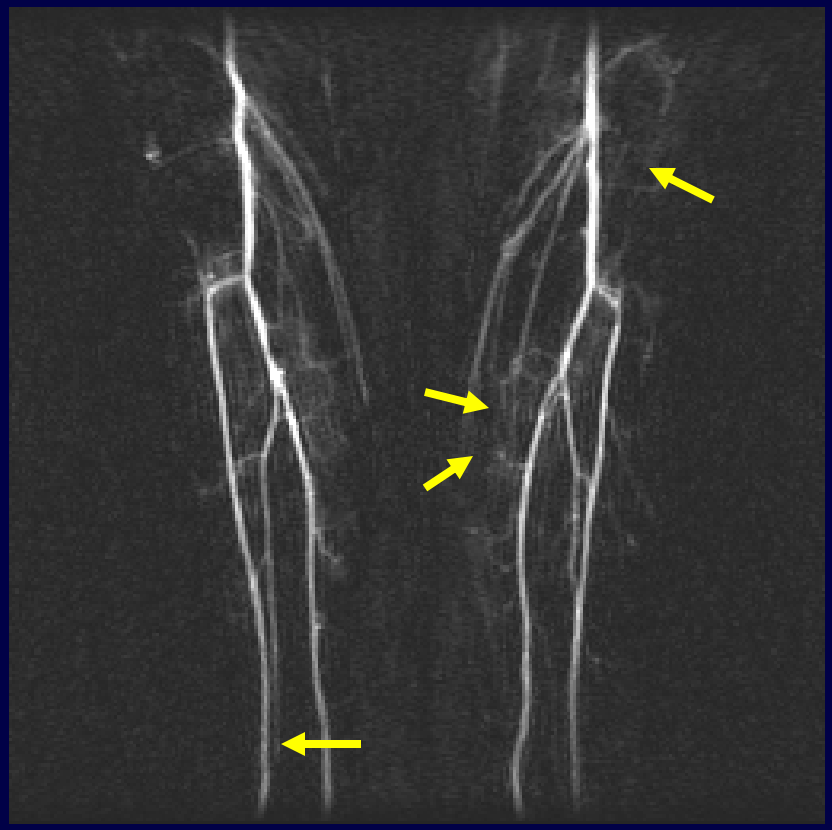


Better geniculate arteries

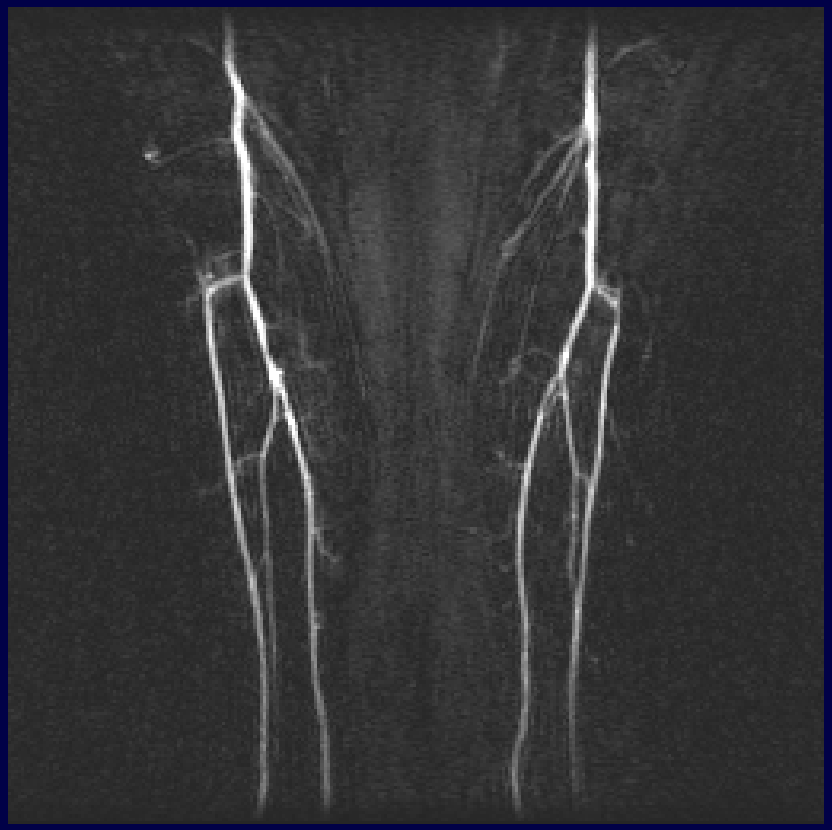
Auto > Manual (both readers)

Automatic wins

Automatic



Manual

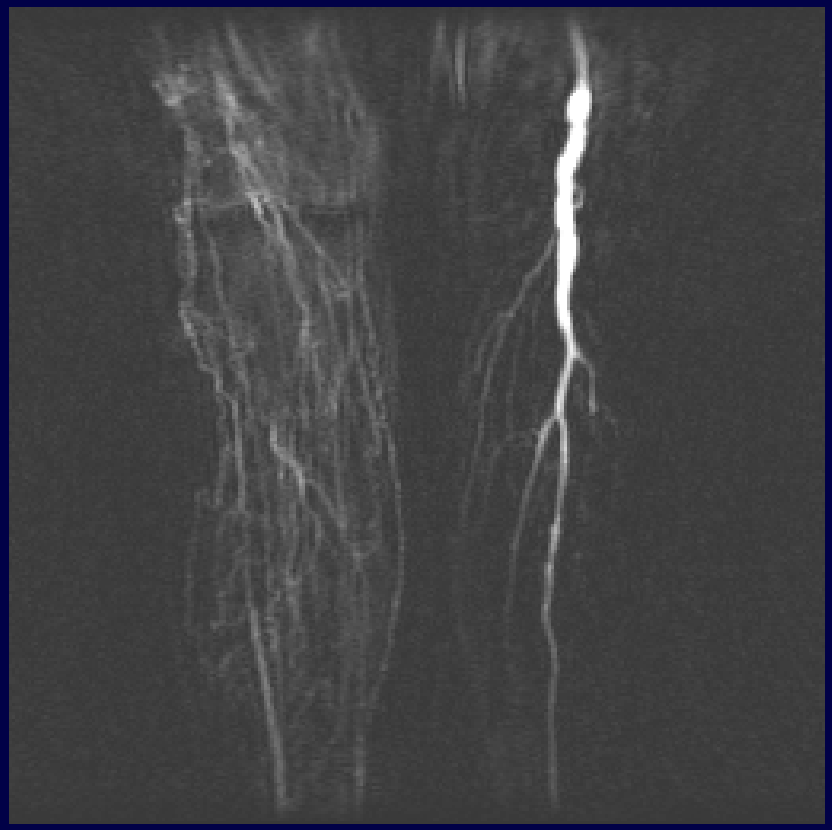


More details of distal arteries but more background veins in the left leg

Auto > Manual (reader 1) and Auto >> Manual (reader 2)

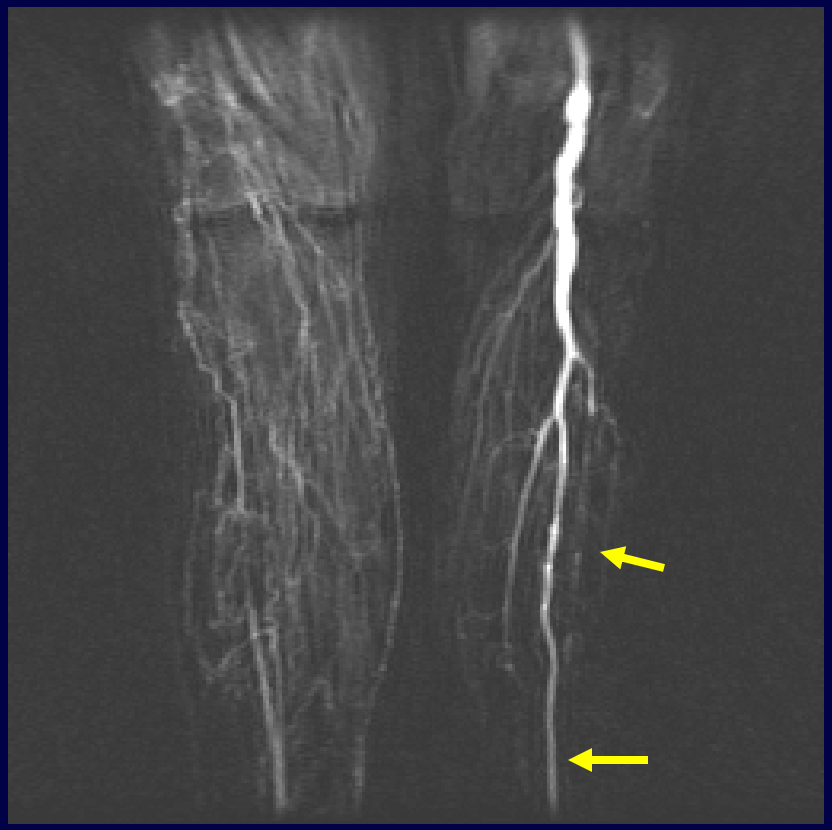
Trade-off

Automatic



Reduction in background motion artifacts

Manual

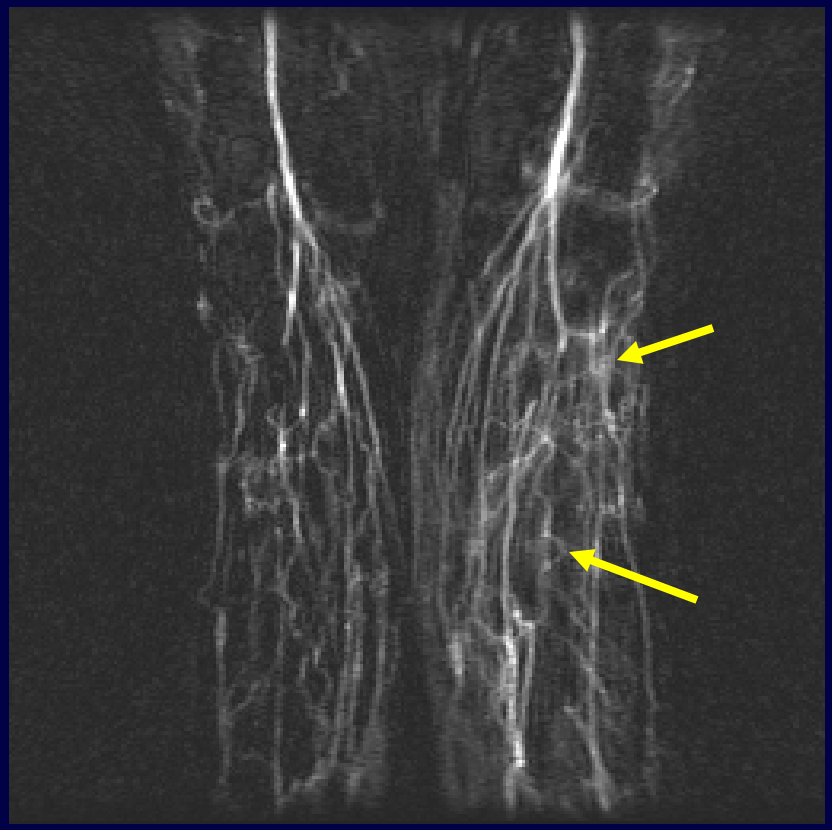


More details in distal left leg

Auto < Manual (both readers)

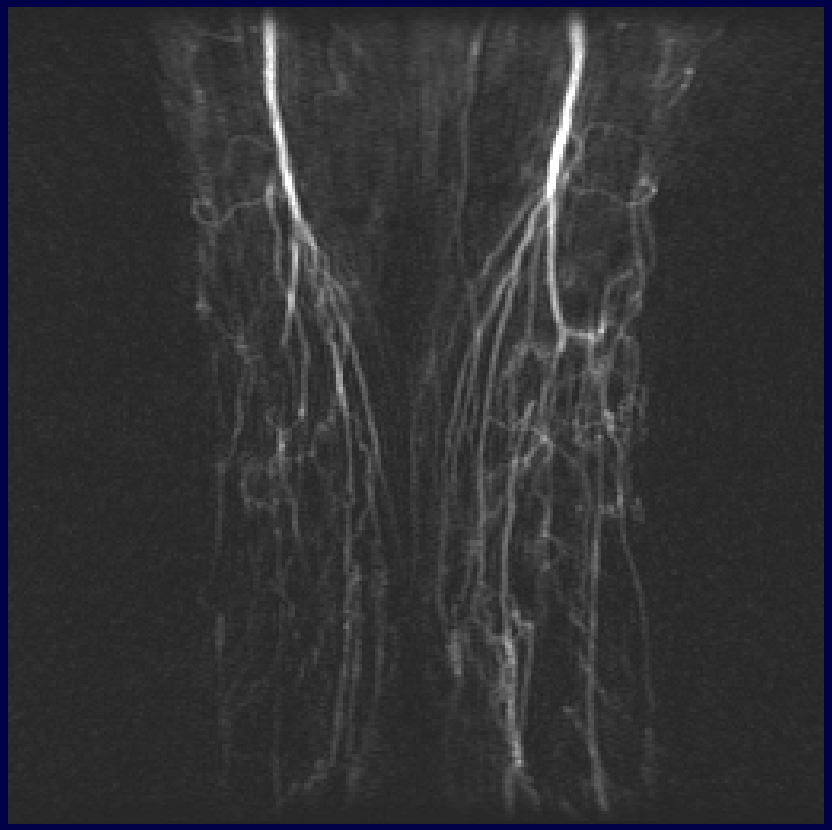
Trade-off

Automatic



More details of distal arteries but more background veins in the left leg

Manual

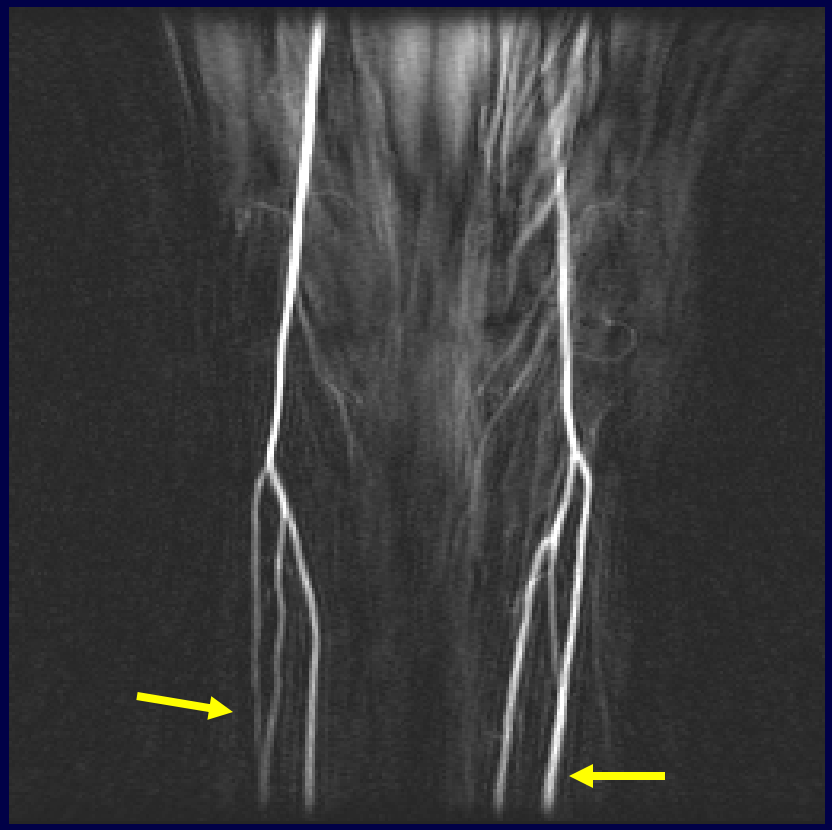


Slightly better proximal arteries

Auto < Manual (reader 1) and Auto ≅ Manual (reader 2)

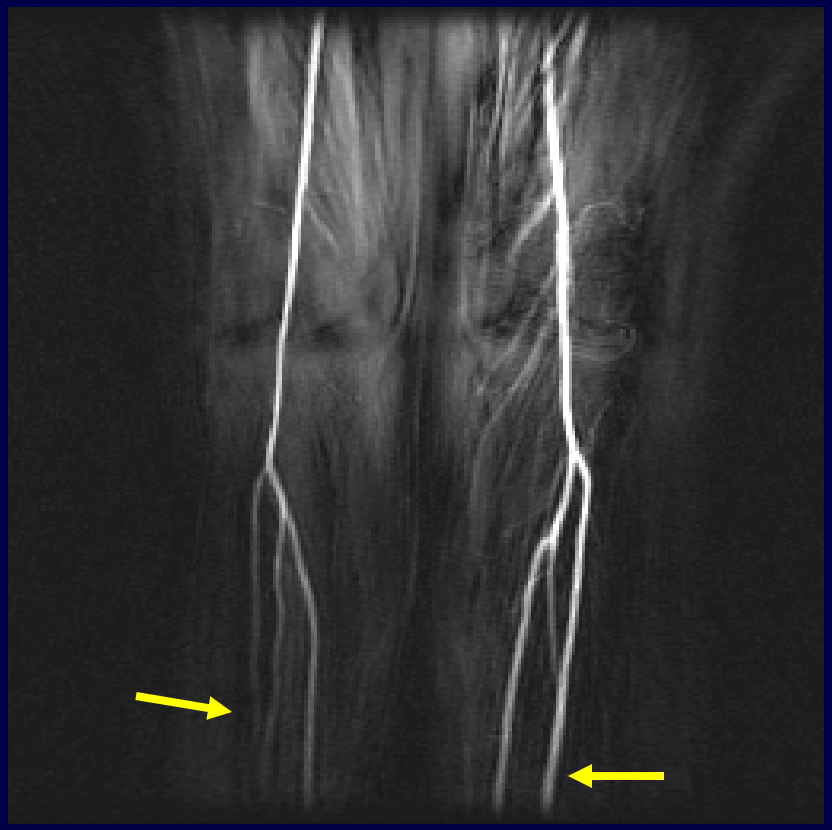
Trade-off

Automatic



Better distal tibial arteries and the right popliteal artery

Manual

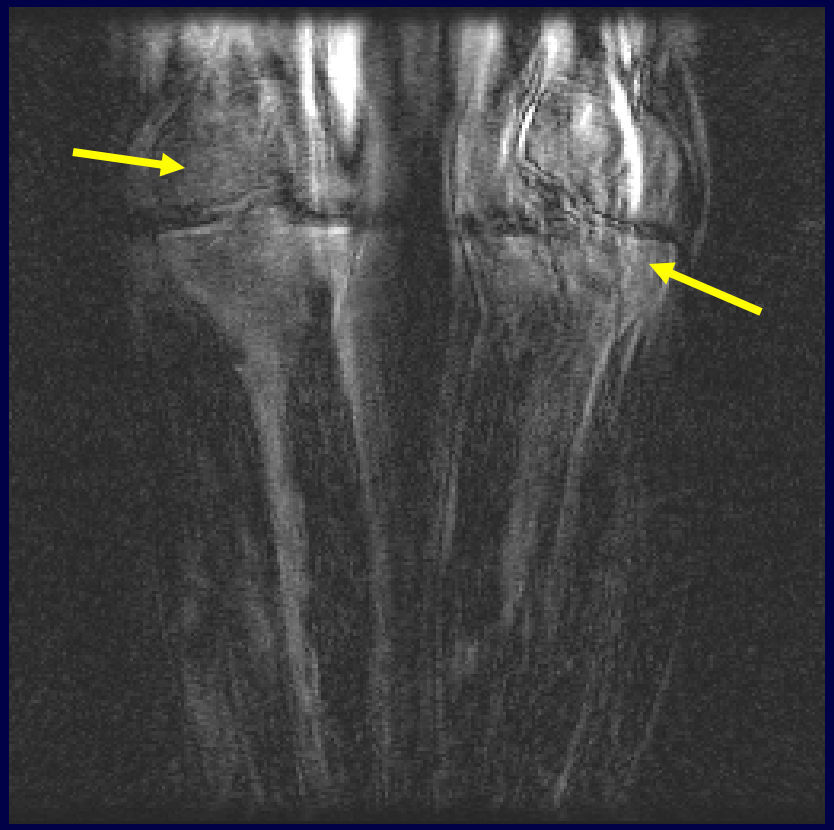


Better detail of the left popliteal artery

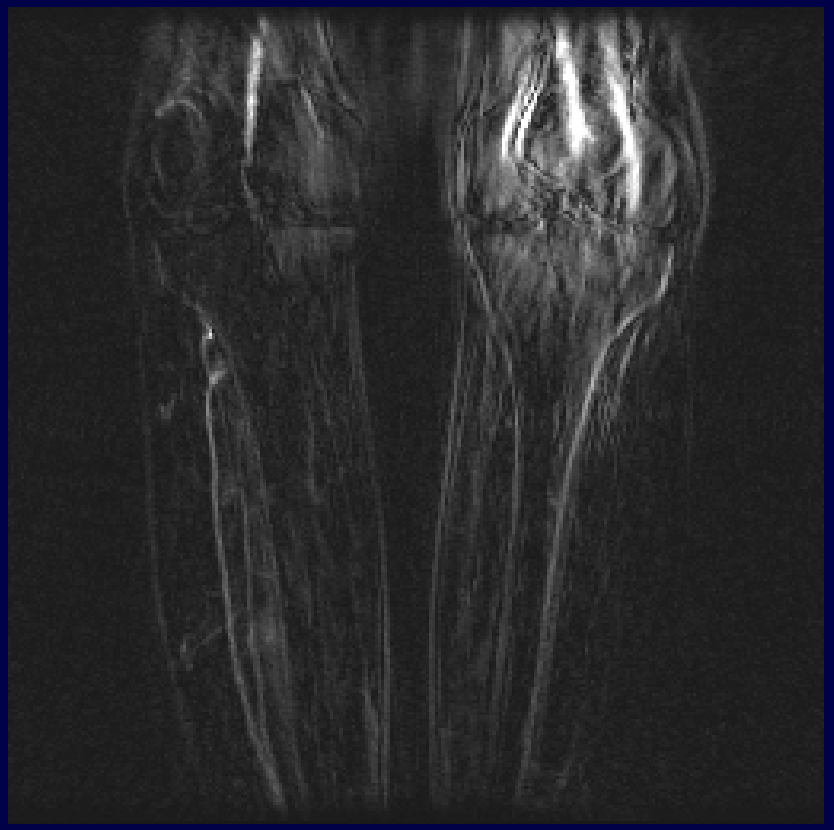
Auto > Manual (reader 1) and Auto ≅ Manual (reader 2)

Manual wins

Automatic



Manual



Enhanced bony structure

Auto << Manual (both readers)

Contribution

- Automatic image post-processing technique
  - Simple yet effective
  - Daily use
  - PC version coming soon!

Special thanks to

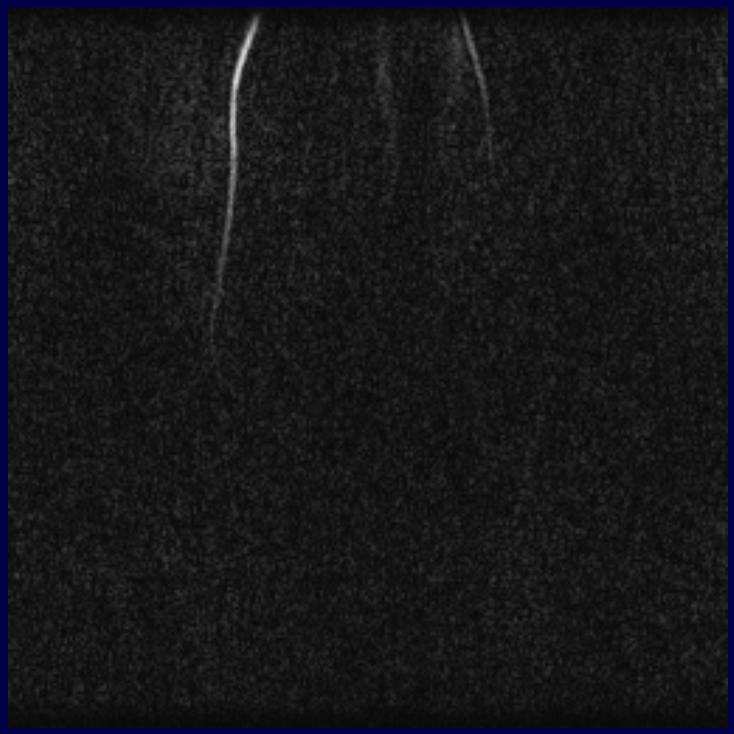
- Younga Kim: Slide preparation
- All of you

Automatic Selection of Mask and Arterial Phase Images

for Temporally-Resolved MR Digital Subtraction Angiography

21 May 2002, ISMRM 2002

Junhwan Kim, Martin R. Prince,
Ramin Zabih, Jeff Bezanson,
Richard Watts, Hale Erel, Yi Wang



Department of Radiology
Weil Medical College of
Cornell University