NON-kontrast MR-Angiografi

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1.reservelæge, PhD

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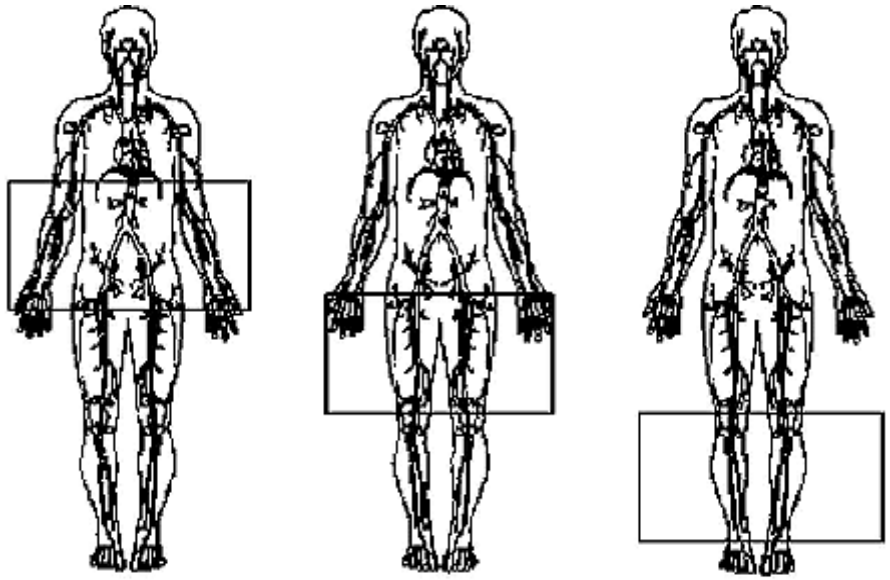
Herlev Hospital

DFIR Årsmøde 2013
Korsør

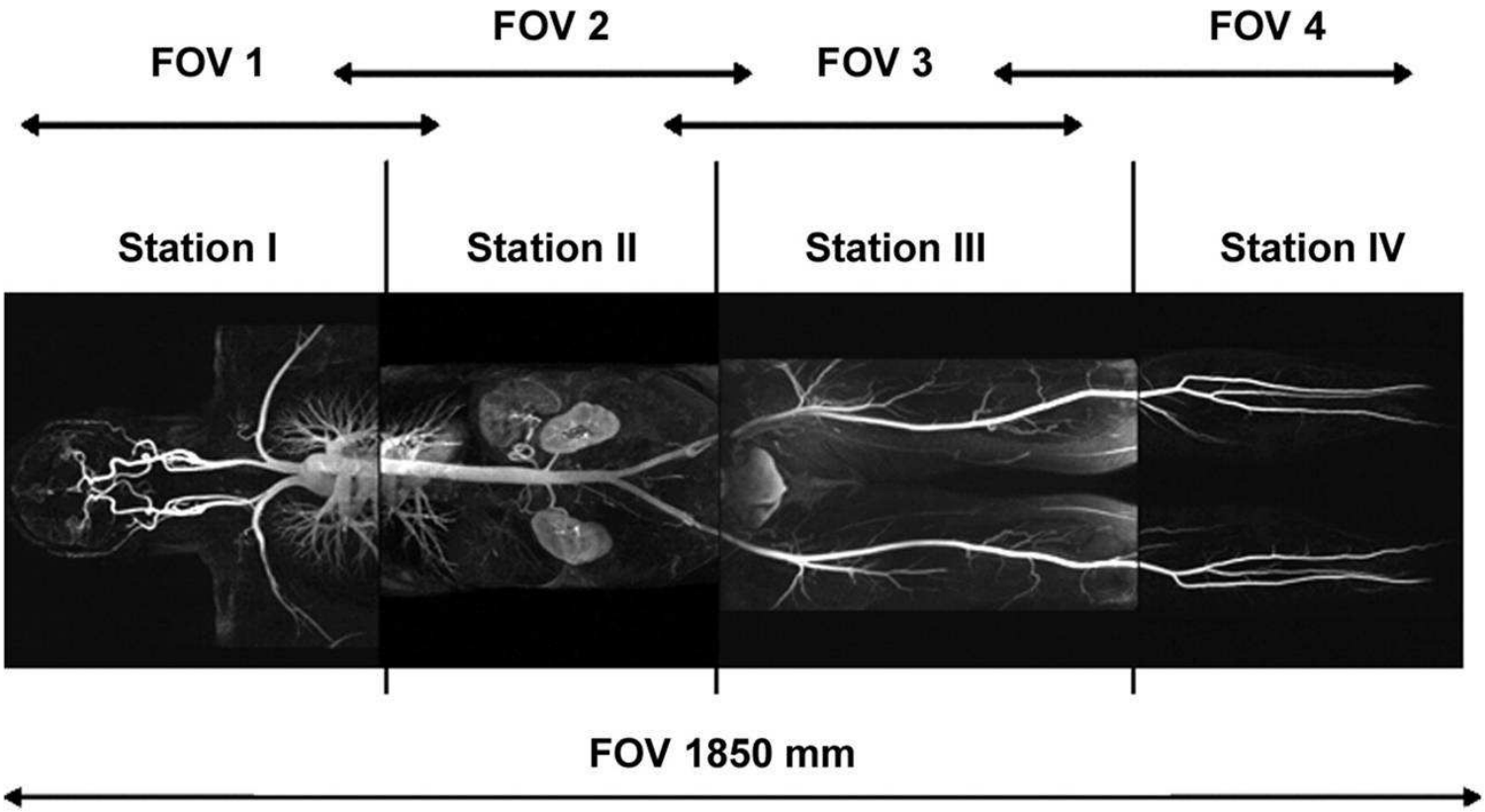
CE-MRA

- Først beskrevet i 1994
- Robust metode
  - Perifer MRA Sens. 0.95 Spec. 0.96 (Ann Intern Med 2010;153:325-34)
  - Nyre-arterier Sens. 0.97 Spec. 0.93 (Clin Radiol 2002;57:617-24)
  - Carotis MRA Sens. 0.94 Spec. 0.93 (Eur Radiol 2009;19:2204-16)
- Teknologisk udvikling over de seneste 20 år
  - Gradienter
  - Parallel billeddannelse
  - Høj-felt MR-skannere

CE-MRA

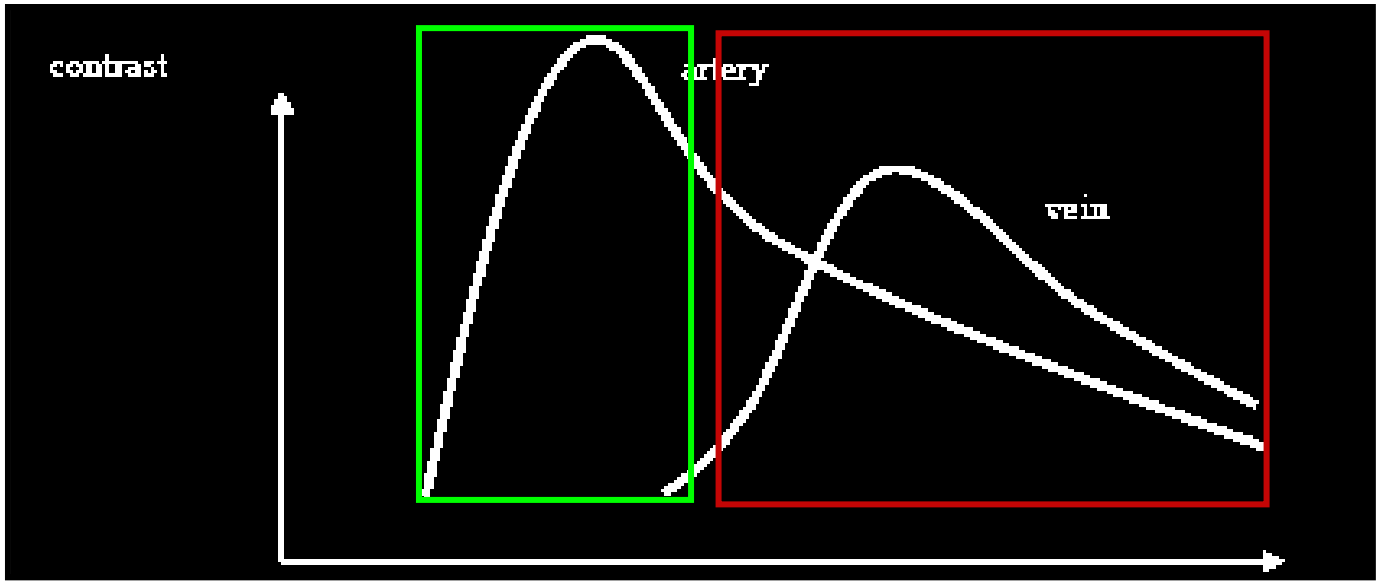


CE-MRA


FOV 1
FOV 2
FOV 3
FOV 4
Station I
Station II
Station III
Station IV
FOV 1850 mm

CE-MRA

Scanning i arteriel fase



CE-MRA

Kontrast til MRA

Typisk dosis: 0.1 mmol/kg (single dose)

Tidligere: 0.2-0.3 mmol/kg (double- og triple dose)

Risiko for Nefrogen Systemisk Fibrose

Mindst stabile Gd-baserede MR-kontraststoffer

(Omniscan, Magnevist, Optimark)

Nedsat nyrefunktion

Non-kontrast MRA

Fordele

Ingen brug for kontrast

Nyrefunktion

Multiple scanninger

(Økonomi)

Ulemper

Teknisk udfordrende

Forskellige teknikker nødvendige

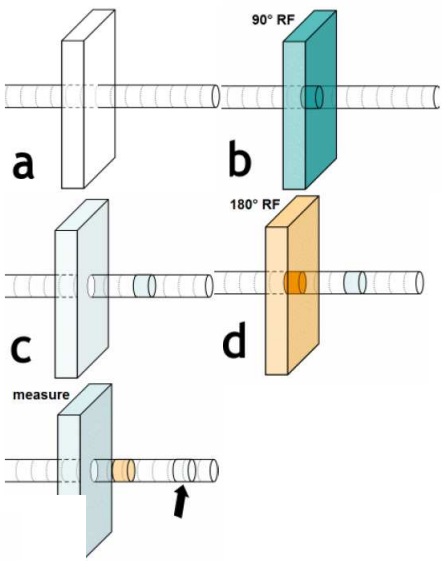
Problematisk ved arrytmier

Non-kontrast MRA

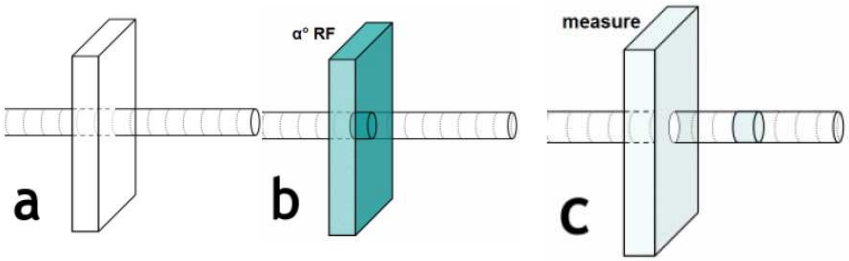
Signalet afhænger af MR-sekvens

Spin echo (SE): Lavt signal (flow void)

Gradient echo (GRE) Højt signal



ignal loss in SE images. (a) initial state, (b) excitation pulse, (c) excited blood leaves the slice, (d) od which has left the slice does not receive the slice-selective 180° pulse, (e) no signal is returned d blood (M_{xy} of the blood has decayed away).



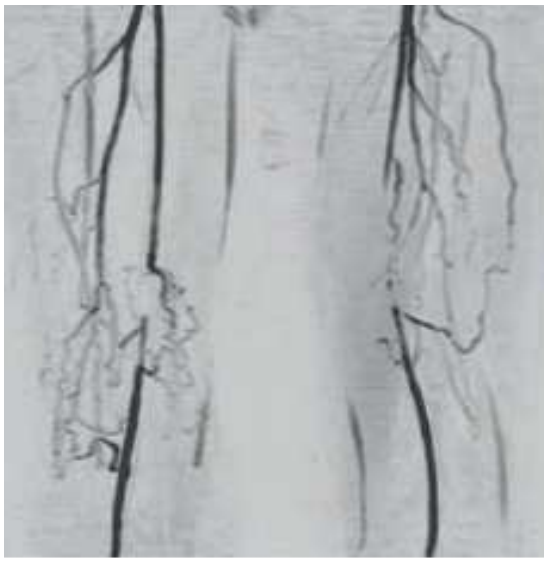
Non-kontrast MRA-teknikker

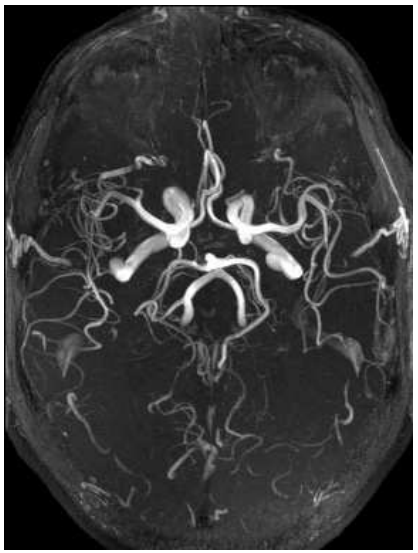
Nyere

- Subtraktion
- bSSFP-baseret MRA

Konventionelle

- TOF
- Phase-contrast





Non-kontrast MRA-teknikker

Subtraktion

- EKG-gated FSE-MRA

bSSFP

- Tagging-teknik
- QISS
- Coronar MRA

JMRI 2013;DOI:10.1002/jmri.24124

EKG-gated FSE MRA

Princip

Subtraktions-teknik

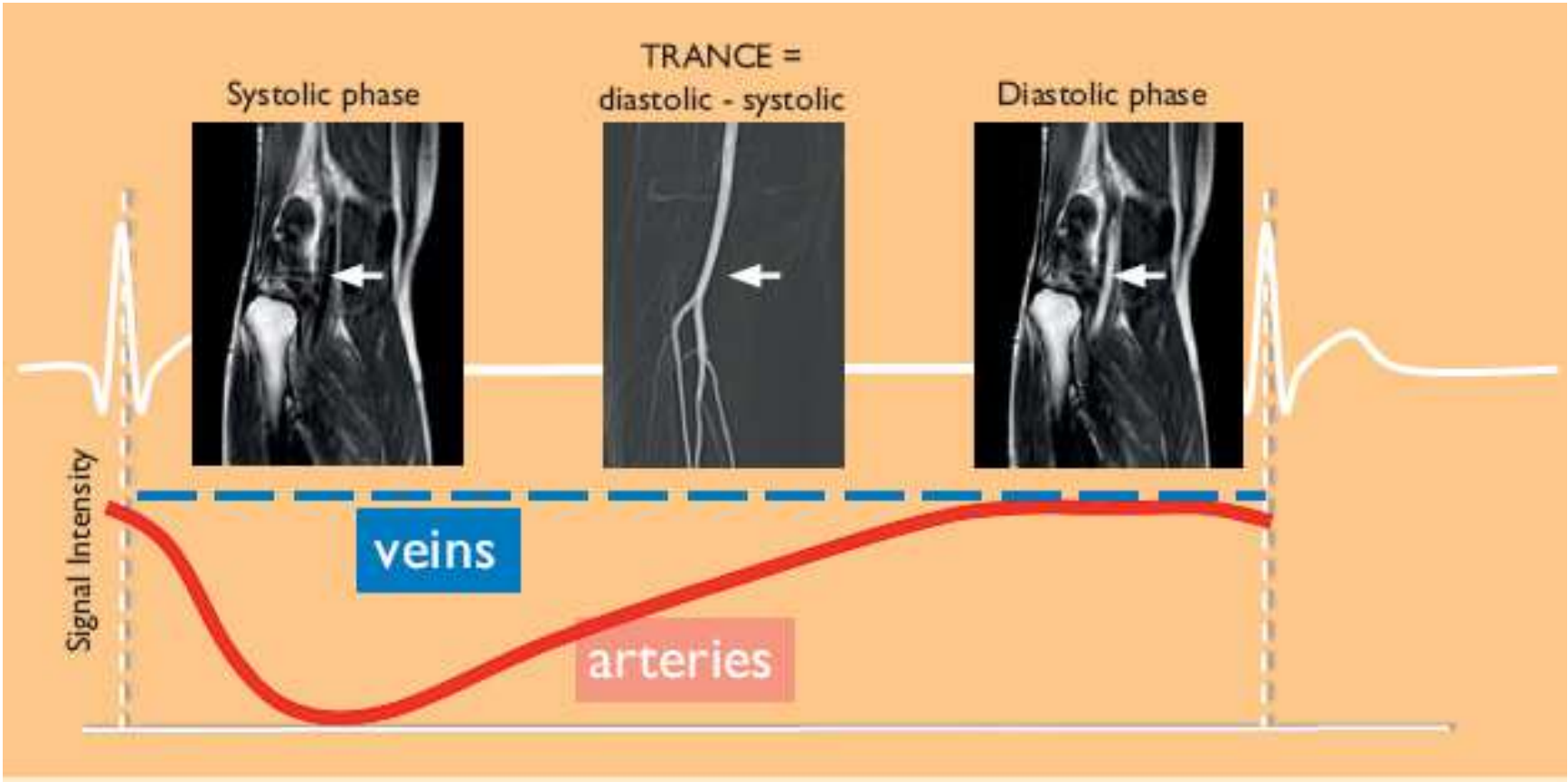
Udnytter forskellen mellem signal i diastole og systole

Kan både udføres som 2D og 3D teknik

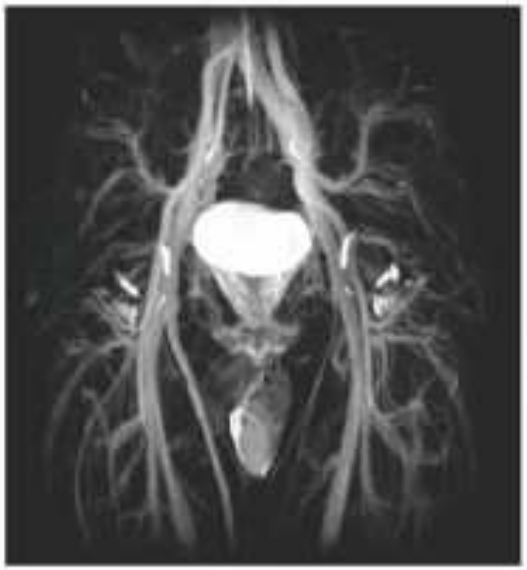
Kræver EKG- eller perifer puls gating

Metoden er tilgængelig til klinisk brug
(TRANCE, native SPACE, FBI, 3D delta flow)

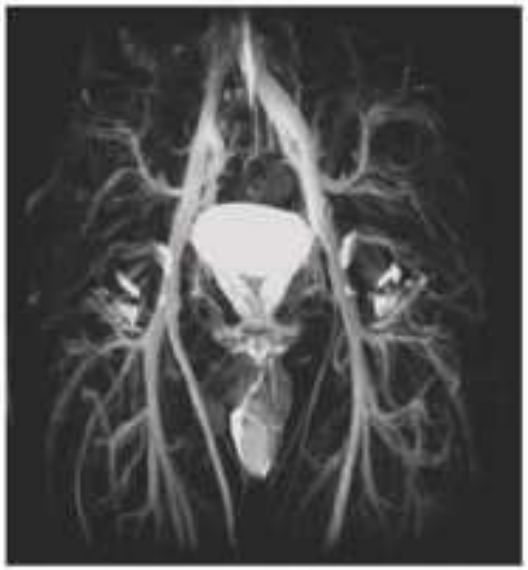
EKG-gated FSE MRA



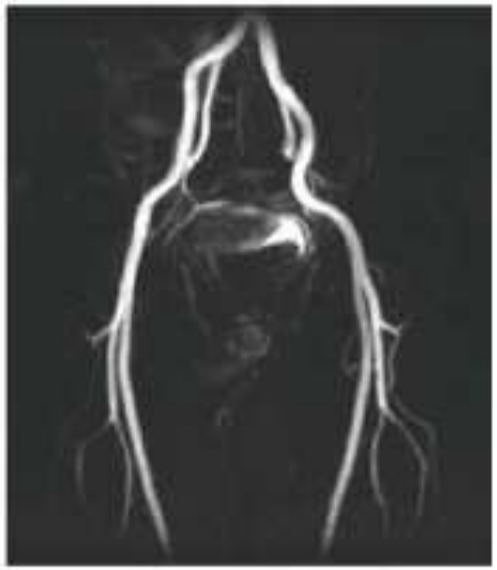
EKG-gated FSE MRA



Diastole (A+V)



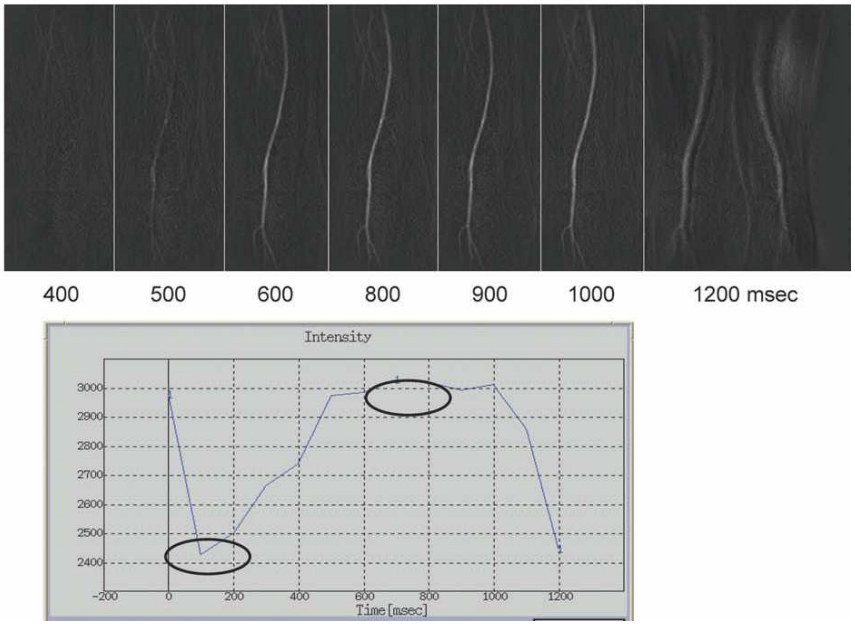
Systole (V)



Subtraktion MIP
(A+V)-V=A

EKG-gated FSE MRA

Trigger delays

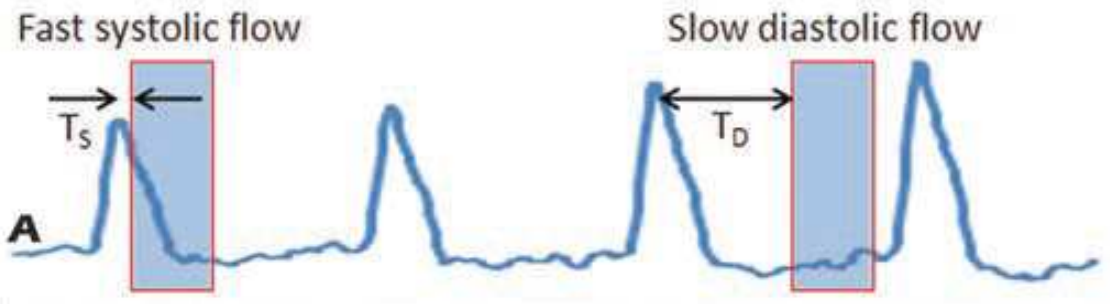


Systole Diastole

Subtraherede
EKG-prep billeder

EKG-gated FSE MRA

Trigger delays



EKG-gated FSE MRA

Applikationer

- Perifer MRA
- Thoraco-abdominal MRA
- MR Venografi

EKG-gated FSE MRA

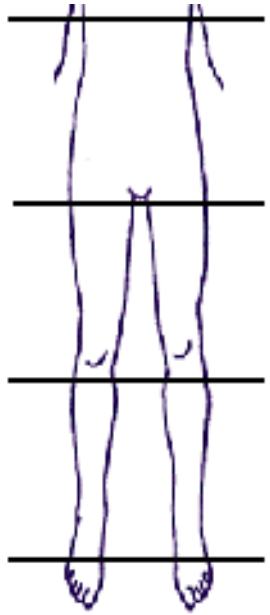
Perifer MRA

Skantid10-12 minutter (3 stationer)

Anvendelse af specielle flow spoiler gradienter

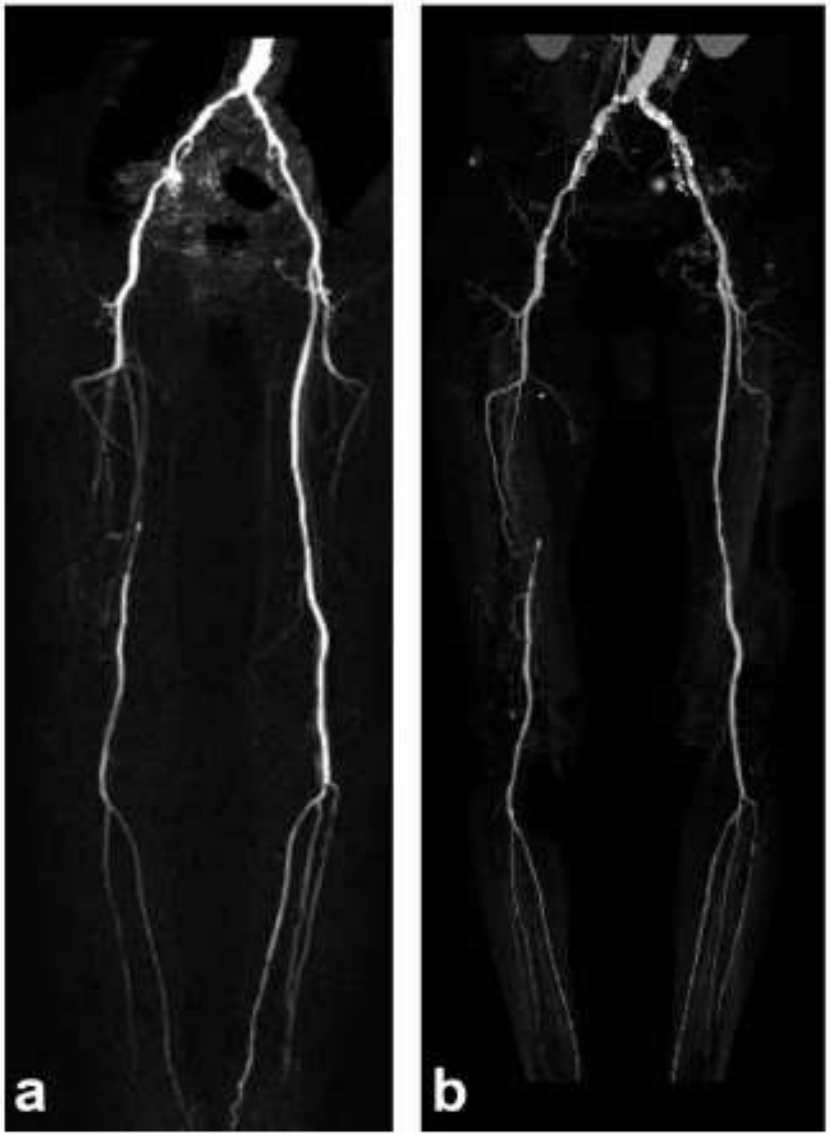
Fremmer forskellen mellem diastole og systole
Hurtigere defasing → accentureret flow void i systole

Fat-sat (STIR)



EKG-gated FSE MRA

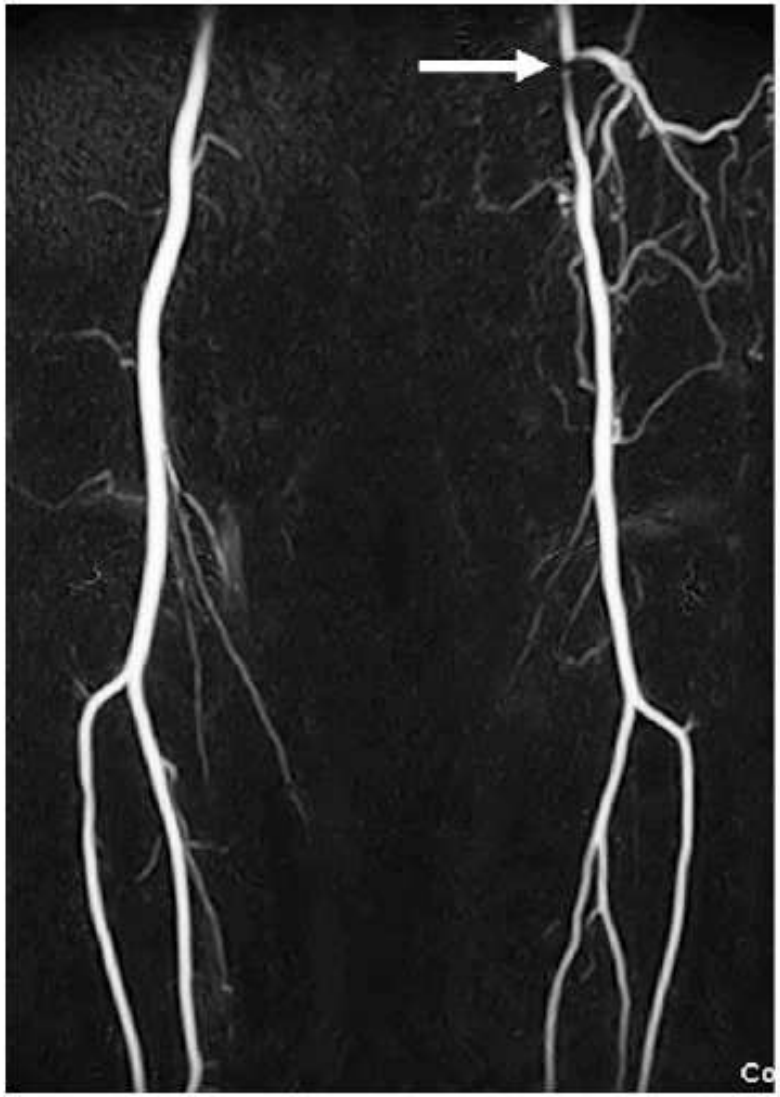
Non-kontrast

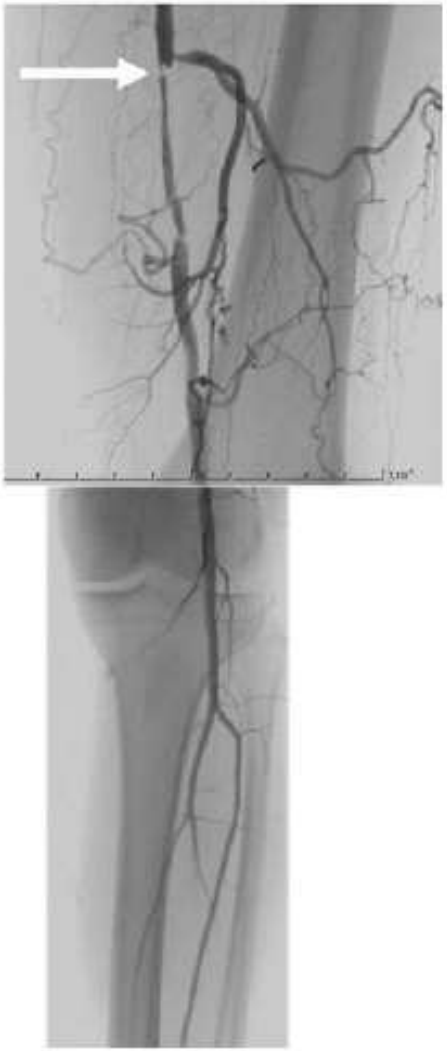


CTA

Magn Reson Med 2011;65:595-602

EKG-gated FSE MRA





JMRI 2012;36:286-304

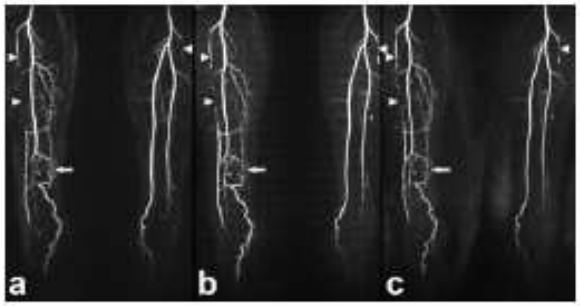
EKG-gated FSE MRA

JOURNAL OF MAGNETIC RESONANCE IMAGING 28:181–189 (2008)

Original Research

3D Nongadolinium-Enhanced ECG-Gated MRA of the Distal Lower Extremities: Preliminary Clinical Experience

Ruth P. Lim, MBBS, MMed, FRANZCR,[1]* Elizabeth M. Hecht, MD,[1] Jian Xu, BS,[2] James S. Babb, PhD,[1] Niels Oesingmann, PhD,[2] Samson Wong, MD,[1] Bart E. Muhs, MD, PhD,[3] Paul Gagne, MD,[3] and Vivian S. Lee, MD, PhD, MBA[1]



36 patienter

24 claudicatio, 7 kritisk iskæmi, 2 distal emboli, 4 andet

Reference metode: CE-MRA (inkl. time-resolved)

Resultater

Sens. 0.85 Spec. 0.76 Interobservatør Kappa 0.70

Betydende artefakter hos 17/36 patienter

EKG-gated FSE MRA

Eur Radiol (2011) 21:1979–1987
DOI 10.1007/s00330-011-2132-4

MAGNETIC RESONANCE

ECG-Triggered Non-Contrast-Enhanced MR Angiography (TRANCE) versus Digital Subtraction Angiography (DSA) in patients with peripheral arterial occlusive disease of the lower extremities

Andreas Gutzeit · Reto Sutter · Johannes M. Froehlich · Justus E. Roos · Thomas Sautter · Erik Schoch · Barbara Giger · Michael Wyss · Nicole Graf · Constantin von Weymarn · Regula Jenelten · Christoph A. Binkert · Klaus Hergan

43 patienter (Fontaine IIa 21, IIb 21, IV 1)

Reference metode: DSA

Resultater

Sens. 0.86 Spec. 0.96

Non-diagnostiske segmenter: 1% femur, 10% crus, 30% fod

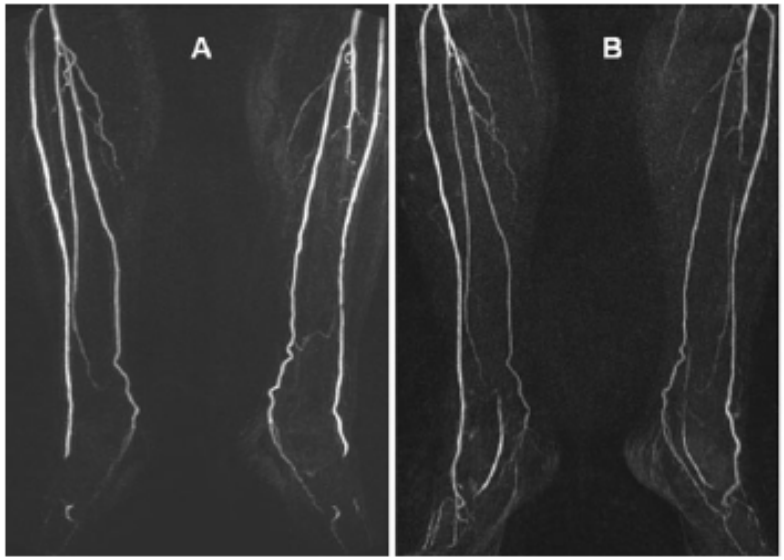
EKG-gated FSE MRA

Eur Radiol (2011) 21:1452–1461
DOI 10.1007/s00330-011-2063-0

MAGNETIC RESONANCE

Magnetic resonance angiography (MRA) of the calf station at 3.0 T: intraindividual comparison of non-enhanced ECG-gated flow-dependent MRA, continuous table movement MRA and time-resolved MRA

Stefan Haneder · Ulrike I. Attenberger · Philipp Riffel · Thomas Henzler · Stefan O. Schoenberg · Henrik J. Michaely



37 patienter med PAD (Fontaine II-IV)

Referencemetode

CE-MRA (inkl. time-resolved)

Resultater

Sens. 1.00 Spec. 0.79

Betydende artefakter 19/37

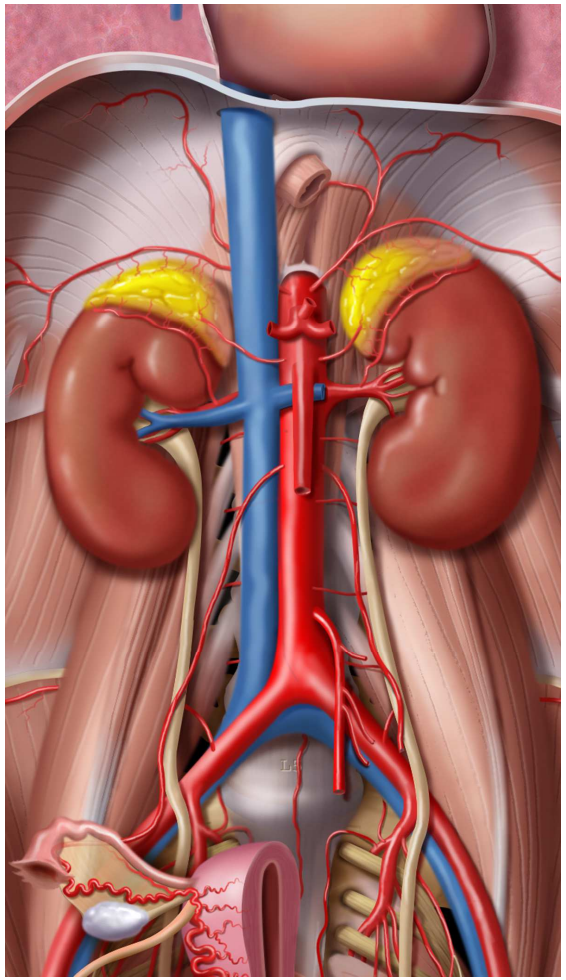
EKG-gated FSE MRA

Thoraco-abdominal MRA

Subtraktion ikke nødvendig

Spin-ekko sekvens er fordelagtig i thorax

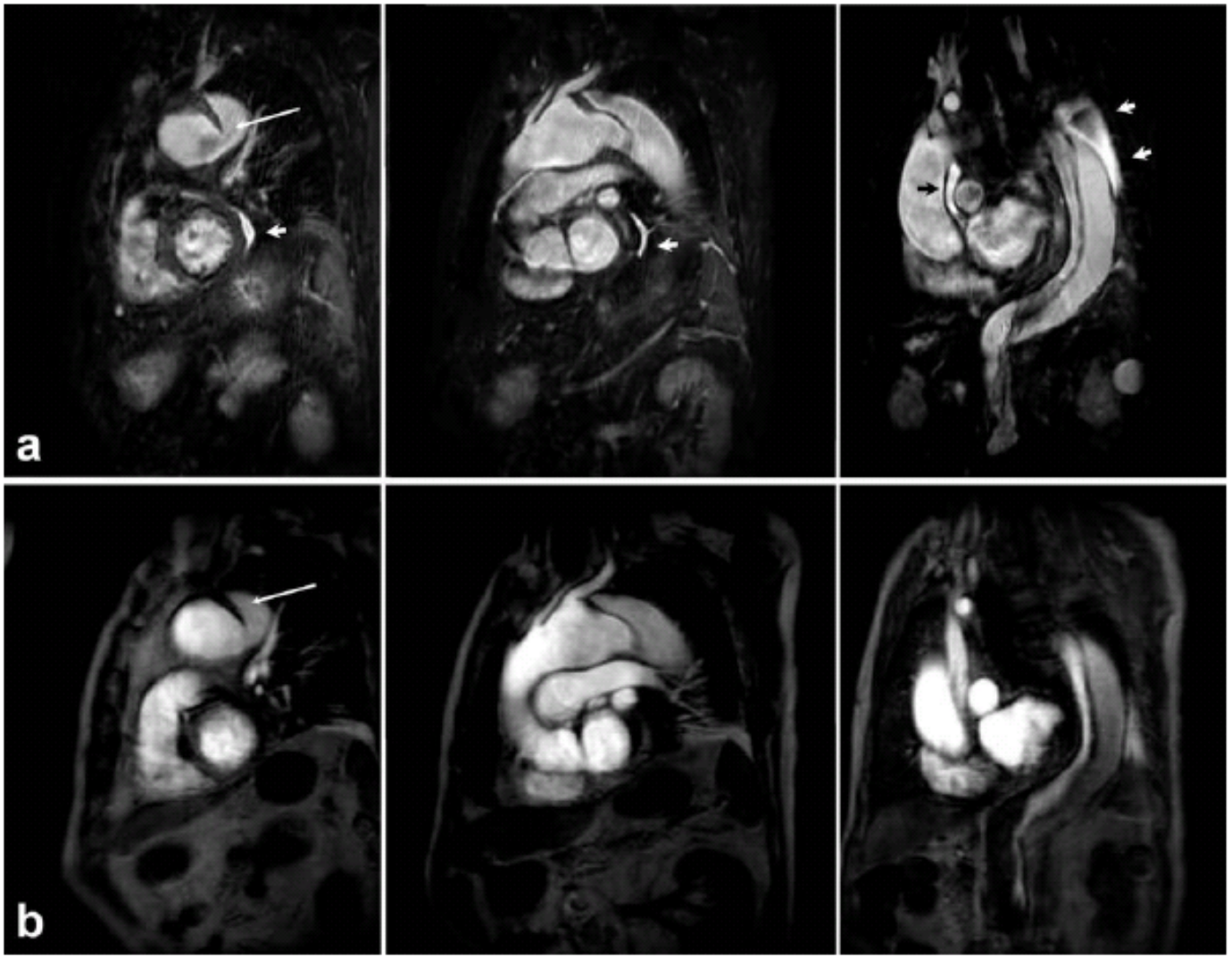
Ikke så vel-undersøgt som perifer MRA



EKG-gated FSE MRA

Non-kontrast

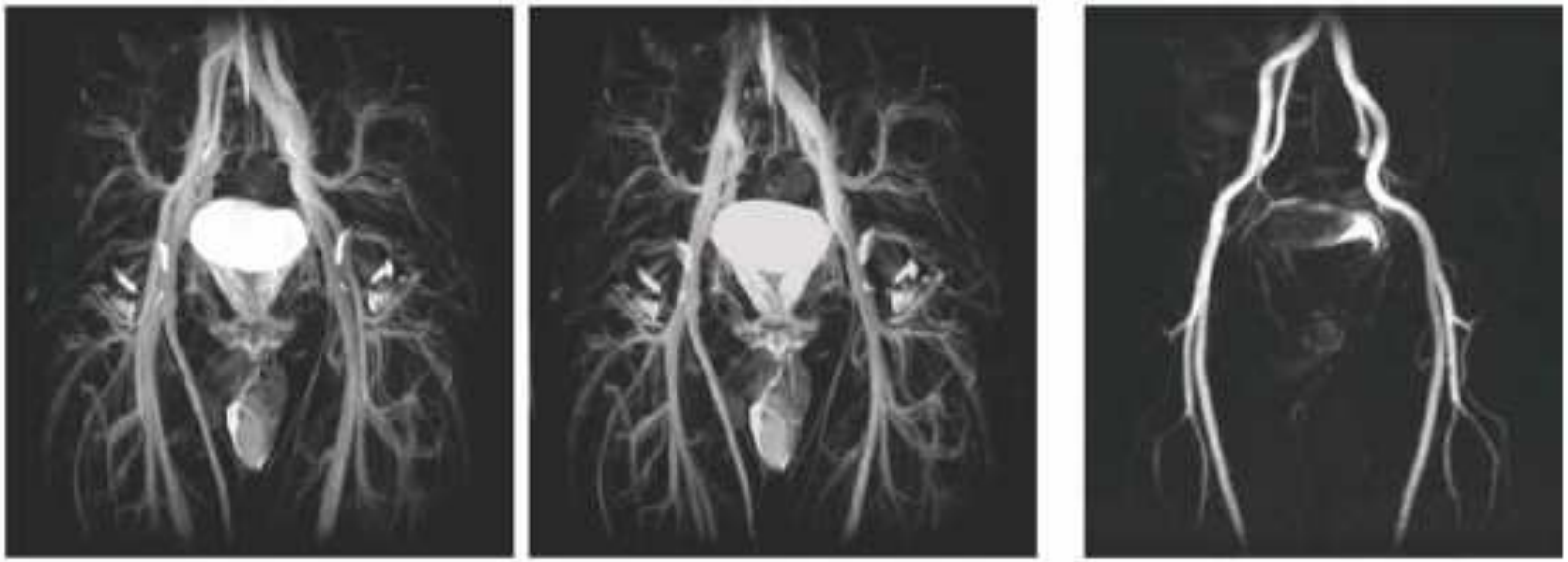
CE-MRA



JMRI 2001;14:113-19

EKG-gated FSE MRA

MR-venografi



Diastole (A+V) Systole (V) Subtraktion MIP (A)

Diastole (A+V) – subtraktions MIP (A) → MR-venogram

EKG-gated FSE MRA

Fordele

- Robust
- Non-kontrast
- Spin-ekko påvirkes ikke af inhomogenitet i magnetfeltet

Ulemper

- Arrytmier kan forstyrre EKG-synkronisering
- Relativ langsom metode
- Subtraktion følsom for bevæge-artefakter
- Nøjagtig indstilling af trigger delays er påkrævet
- Overestimering af stenoser

- Ikke mange studier af patienter med kritisk iskæmi

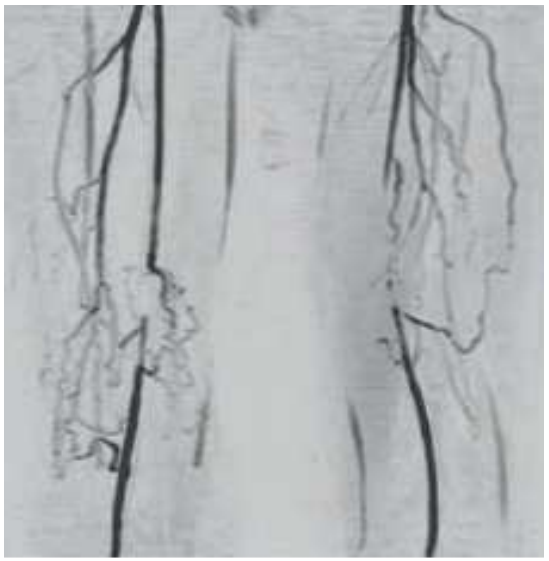
Non-kontrast MRA-teknikker

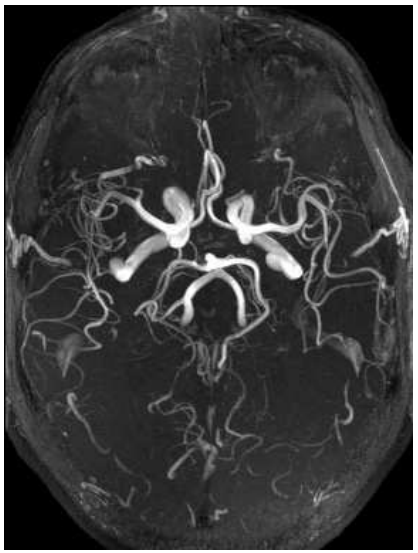
Nyere

- Subtraktion
- bSSFP-baseret MRA

Konventionelle

- TOF
- Phase-contrast



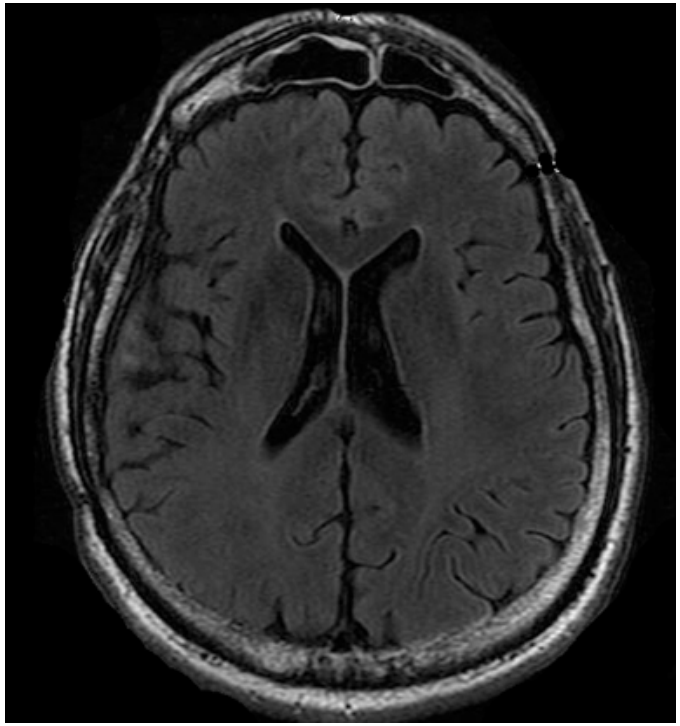


bSSFP-baseret MRA

- Gradient echo MR sekvens
- T2/T1 kontrast
- Ulempe ved metoden: Højt signal fra arterier, vener og baggrund
- Modvirkes ved brug af inversions-pulse

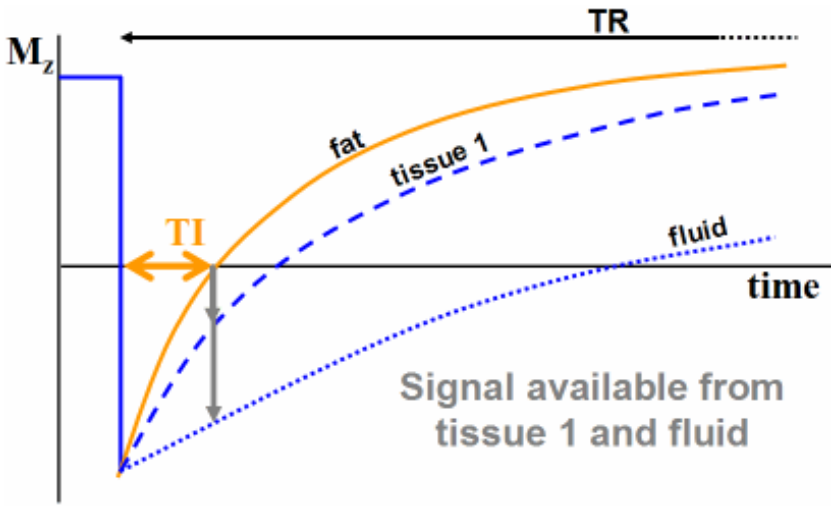
Inversions-puls

- Meget udbredt MR-teknik til suppression af signal fra forskellige væv
- Eksempler: STIR (fat-sat) FLAIR (suppression af vand)

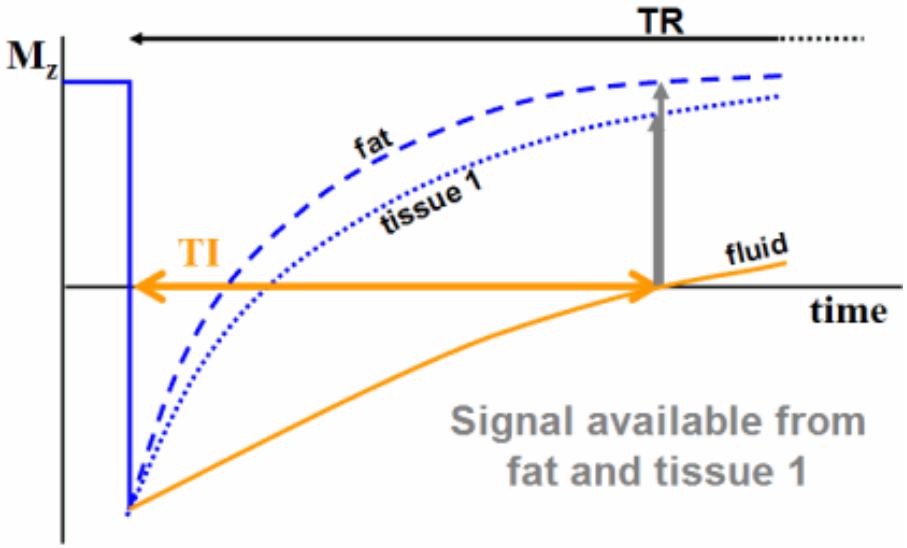


Inversions-puls

STIR – fedt satureres



FLAIR – vand satureres



bSSFP-baseret MRA

Applikationer

- Tagging-metode → Renal MRA
- EKG-gating → QISS → Perifer MRA
- EKG-gating → QISS → Coronar MRA

Tagging MRA

Princip

1.Inversions-puls

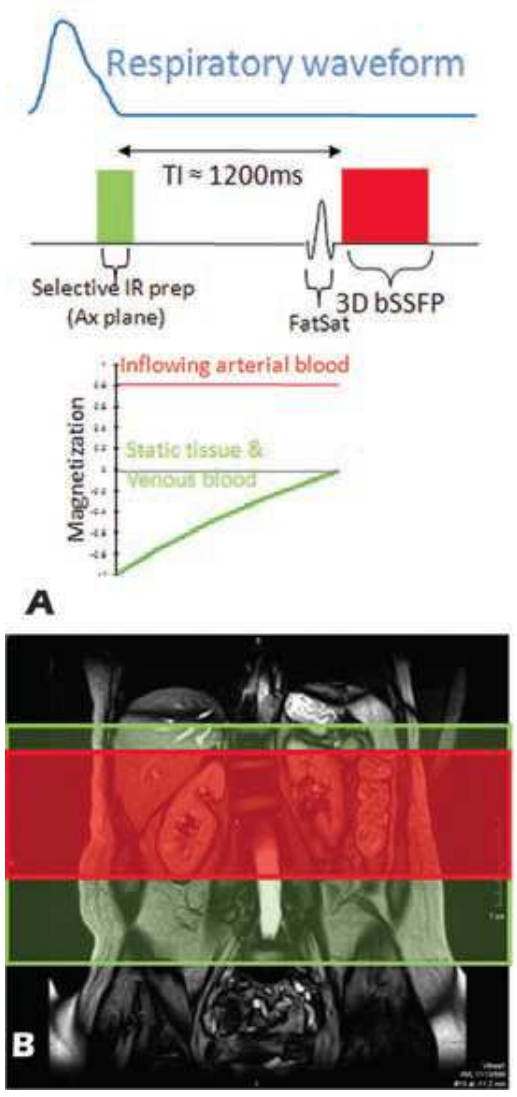
2.TI-periode (ca. 1200 ms for renal MRA)

3.Fat-sat

4.Scanning med bSSFP-sekvens

Anvender respirations-synkronisering

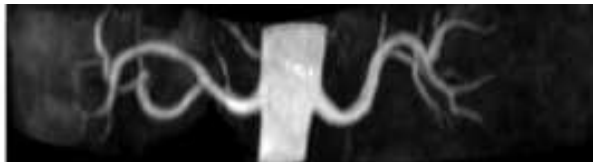
Scantid for renal MRA 2-4 min.



Tagging MRA

Renal Artery Assessment with Nonenhanced Steady-State Free Precession versus Contrast-enhanced MR Angiography[1]

Radiology



Radiology 2007;245:186-95

53 patienter (hypertension, mistanke om RAS)

Reference-metode

CE-MRA

Resultater

Sens. 0.95-1.00 Spec. 0.93-0.95

Tagging MRA

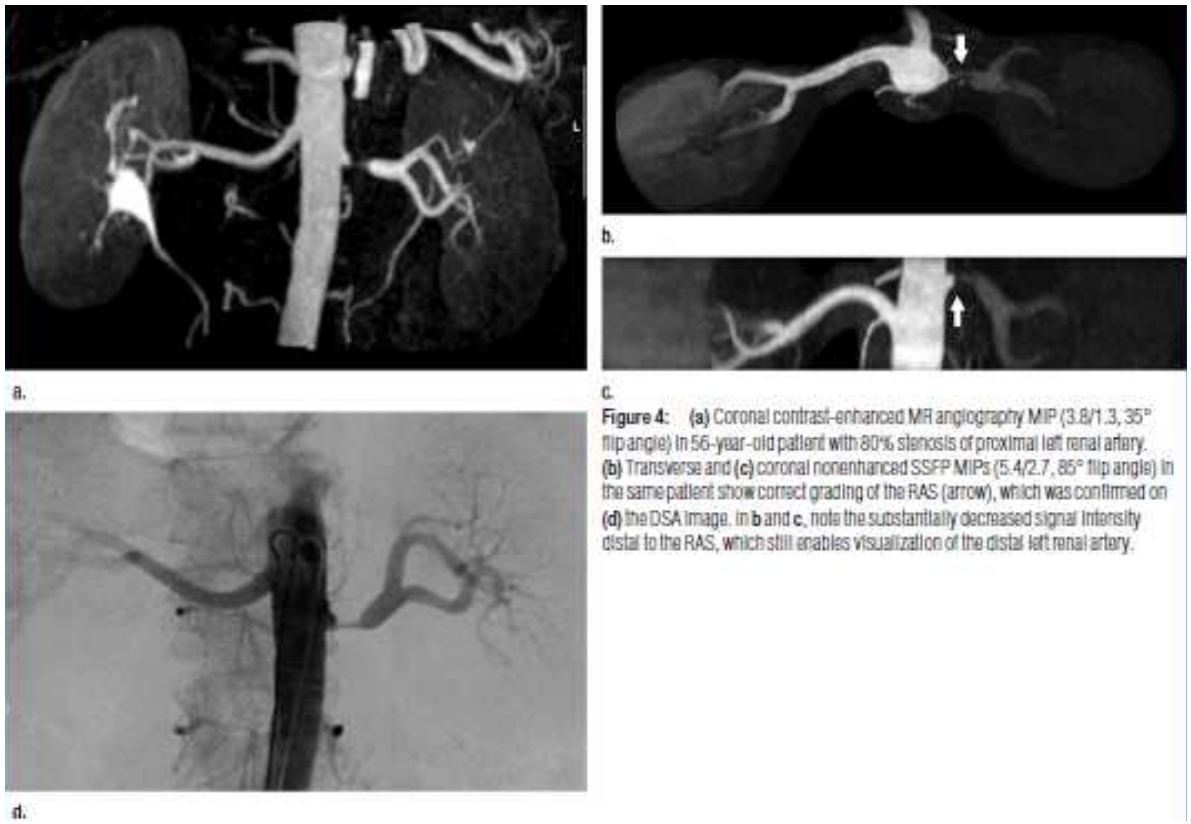
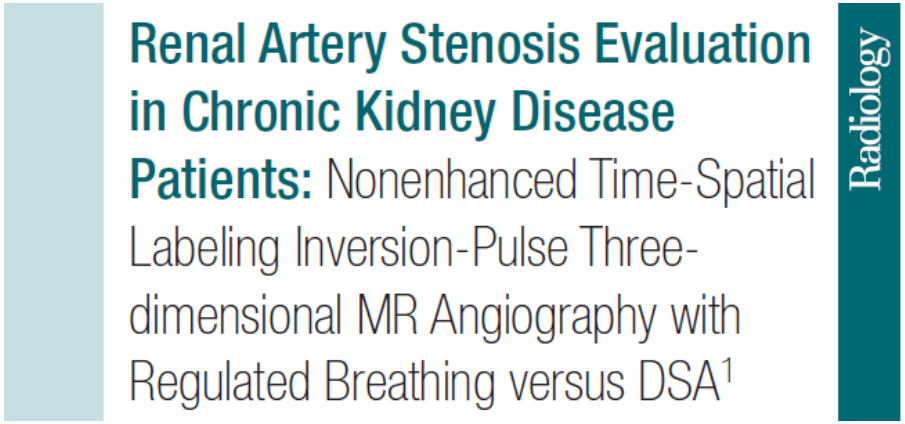


Figure 4: **(a)** Coronal contrast-enhanced MR angiography MIP (3.8/1.3, 35° flip angle) in 56-year-old patient with 80% stenosis of proximal left renal artery. **(b)** Transverse and **(c)** coronal nonenhanced SSFP MIPs (5.4/2.7, 85° flip angle) in the same patient show correct grading of the RAS (arrow), which was confirmed on **(d)** the DSA image. In **b** and **c**, note the substantially decreased signal intensity distal to the RAS, which still enables visualization of the distal left renal artery.

Radiology 2007;245:186-95

Tagging MRA



Radiology 2011;259:592:601

23 patienter (kendt RAS, planlagt DSA)

Sens. 0.93 Spec. 0.88

Diagnostisk kvalitet hos alle 23 patienter

bSSFP-baseret MRA

Applikationer

- Tagging-metode → Renal MRA
- EKG-gating → QISS → Perifer MRA
- EKG-gating → Coronar MRA

QISS-MRA

- Nyere non-kontrast MRA-teknik
- Inflow-baseret
- EKG-gated
- Kun tilgængeligt hos Siemens

QISS-MRA

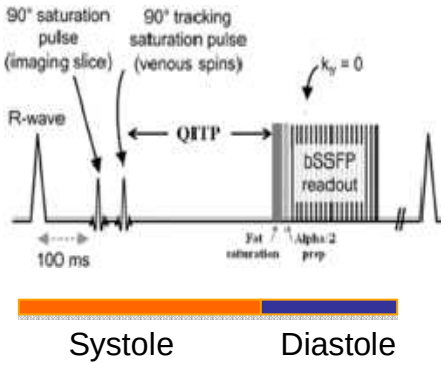
Princip

Fjern baggrundssignal (saturation)

Fjern venesignal (saturation)

QI-periode – arterielt inflow

Scanning i diastole



QISS-MRA

JOURNAL OF MAGNETIC RESONANCE IMAGING 00:000–000 (2013)

Original Research

Comparison of Quiescent Inflow Single-Shot and Native Space for Nonenhanced Peripheral MR Angiography

Emily V. Ward, MBBChBAO,[1,2] Mauricio S. Galizia, MD,[1,2] Asad Usman, MD,[2] Andrada R. Popescu, MD,[2] Eugene Dunkle, RT (R) (MR),[1] and Robert R. Edelman, MD[1]*

20 patienter (symptomgivende PAOD/abnormt ABI)

Referencemetode
CE-MRA (inkl. time-resolved)

Resultater
QISS: Sens. 0.85 Spec. 0.96
FSE-MRA: Sens. 0.87 Spec. 0.87

Non-diagnostiske segmenter: QISS 0%
FSE-MRA 5%

QISS-MRA

Clinical Radiology 67 (2012) 441–446

Contents lists available at SciVerse ScienceDirect

Clinical Radiology

journal homepage: www.clinicalradiologyonline.net

Nonenhanced ECG-gated quiescent-interval single-shot MRA (QISS-MRA) of the lower extremities: Comparison with contrast-enhanced MRA

J. Klasen [a], D. Blondin [a,*], P. Schmitt [b], X. Bi [c], R. Sansone [d], H.-J. Wittsack [a], P. Kröpil [a], M. Quentin [a], J. Kuhlemann [a], F. Miese [a], C. Heiss [d], M. Kelm [d], G. Antoch [a], R.S. Lanzman [a]

27 patienter (PAOD)

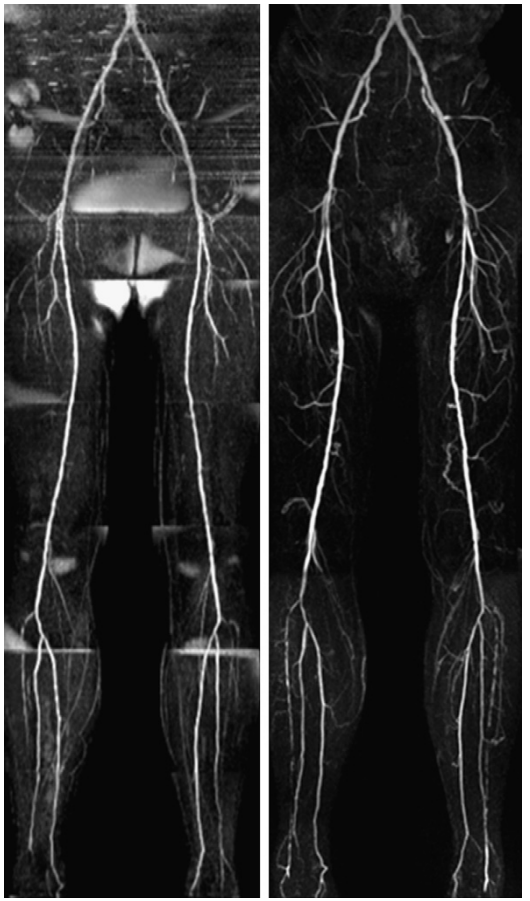
Reference metode

CE-MRA

Resultater

Sens. 0.99 Spec. 0.96

Betydende artefakter i 2% af vurderede arterielle segmenter



CE-MRA QISS-MRA

QISS-MRA

AJR JOURNAL CLUB

Peripheral Arterial Disease in a Symptomatic Diabetic Population: Prospective Comparison of Rapid Unenhanced MR Angiography (MRA) With Contrast-Enhanced MRA

AJR 2011;197:1466-1473

25 patienter (PAOD)

Reference metode
CE-MRA

Resultater
Sens. 0.87 Spec. 0.97

CE-MRA QISS-MRA

Coronar MRA

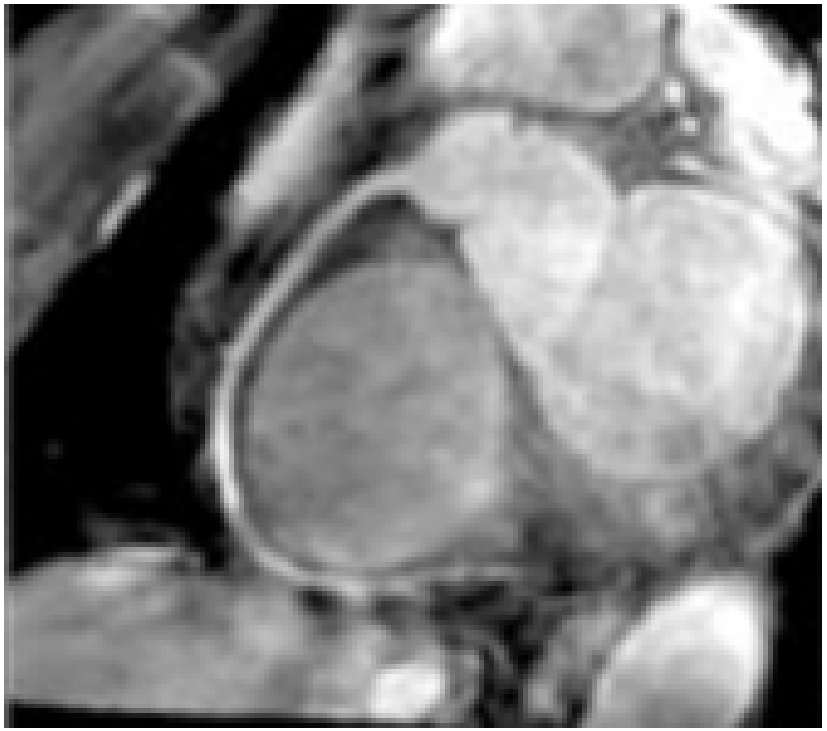
Teknisk muligt

SSFP-sekvenser
CE-MRA

Respiratorisk gating
EKG gating

Ikke så robust metode som CTA

Pædiatriske undersøgelser



Højre coronar-arterie fremstillet ved non-kontrast MRA (bSSFP)

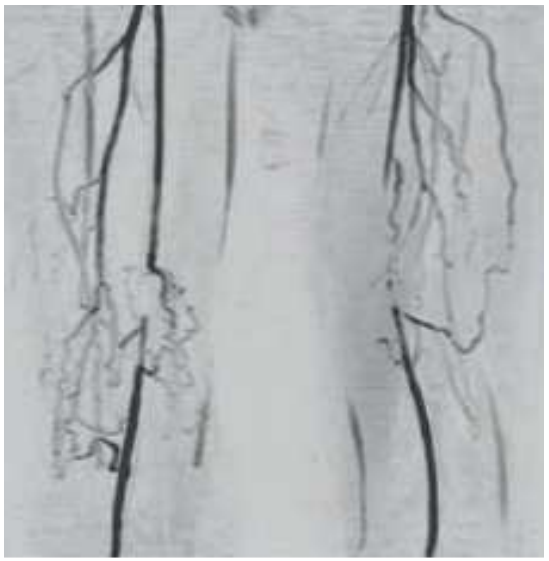
Non-kontrast MRA-teknikker

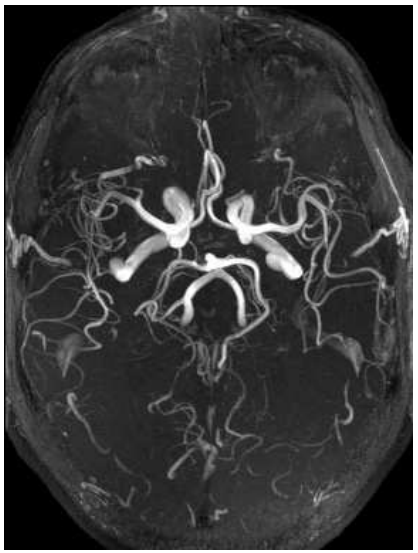
Nyere

- Subtraktion
- bSSP-baseret MRA

Konventionelle

- TOF
- Phase-contrast





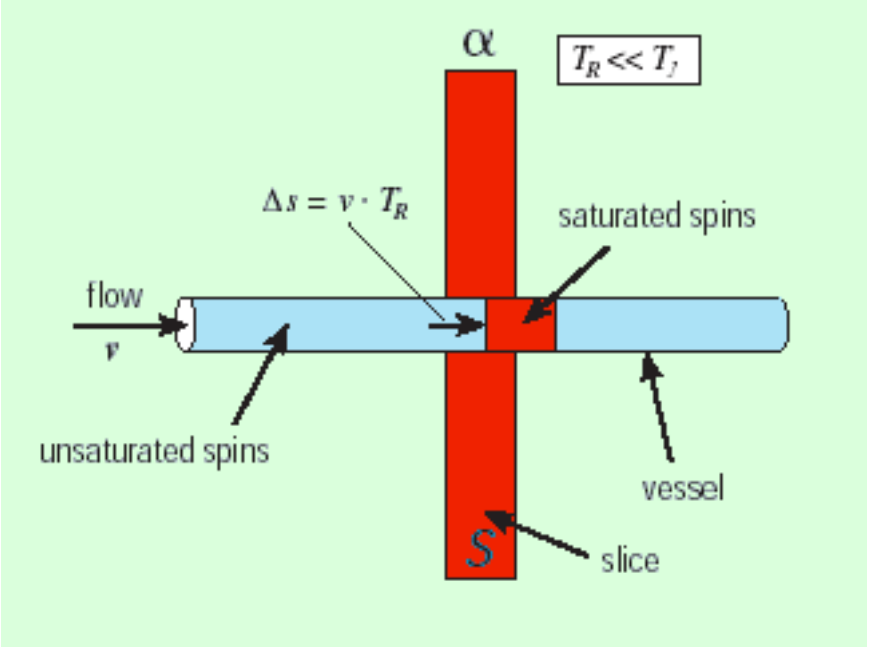
TOF-MRA

Princip

Gradient echo sekvens

Baggrunden satureres pga. kort TR

Inflow af blod → højt signal



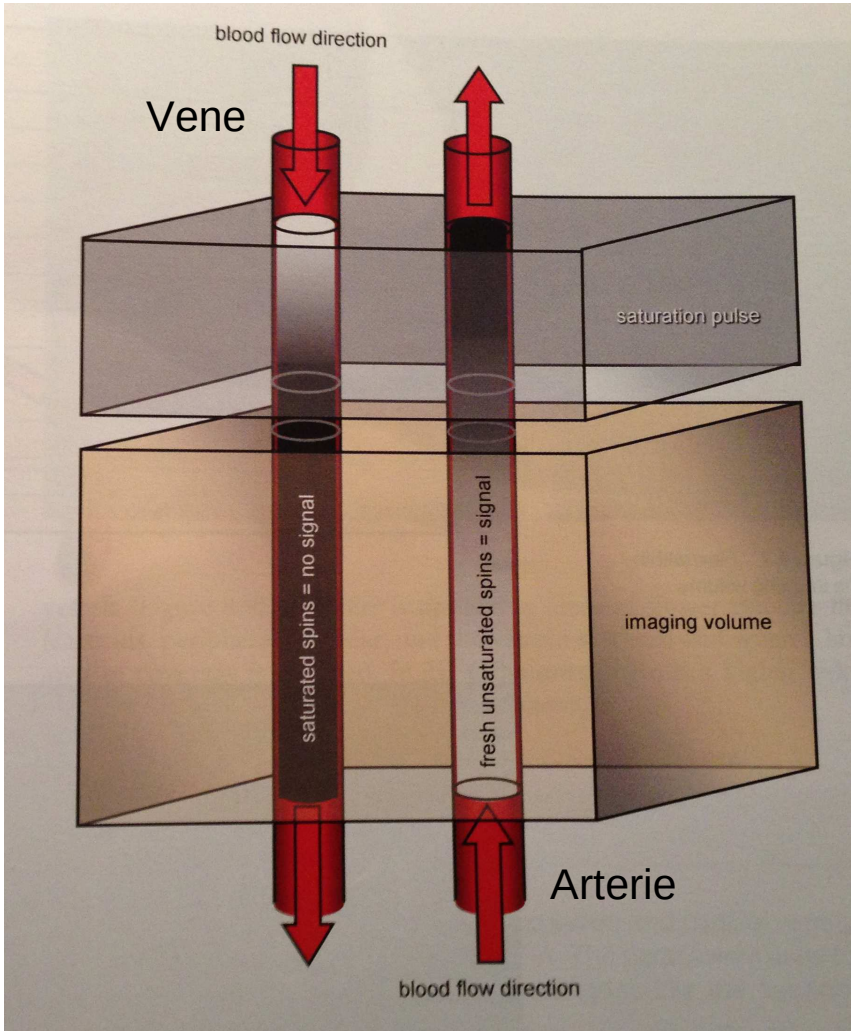
Begrænsninger

In-plane saturation

Turbulent flow → overgradering af stenoser

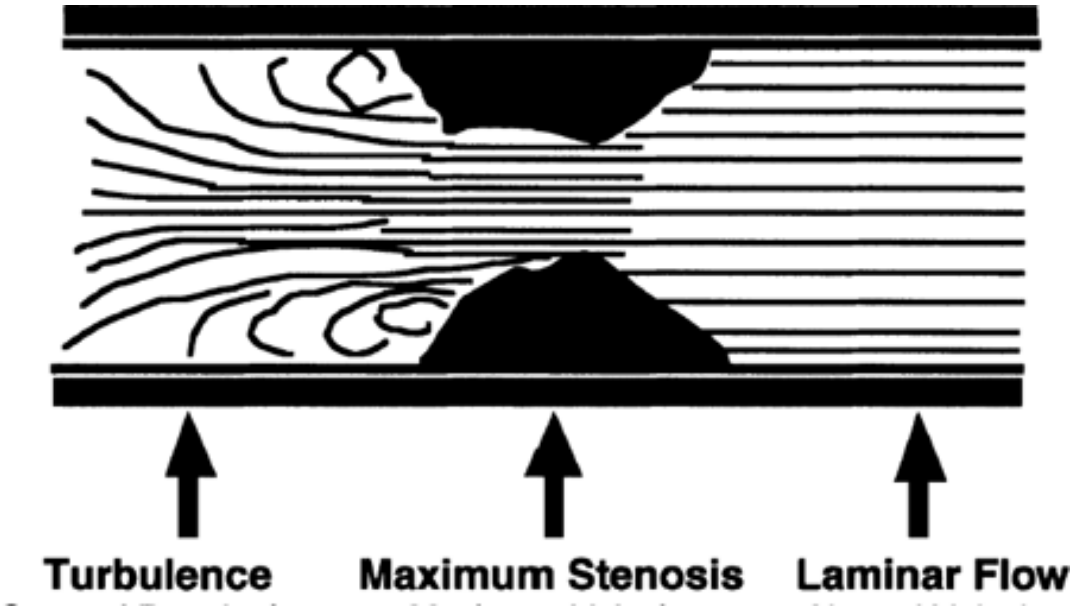
3D TOF-MRA har lang skan-tid (5-10 min)

TOF-MRA


blood flow direction
Vene
saturation pulse
saturated spins = no signal
fresh unsaturated spins = signal
imaging volume
Arterie
blood flow direction

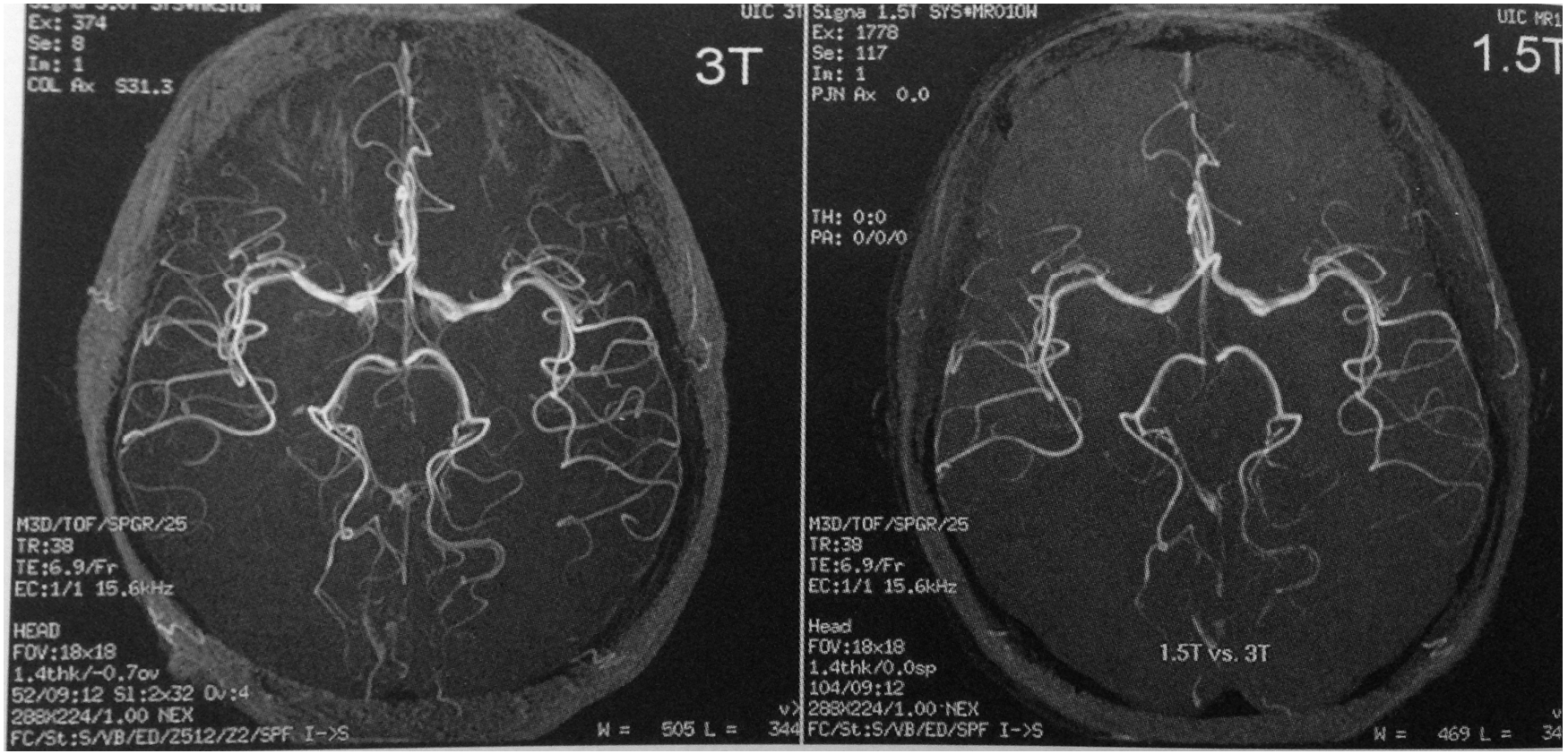
TOF-MRA

Over-estimering af stenoser



TOF-MRA

Intrakraniel 3D TOF-MRA er hyppigste anvendte MRA-teknik



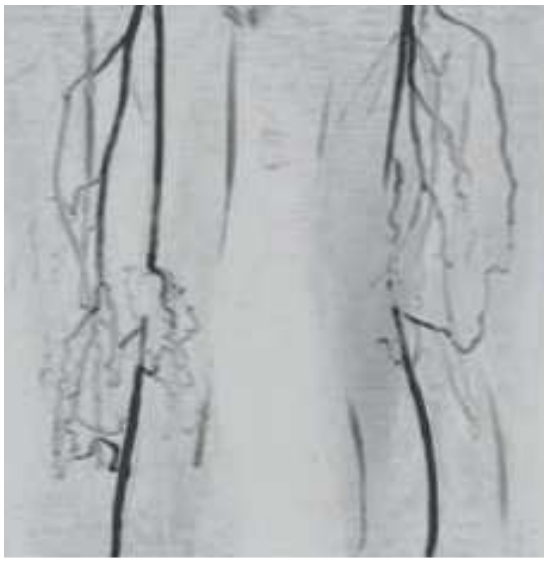
Non-kontrast MRA-teknikker

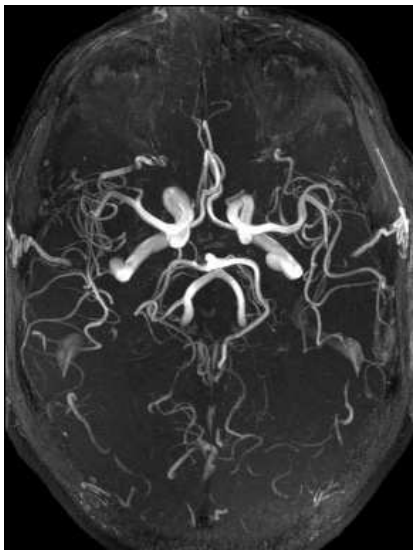
Nyere

- Subtraktion
- bSSP-baseret MRA

Konventionelle

- TOF
- Phase-contrast





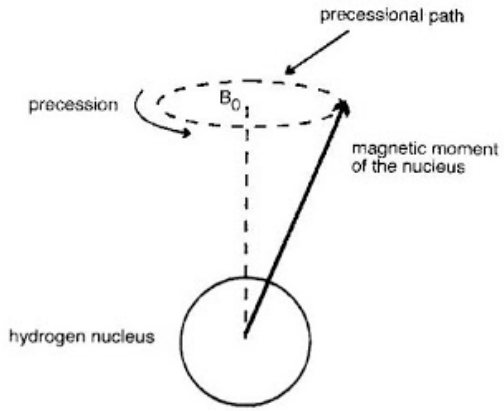
Phase-contrast MRA

Princip

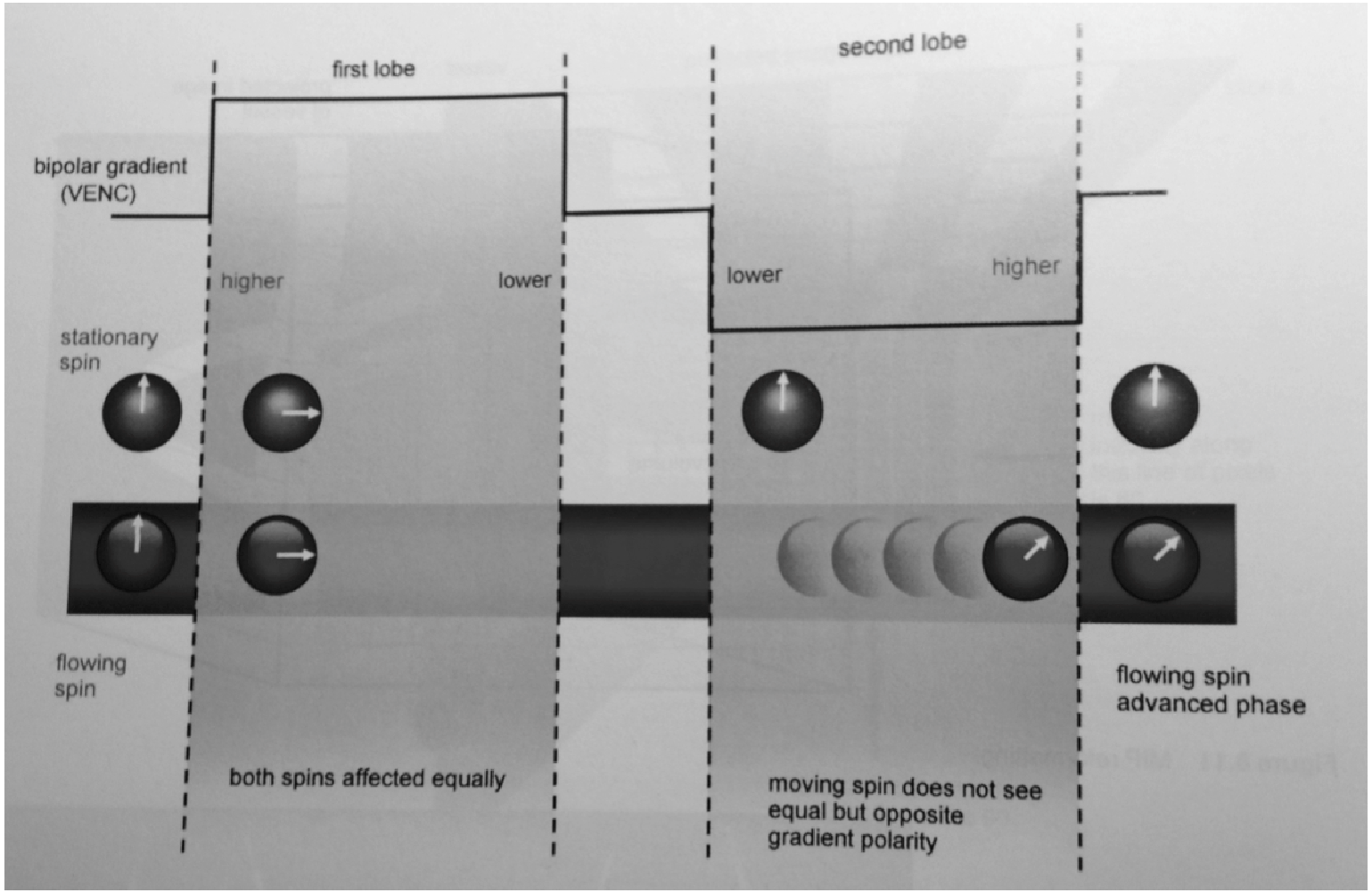
Fase-skift i protoner induceres med gradient

Bipolar gradient → stationære protoner ændrer ikke fase

→ protoner i kar ændrer fase pga. flow



Phase-contrast MRA



Phase-contrast MRA

Flow-hastighedsmålinger

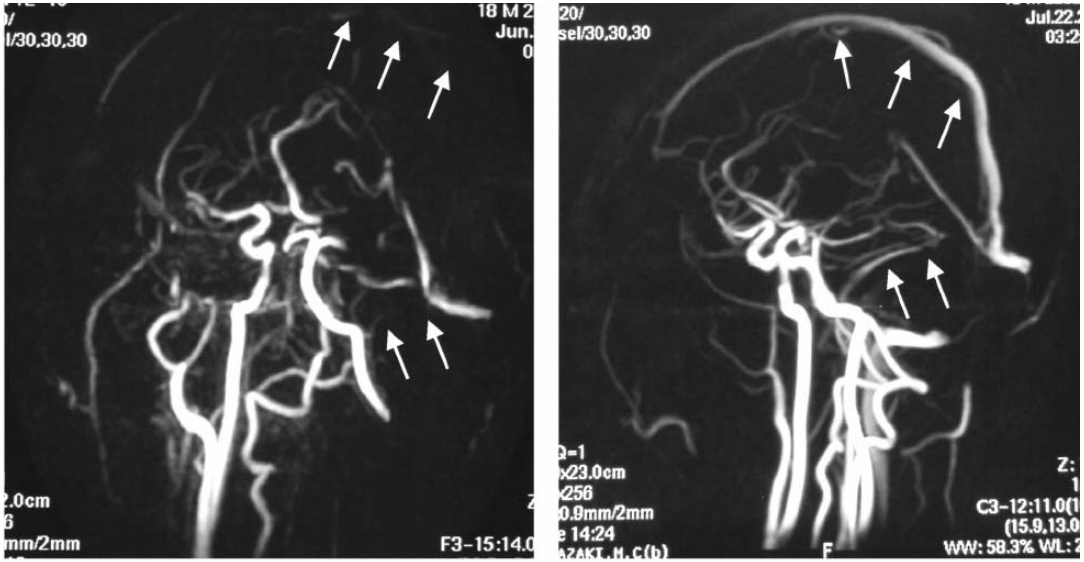
Fase-skiftet proportional med flow-hastighed

Phase-contrast MRA

Lang scantid

Bevægeartefakter

Få kliniske anvendelser



Internal Medicine 2004;43:400-403

Non-kontrast MRA

	EKG-gated FSE MRA	Tagging MRA	QISS
Philips	TRANCE	bTRANCE	n/a
Siemens	Native SPACE	Native trueFISP	QISS
Toshiba	FBI	time-SLIP	n/a
GE	3D delta Flow	Inflow-IR	n/a

Opsummering

Non-kontrast MRA

- Mange nye metoder under udvikling
- Betydelig forskningsaktivitet
- Teknisk krævende undersøgelser – optimering nødvendig
- Få studier hos patienter med kritisk iskæmi
- TOF-MRA er den hyppigst anvendte MRA-teknik
- Phase-contrast MRA – effektiv til flowmålinger