Objectives and Outline

- Objectives:
  - Share some key developments in MRA conceived by Chuck Mistretta, PhD
  - Describe the clinical impact of the innovations
- Part 1: Time-resolved MRA during passage of contrast
- Part 2: Time-resolved MRA during cardiac cycle

Development of the MRA version of DSA

- Gd-DTPA invention: Weinmann 1982
- Gd MRA: Prince 1994
- X-ray DSA: Mistretta
- Clinical Needs: Grist
- CFR research: Polzin
- MRI PSD: Korosec

UW MRA Research Group

1980
Pitfalls: Timing

Timing Artifacts……..

...........Needed 3D MRA with method for optimal timing
3D Time Resolved Imaging of Contrast Kinetics (TRICKS)
aka: TREAT, DIRKS


3D TRICKS: Technique

Contrast curve
Artery
Vein

Time frame
10 11 12 13 14 15 16 17 18 19 20 21 22

... D A C A B A D A C A B A D ...

Image at time frame 15
TRICKs – Time-Resolved CE 3D MRA

Frame 4 (17s)
Frame 6 (28s)
Frame 8 (39s)

TR = 10.8 (1996)
512 x 128 x 16
Frame Time 5.6 s

Reconstruction: 6 hours + 1 graduate student

3D TRICKS
Korosec et al
Mag Res Med
1996

Time resolved digital vascular imaging

X ray DSA
1980

3D MR DSA
1996
Benefits of time-resolved imaging

Left Popliteal Occlusion

Benefits of time-resolved imaging

Improved Peripheral MRA

- Significantly more arteries diagnostic with TRICKS
- Significantly more venous contamination with moving SmartStep in lower station
- n=20, p < 0.05
  Hany TF, et al
  Radiology 2001;221:266-272.
TRICKS: Peripheral MRA

Accuracy:
SN = 93%
SP = 86%
n = 68
Swan JS, et al
Radiology 2002
225; 435-52

70 y/o had fainting spell while welding overhead

“Subclavian Steal” Syndrome
Type II endoleak

→ k-space sampling and image reconstruction strategies help to achieve high spatial resolution time-resolved MR angiograms.

MRA Remains A Balancing Act

Innovating at the UW Fishing Meeting
Undersampled Cartesian Imaging

Undersampled Radial Imaging
Time-resolved 3-dimensional 3-directional Velocity-encoded MRI

Acquisition:
- Volumetric coverage with conventional cartesian encoding
- 3-directional flow encoding
- ECG gating
- Respiratory correction
- Clinically Impractical
  - Acquisition times 40 min – 4 hours

3D RADIAL ACQUISITIONS

PC VIPR vs 3D Cartesian PC
Acceleration Factor 30 With Contrast

Cartesian 3D PC
Time: 7:22
S/I Coverage: 4 cm
Through-plane resolution 2mm
0.94 x 0.94mm

PC VIPR
Time: 7:30
S/I Coverage: 18 cm
Isotropic resolution
0.63 x 0.63 x 0.63mm

4D Flow: Visualization

Too much data?
Need for advanced visualization.

Animation courtesy of M. Markl PhD, Freiburg, and Chicago, IL

Patient presents with persistent pain despite HTN treatment
MRA Flow analysis for further evaluation

PC VIPR acute aortic dissection
66 yo F with portal HTN

- No flow in MPV - ? thrombus
- Reversed flow in LPV

66 yo F with portal HTN

- Stomal varices draining from SMV
- Patent portal vein (no thrombus)

66 yo F with portal HTN

PC-VIPR Magnitude  PC-VIPR Flow Visualization
• Chest pain, dizziness.
• Right sided cardiac enlargement
• History of palpitations.
• Patient had TEE which showed possible shunt.
Vessel Selective Seeding

Patient with AVM: Nidus seeding + Reverse

4D Flow: Quantitative Hemodynamics

Animal model of renal artery stenosis


Pearson Correlation

r = 0.977; p < 0.001

95% CI: 0.939-0.991
Quantitative flow analysis: Measuring pressure gradient

18 month old with aortic coarctation

\[ V \cdot P = \rho \cdot g \cdot V^2 + \mu \cdot V + \rho \cdot V^2 \]

- \( P \) = pressure
- \( V \) = velocity
- \( \mu \) = viscosity
- \( g \) = gravitation
- \( \rho \) = density

Summary: Time-resolved MRA

- Time-resolved MRA during contrast passage
  - “Can’t miss” approach to timing
  - Window into functional significance of stenosis
- Time-resolved during cardiac cycle
  - Clinically practical using under-sampling
  - Demonstrates complex flow patterns
  - Provides quantitative hemodynamics

Mistretta’s Impact

Trainees!

What impact have they had, and what will they do in the future?
“The greatest danger facing us is the fear of the unknown. But there’s no such thing as the unknown – only things temporarily not understood”