



# MR Angiografi

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# Agenda

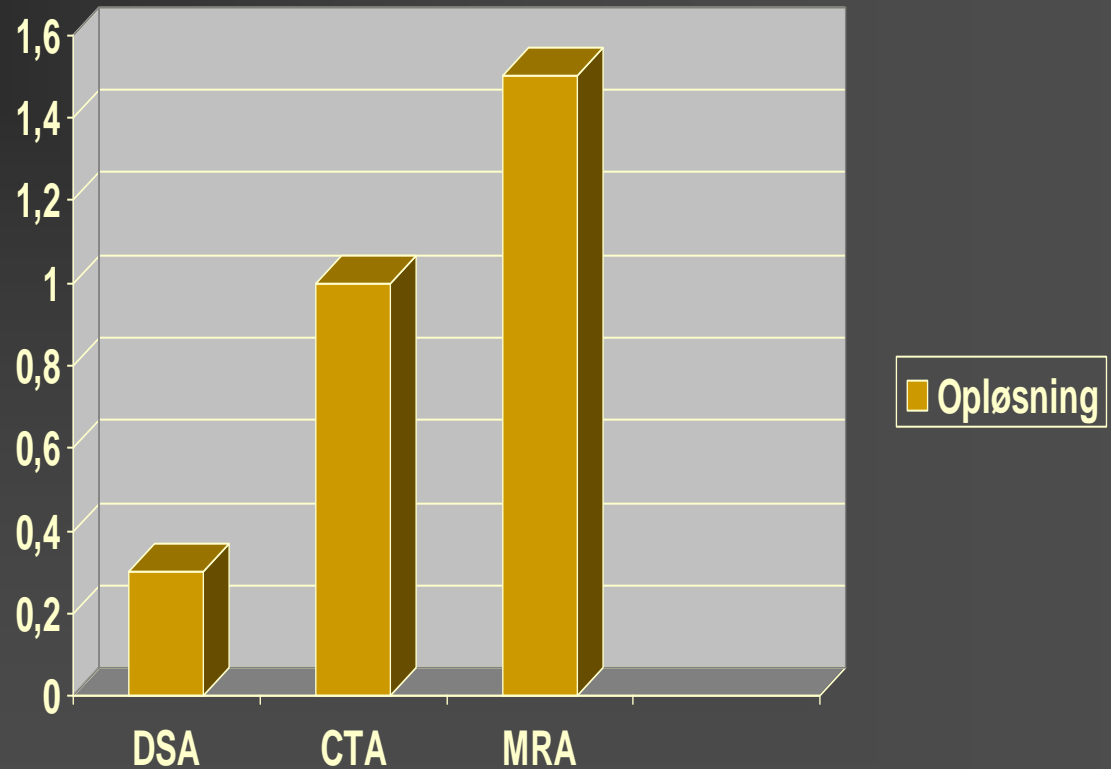
- MR angiografi
  - Underekstremiteter
  - Viscerale kar
- ~~■ Hjernen og hjertet~~

# Angiografi karakteristika

- Spatiel opløsning
- Temporal opløsning
- Kontrast-stof og forskellen mellem kar og omgivende væv

# Spatial opløsning

- DSA: 0,3 mm<sup>2</sup>
- CTA: 1,0 mm<sup>2</sup>
- MRA: 1.5 mm<sup>2</sup>

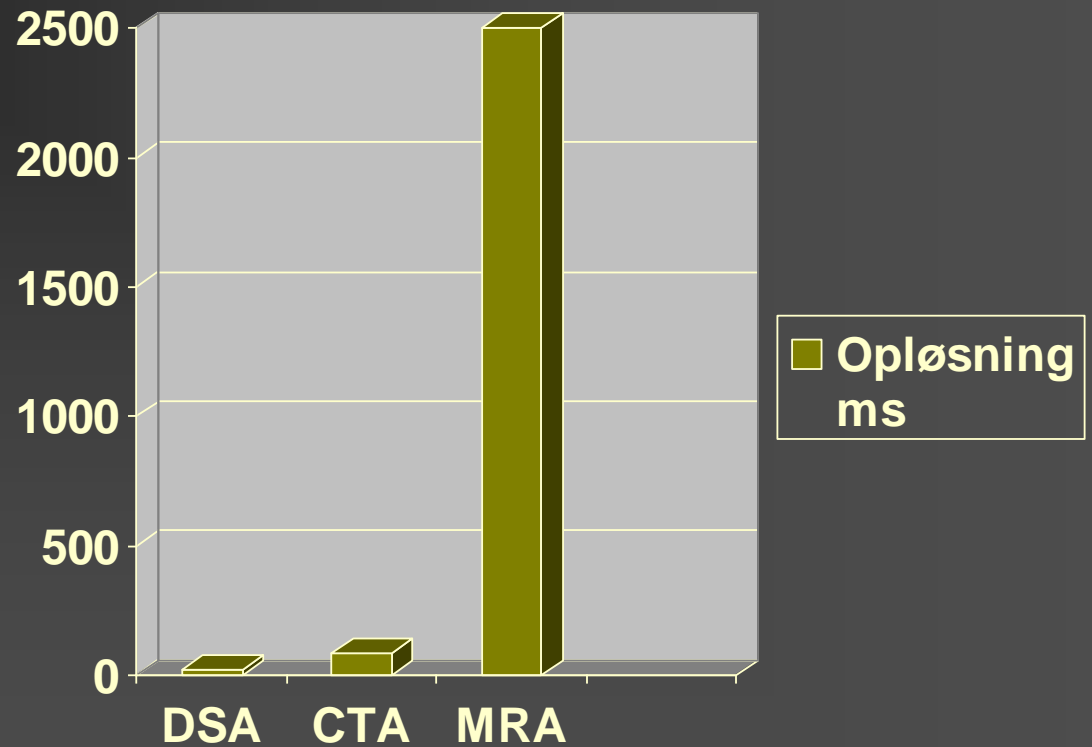


# Crus MR og Agrafi



# Temporal opløsning

- DSA: 20 msec
- CTA: 83 msec
- MRA: 2500 msec



# MR Carotis og agrafti



# Digital subtraktions arteriografi

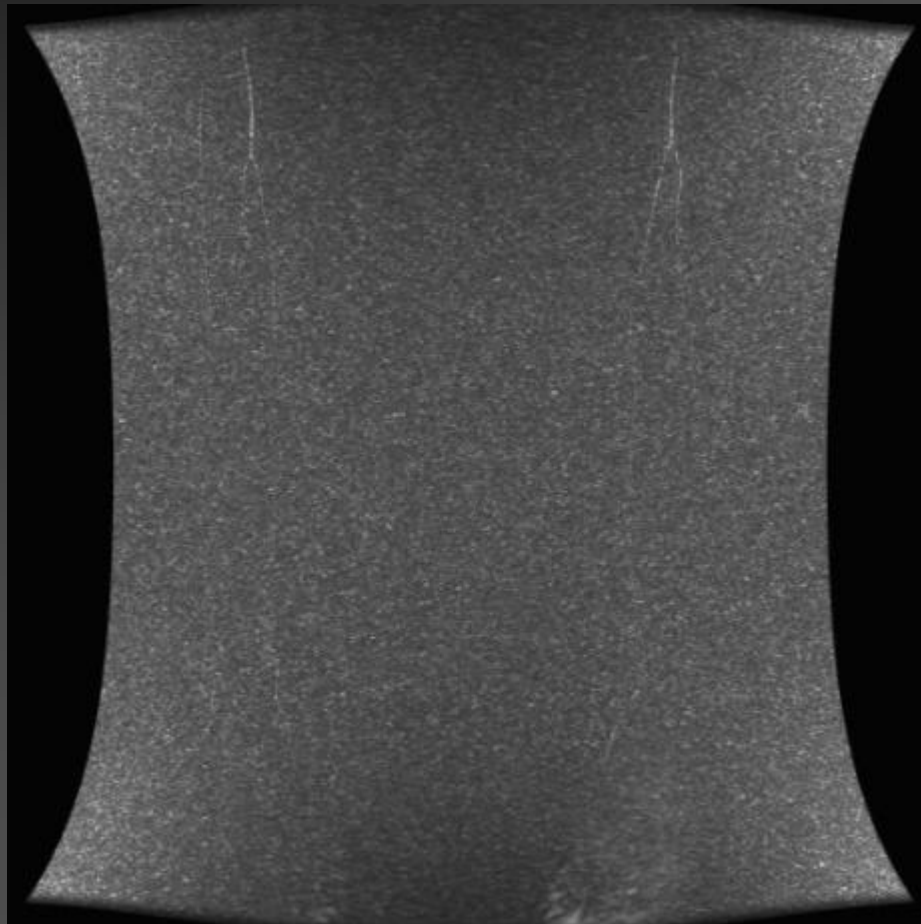




# TRICKS:

## Time-Resolved Imaging of Contrast Kinetics

Crus



# MR fordele

- Ingen ioniserende stråling
- Ikke invasiv
- “Ingen nefrotoksisk kontrast”
- Diagnostisk sikker

# Diagnostic accuracy

## DSA er golden standard

Forfatter/år	Antal patienter	Sensitivitet	Specificitet	Vasculært territorie
Hany/97	39	93-96	96-100	Aorto-iliac
Ho/ 98	28	93	98	All vessels
Quinn/98	57	NR	NR	K=0,61-1,0 All vessels
Meaney/98	20	95	98	All vessels
Ruehm/00	61	92	96-99	All vessels
Loewe/02	106	97	96	All vessels
Klein/03	72	84-96	59-96	All vessels

# Hvad skal radiologen/grafen vide?

- Kendskab til sekvenser og K-space
- Kar anatomi
- Hæmodynamik
- Patologi
- Behandlingsmuligheder
- Fejlkilder

# Hvad vil kirurgen og/eller interventionsradiologen vide?

- Hvad er åbent/lukket
- Er der run off?
- Er karrene syge selvom de er åbne?

# MR Angio metoder

- 3D CE-MRA – 3 dimensional Contrast – Enhanced Magnetic Resonance Angiography
- TOF - Time of Flight
- Phase kontrast

# 3D CE-MRA

- Baseret på forskellen i  $T_1$  relaxation mellem det kontrast fyldte blod og omgivelserne.
- Ikke følsomt for flowhastighed eller snoede kar.

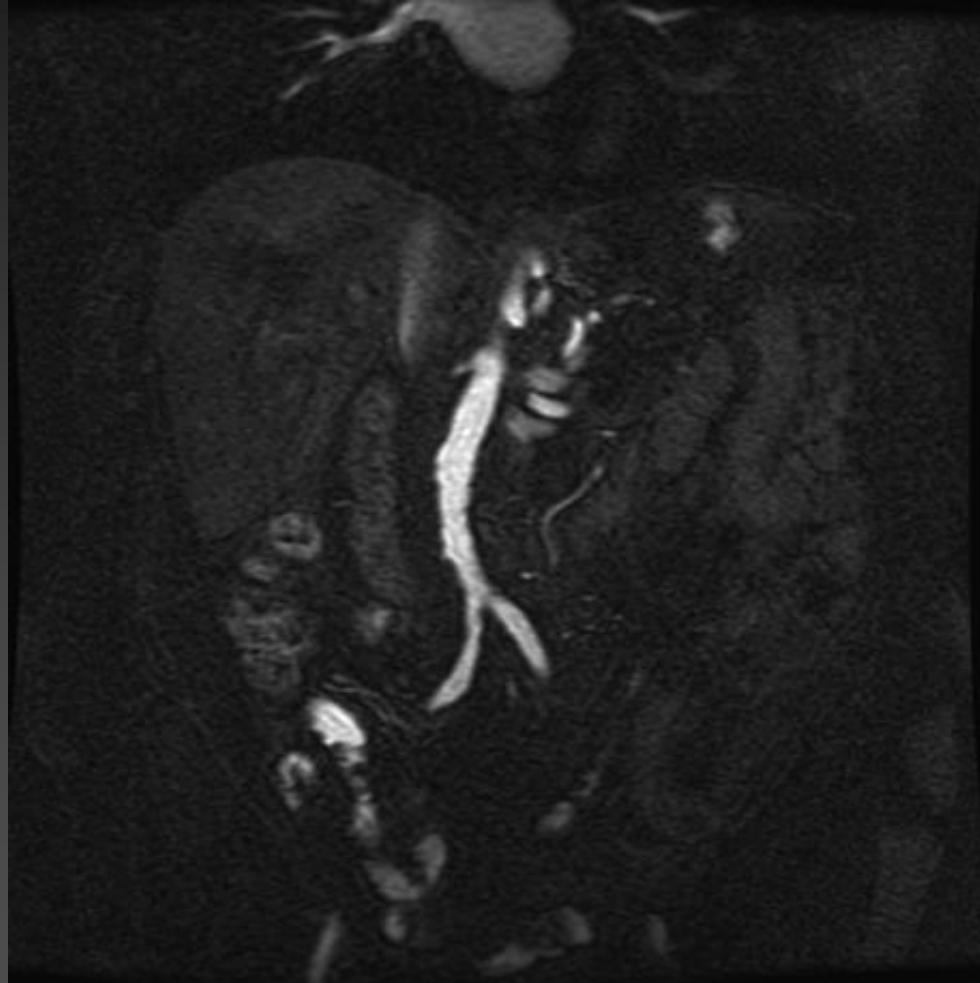
# 3D SPGR

## Spoiled gradient echo sekvens

- Kort ekkotid.
- Høj hastighed.
- Spoiling accentuerer T1 kontrast:  
“forstærker” effekten af T1 relaxations midler såsom Gadolinium.



# Hvide kar sort baggrund



# MR-scanner

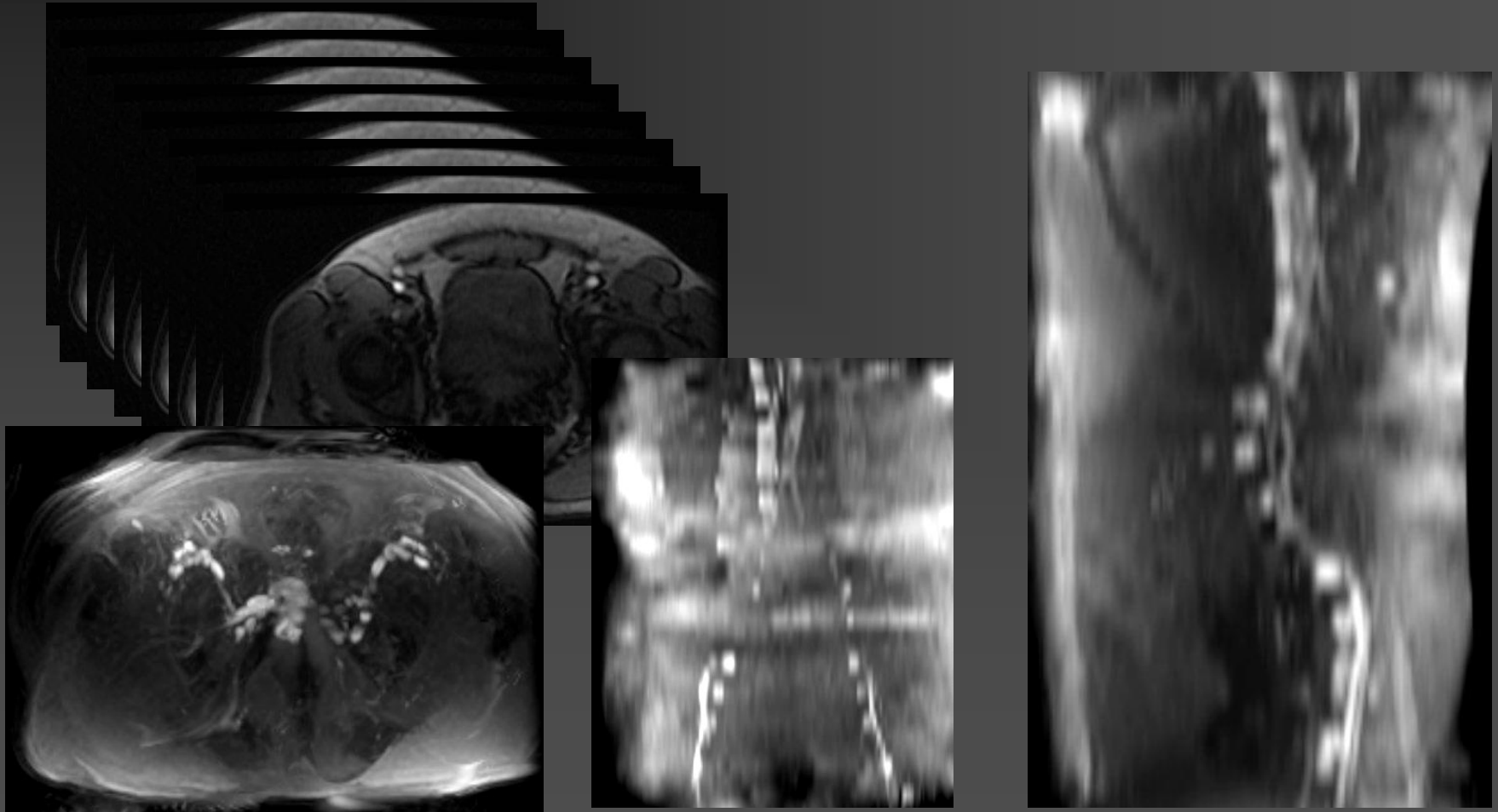
- Høj Tesla 1,5 T (3 T)
- Gradientspoler
  - Ampl. = 23 mT/m
  - Slew rate = 80 mT/m/s
- Evt moving table
- Coil
- Automatsprøjte
- Computer software



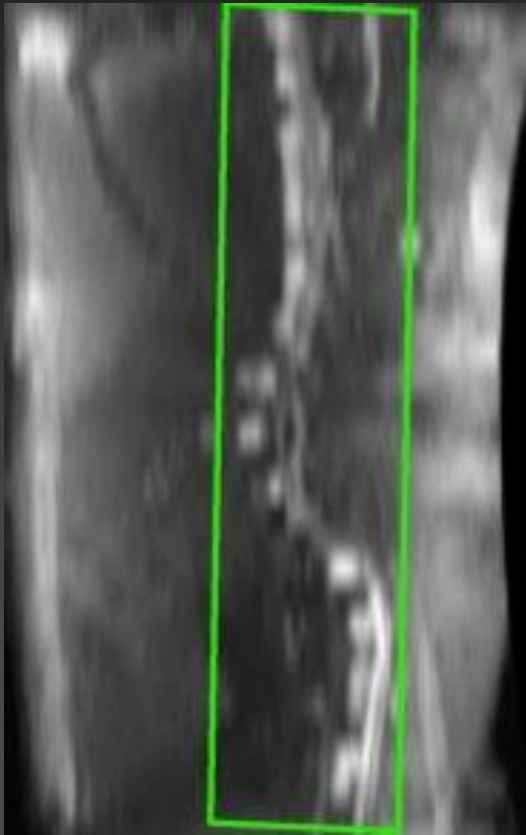
# Automat sprøjte



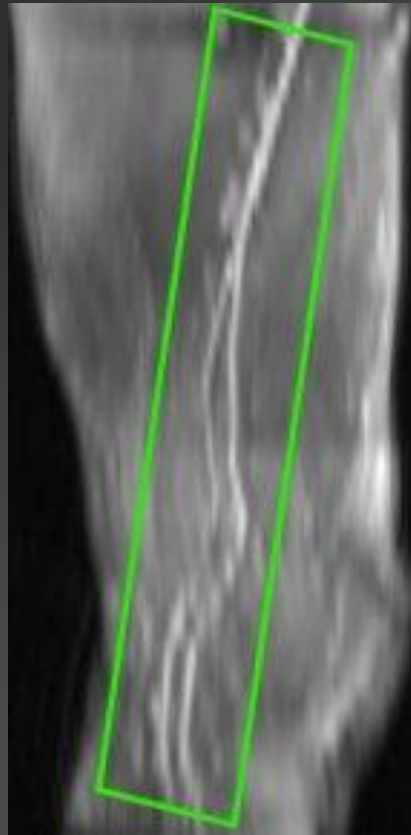
# Axial TOF med rek. i 3 planer



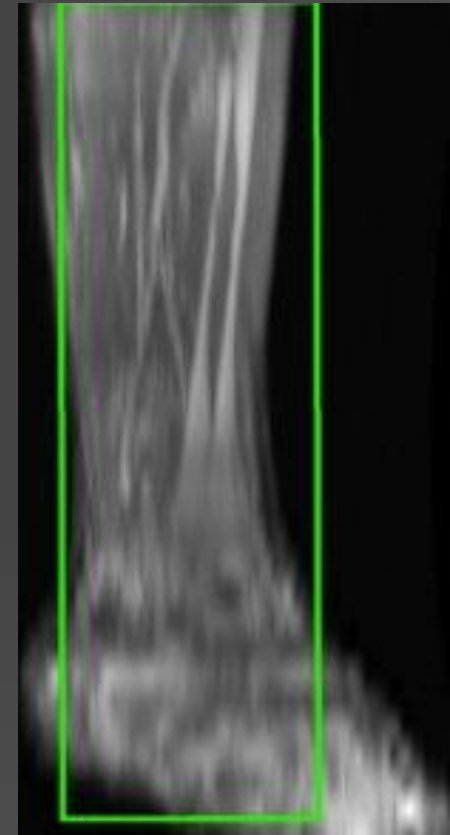
# 3D kasser ca 70 sek



14 sek.

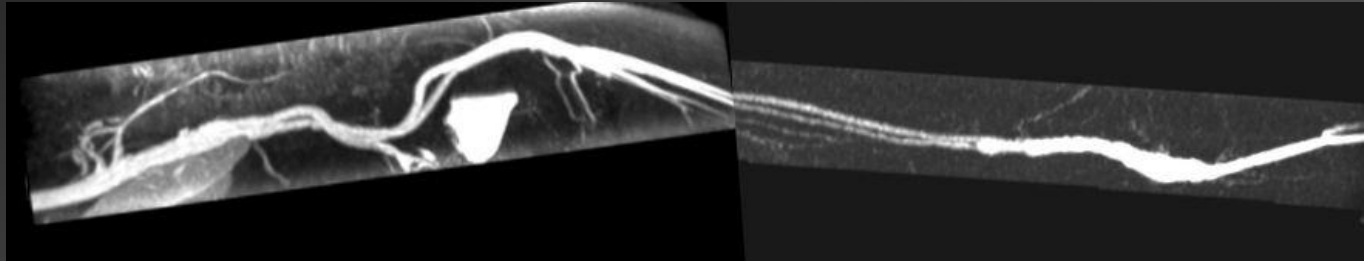


13 sek.



40 sek.

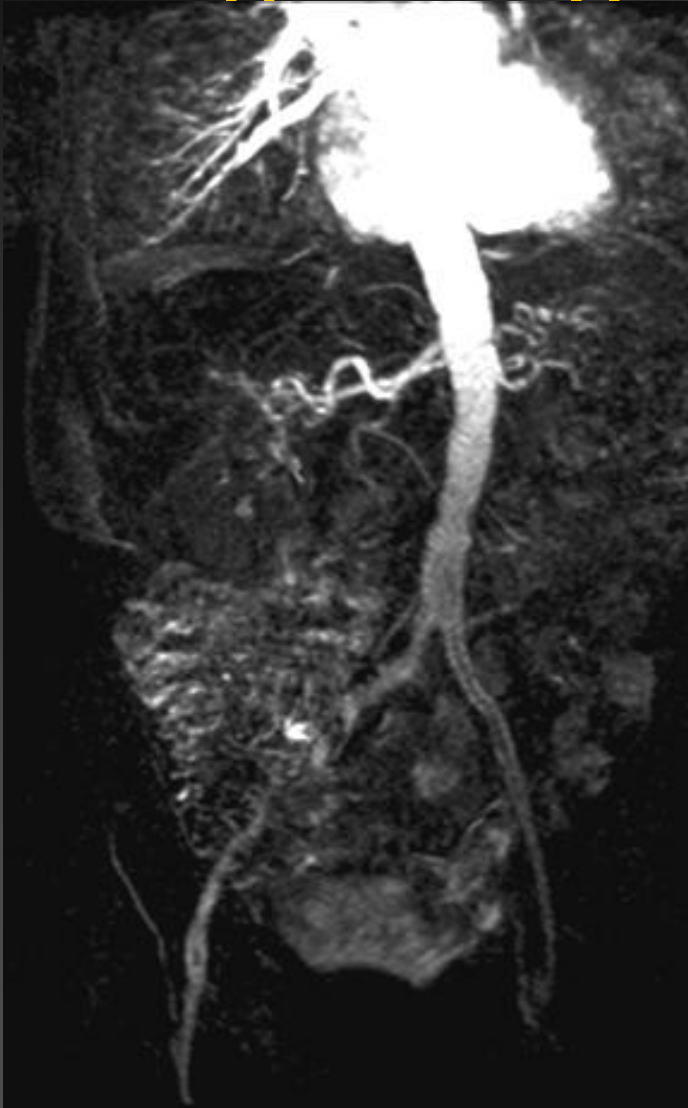
# Karrene set fra siden



# Kontrast timing

1. Når det centrale K-space samples skal karrene være homogent fyldt med kontrast
2. Scannings delay optimeres til 1. station.

Dårlig timing

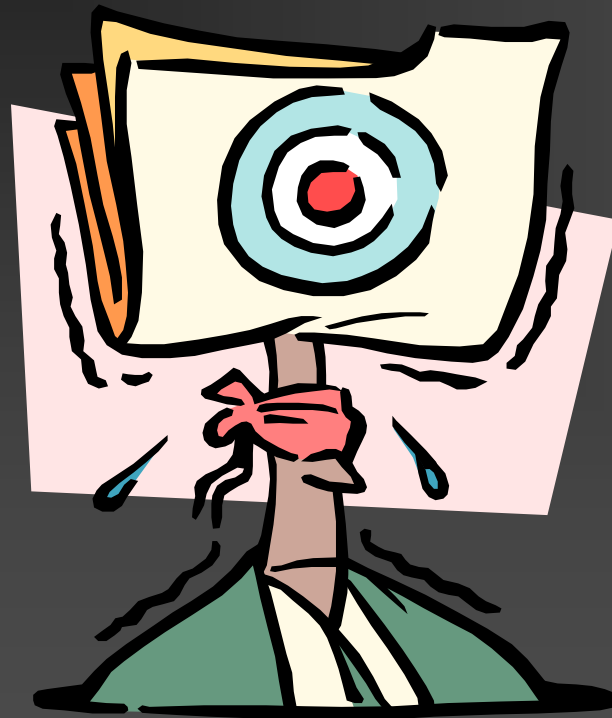


Perfekt timing



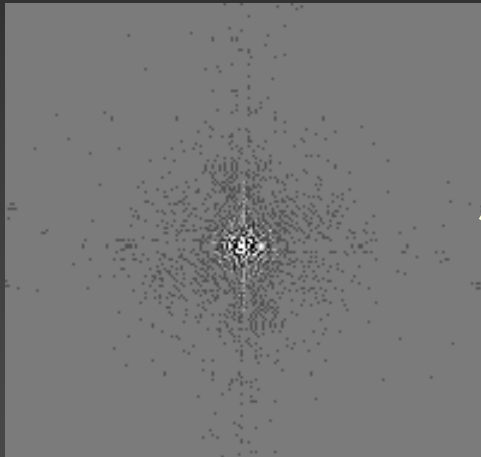


# K-space



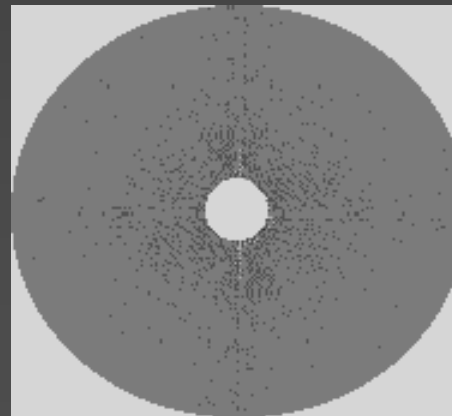
# K-space sampling

Central k-space



Kontrast

Perifere k-space



Detaljer

# “gode K space samplings”

- Sequential sampling
  - Det centrale k space samples i midten af sekvensen
- TRICKS (GE), Syngo TWIST ( Siemens)
  - Time-Resolved Imaging of Contrast KineticS

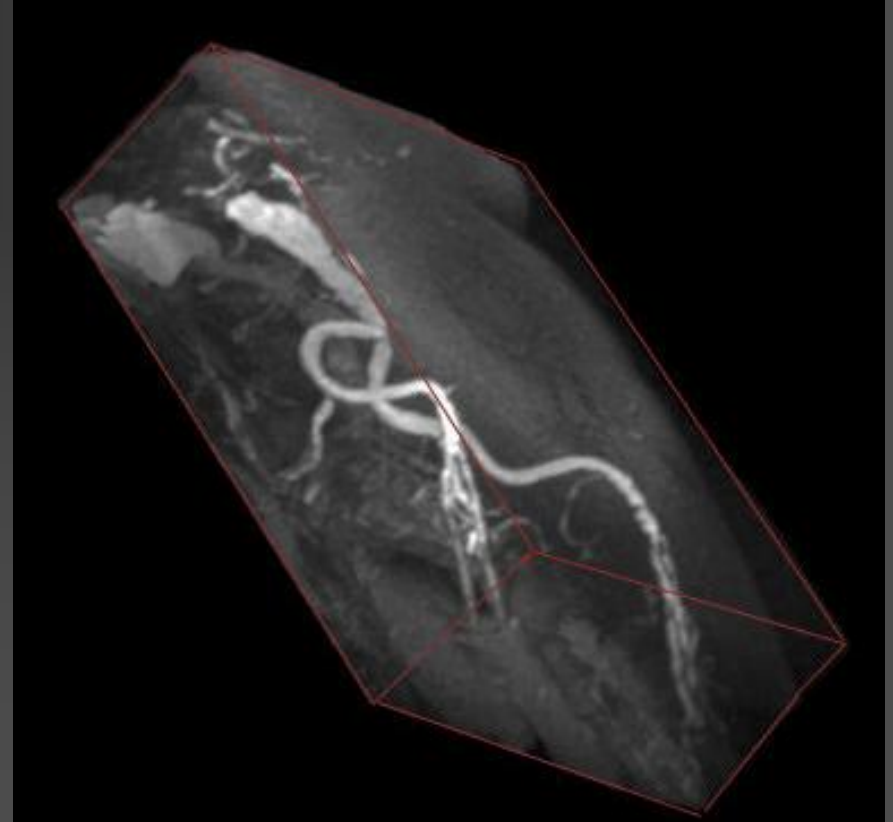
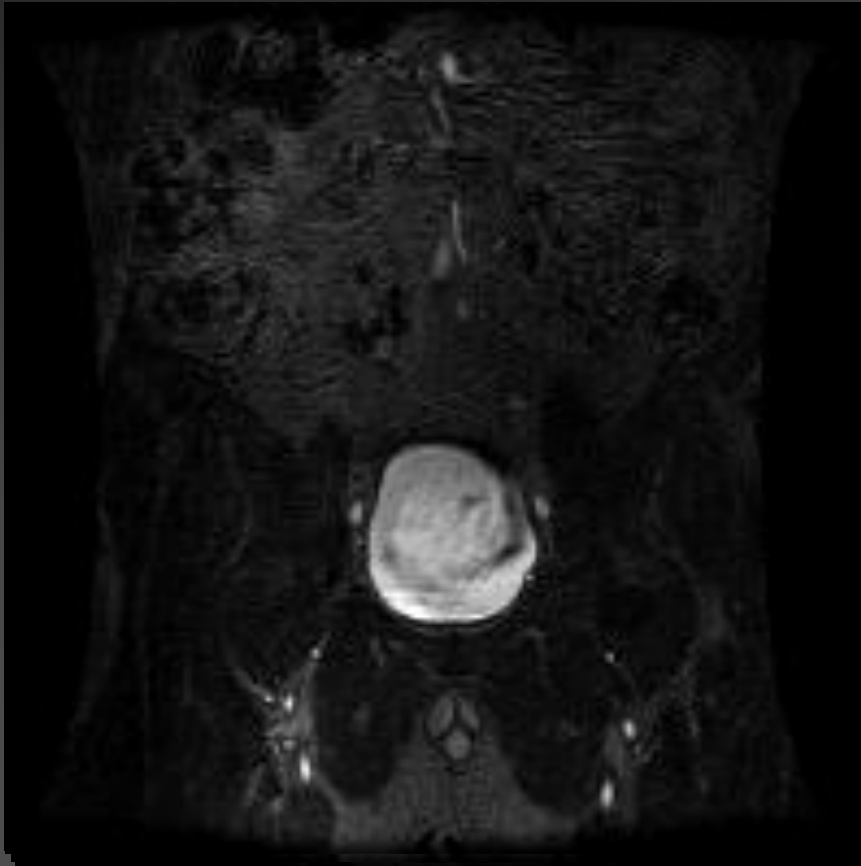
# Kontrast ankomsten skal times til 1. station

- Testbolus
- Automatisk detection af kontrasten
- Synets vejledning
- Best guess!

# Kontrast mængde

- Til standard UE MR angio
- 45 ml kontraststof: 0,5 mmol/ml.
- $\approx 0,25$  mmol/kg – 0,35 mmol/kg

# Resultat



# Post processing

- Subtraktion
- MIP: Maximal intensity projection
- Volume Rendering
- Multiplanar reformatering
- Gennemsyn af enkelt partitions

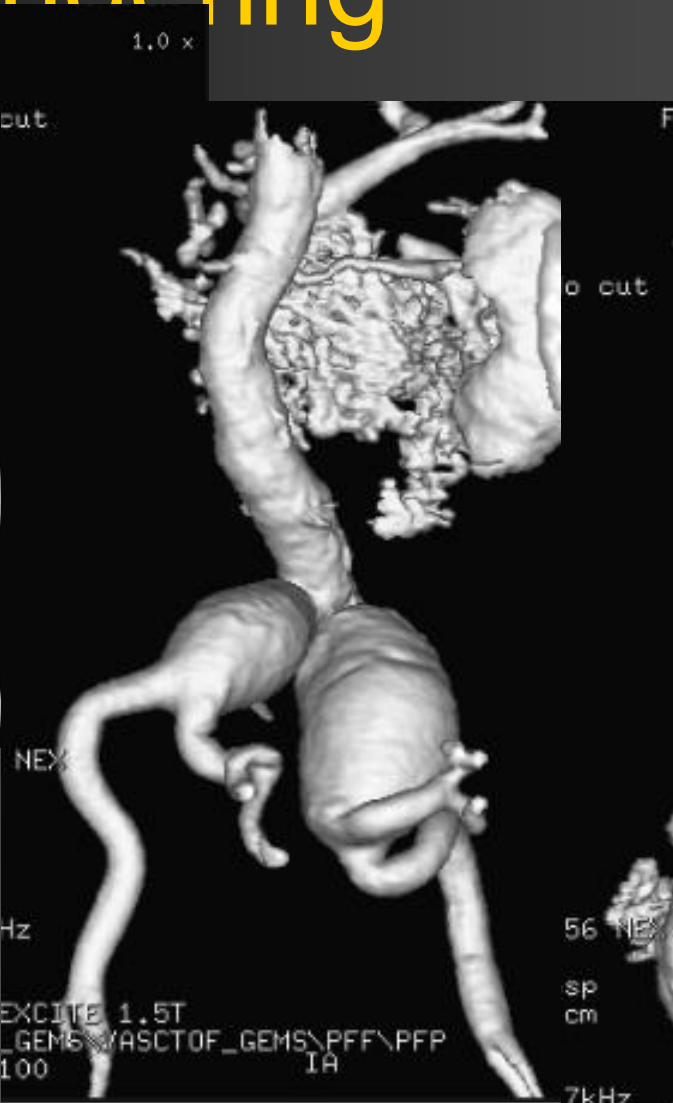
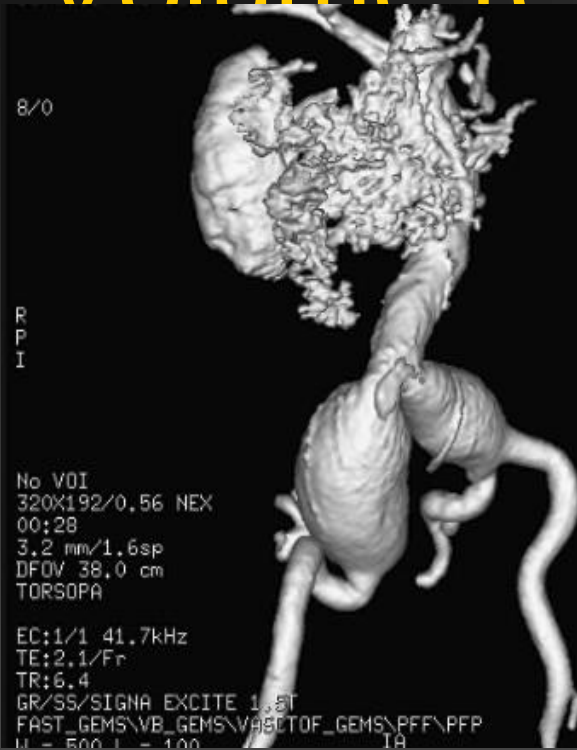
# 3D MIP



Maximum  
intensity  
projection



# Volume rendering



# Resultat

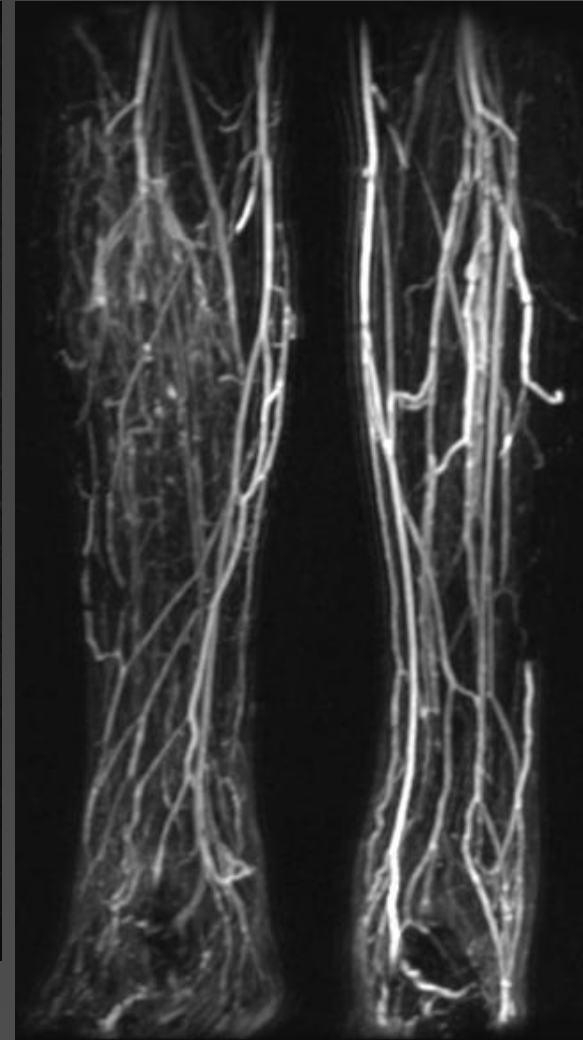
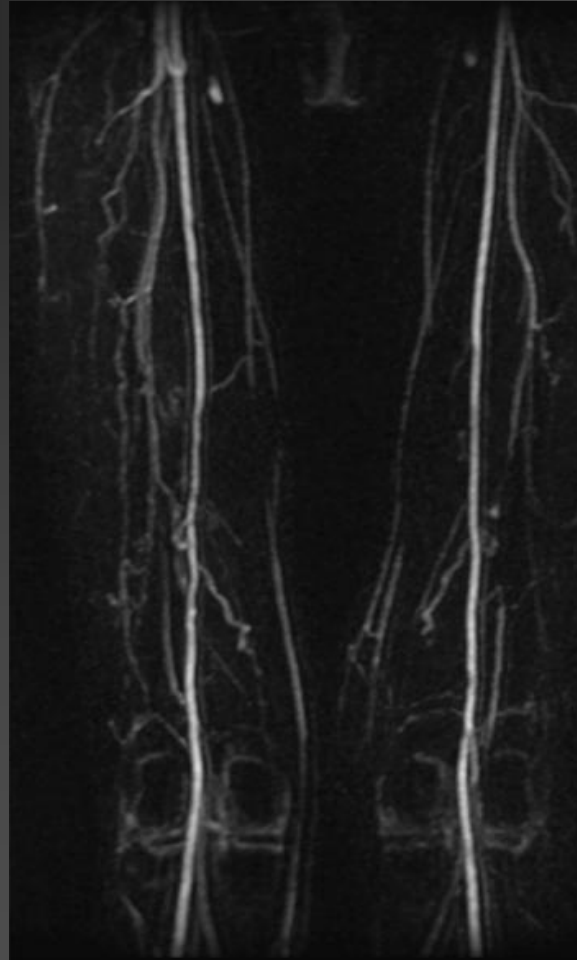
Normal  
undersøgelse



# Aorta okklusion



# Venøs kontaminering overløb

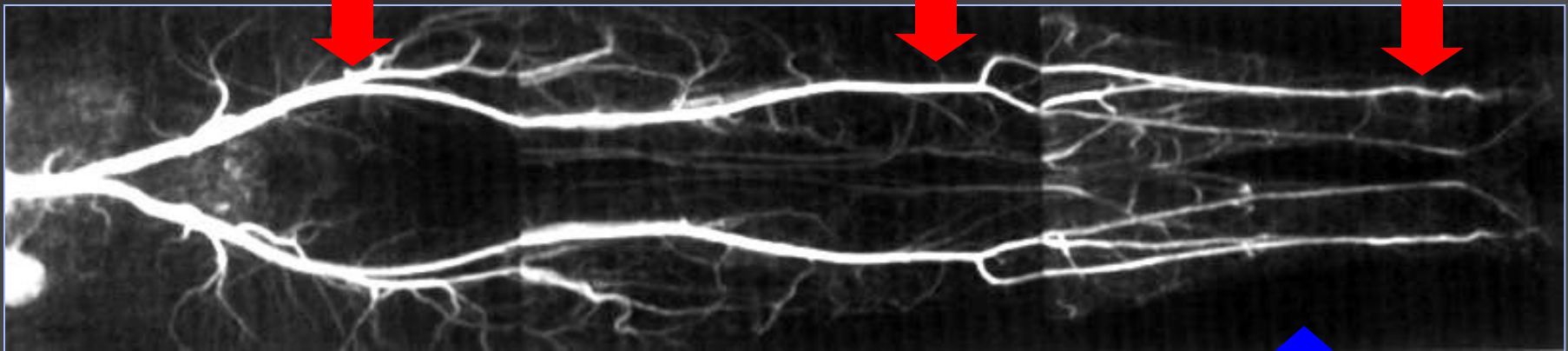


# Kontrast ankomst tid

24 sek. (14-45)

29 sek. (16-49)

36 sek. (18-64)



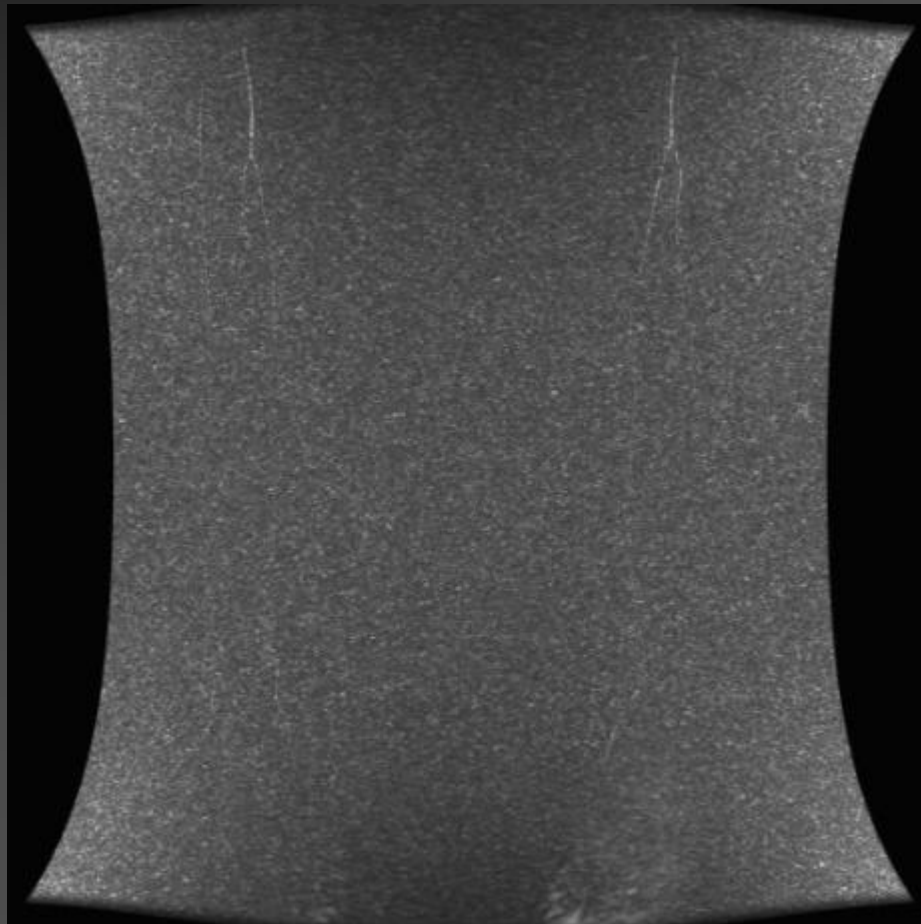
87 undersøgelser  
gennemsnit

68 sek. (29-117)

TRICKS:

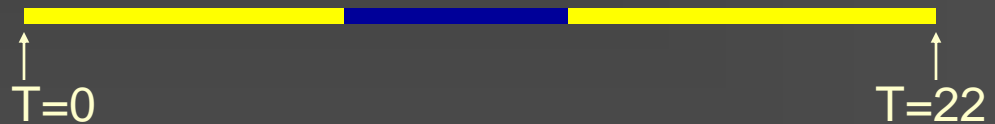
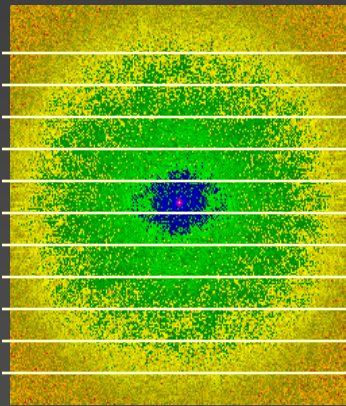
Time-Resolved Imaging of Contrast  
KineticS

Crus



# K-space sampling

- Sequential sampling
  - Det centrale k-space samples i midten af sekvensen



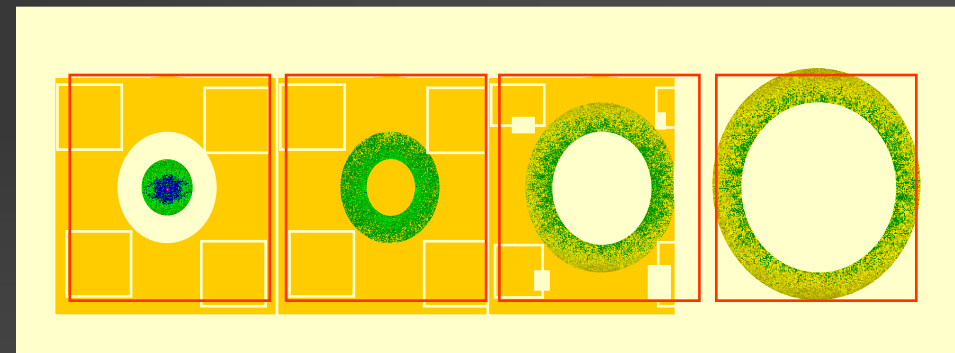
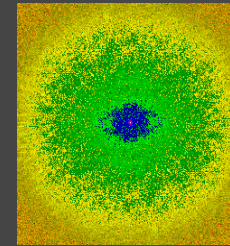
# TRICKS

- Time-Resolved Imaging of Contrast Kinetics
  - Høj spatial opløsning
  - Højere temporal opløsning
- Time: 2:17 (0.46) Temp res: 0:11,3



# TRICKS K-space sampling

- Opdeler k-space i 4 koncentriske regioner ABCD
- Den centrale region måles for hver 2. fase, de andre hver 6.

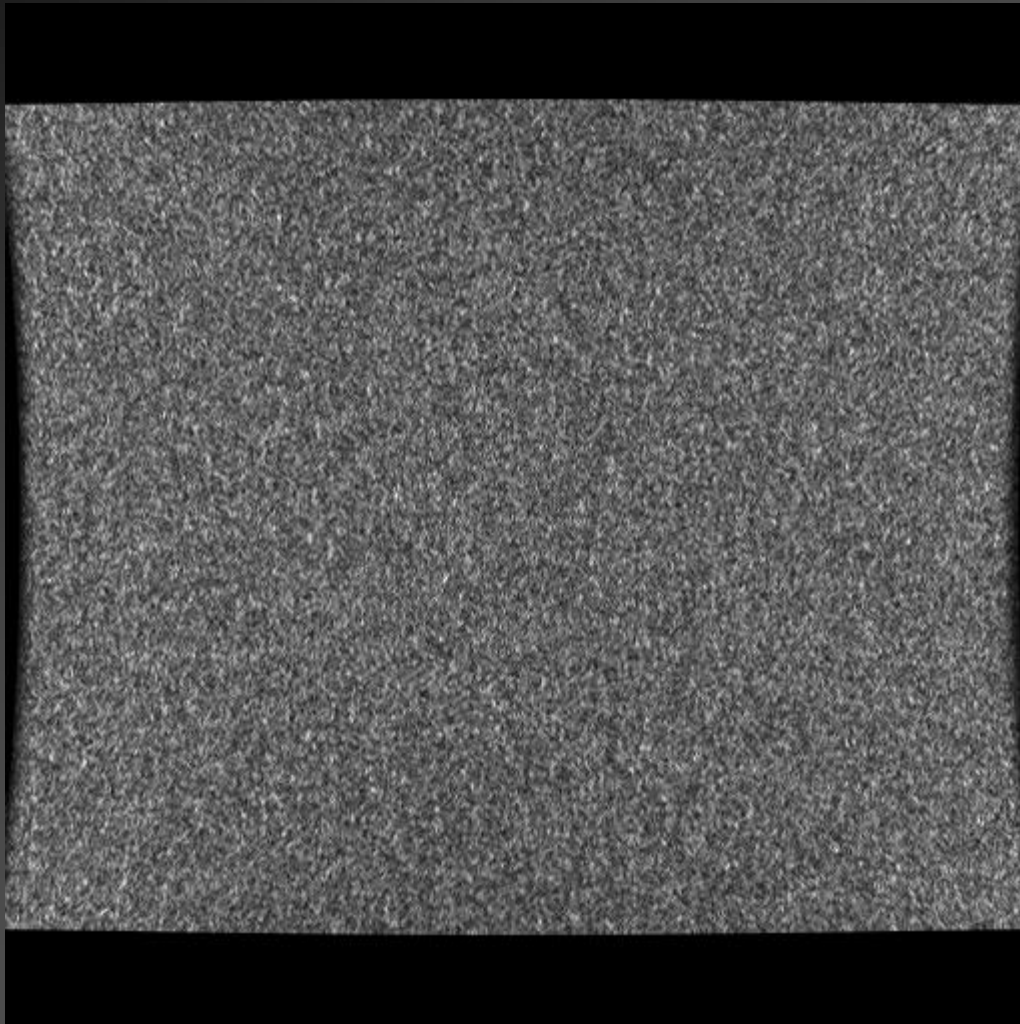


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 ...

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

Mask

# Time resolved sequence

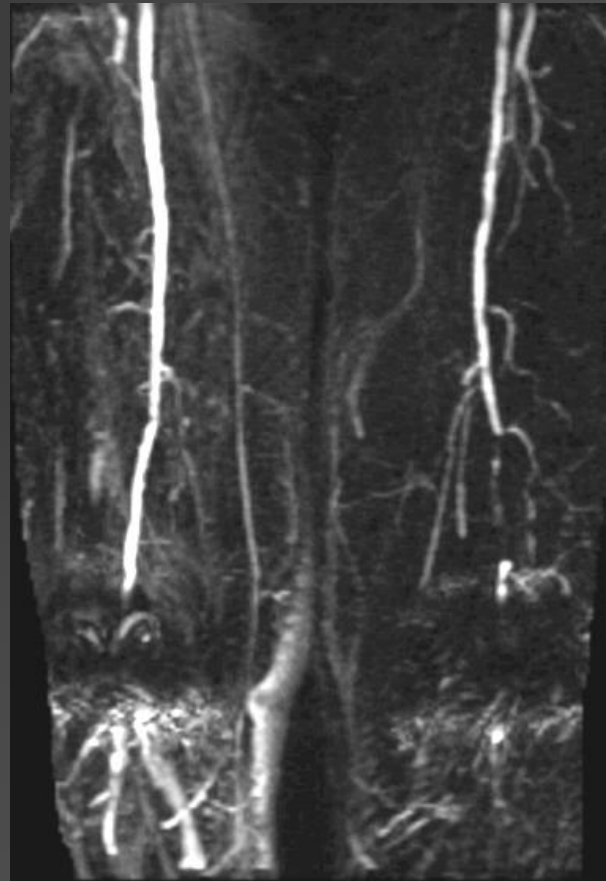
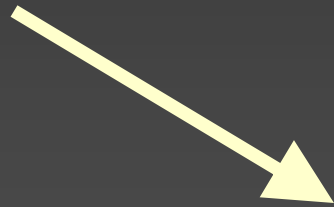


# Fejlkilder

- Indsat metal
  - Ledproteser
  - Stents
  - Hæmoclips
- Bevægeuro
- Karret er ikke medscannet, eller dårlig kontrast timing
- Overestimering af svære stenoser

# Indsat metal

Bilateral  
knæ  
alloplastik

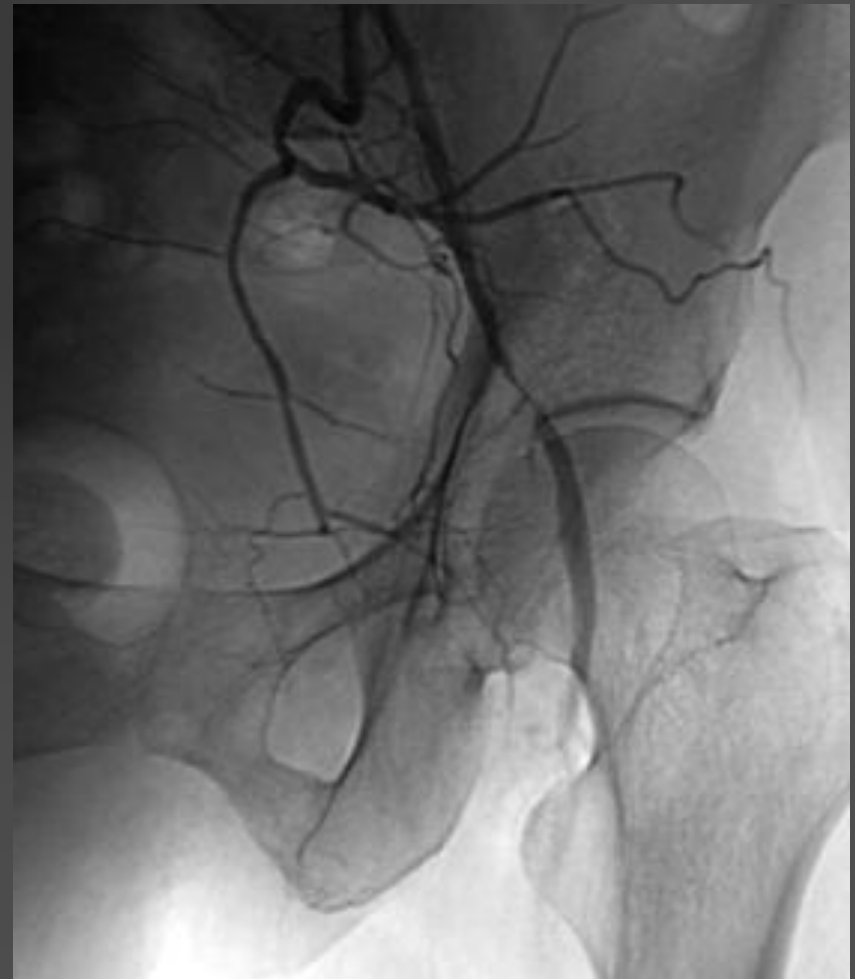


# Susceptibility artefakt

- Hæmoklips efter in situ by-pass



# Overestimering af svære stenoser



# Tryk udefra



# Bilateral emboli

23 årig mand

Tidligere virus  
myocarditis

Nu UE iskæmi

