UMC Utrecht

Vascular imaging – the renal arteries

Anneloes de Boer, MD, BSc

Clinical rationale

renovascular hypertension

renal denervation

renal transplantation

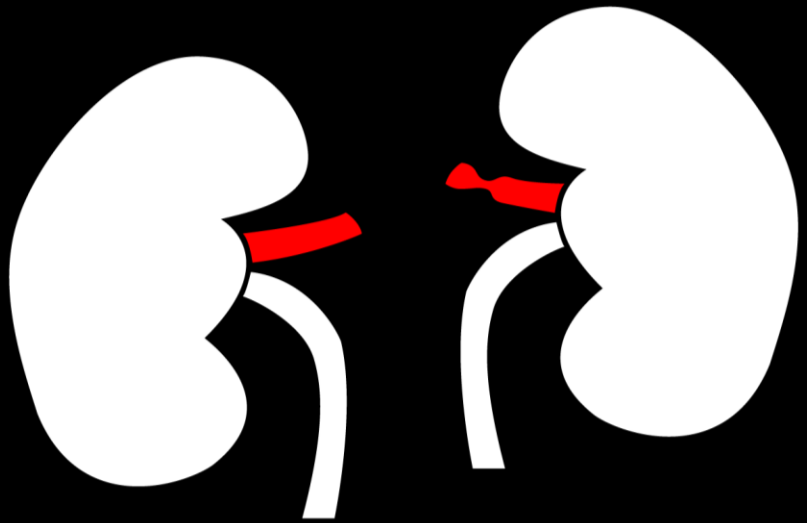
Clinical rationale

renovascular hypertension

renal denervation

renal transplantation

Goldblatt phenomenon

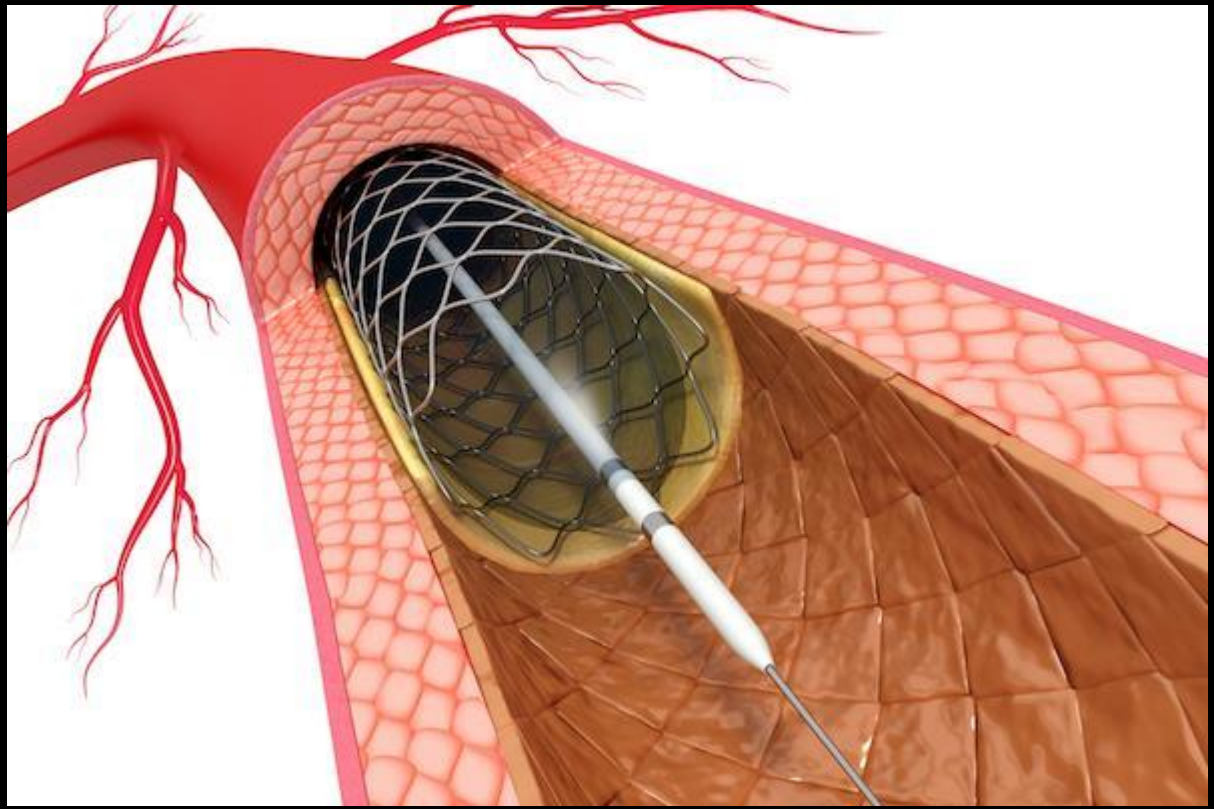


RAAS activation

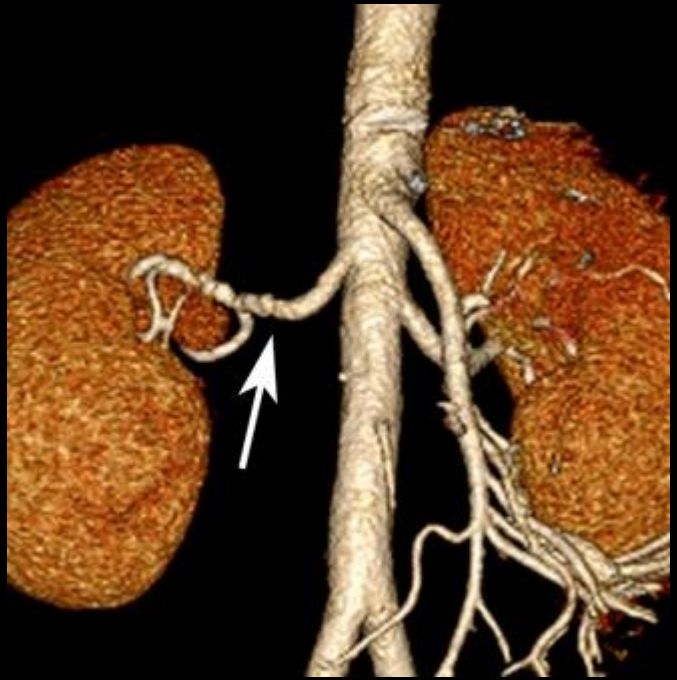
sodium retention
blood pressure ↑

renal blood flow ↑
GFR (↑)

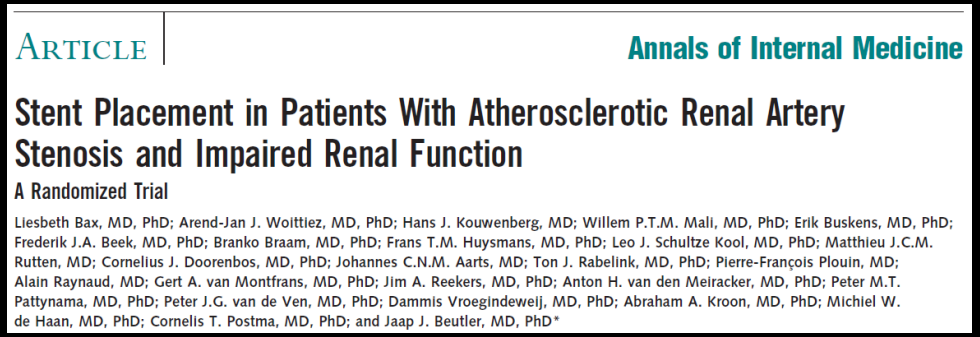
Goldblatt et al. J Exp Med. 1934 Feb 28;59(3):347-79.



Fibromuscular dysplasia



Fabrega-Foster KE, et al. J Magn Reson Imaging. 2018 Feb;47(2):572-581.



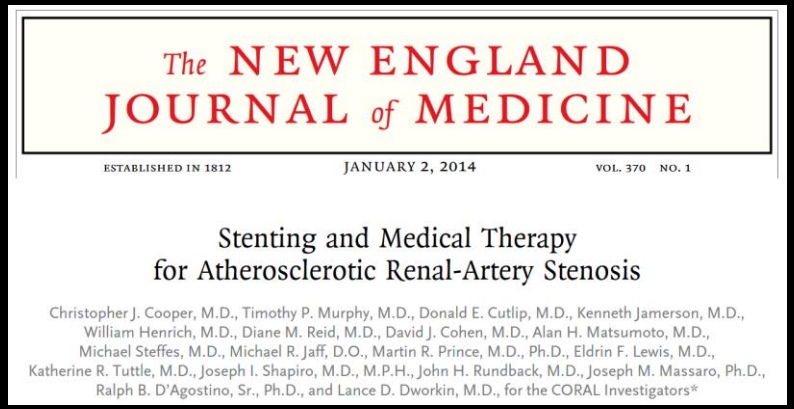
ARTICLE

Annals of Internal Medicine

Stent Placement in Patients With Atherosclerotic Renal Artery Stenosis and Impaired Renal Function

A Randomized Trial

Liesbeth Bax, MD, PhD; Arend-Jan J. Woittiez, MD, PhD; Hans J. Kouwenberg, MD; Willem P.T.M. Mali, MD, PhD; Erik Buskens, MD, PhD; Frederik J.A. Beek, MD, PhD; Branko Braam, MD, PhD; Frans T.M. Huysmans, MD, PhD; Leo J. Schultze Kool, MD, PhD; Matthieu J.C.M. Rutten, MD; Cornelius J. Doorenbos, MD, PhD; Johannes C.N.M. Aarts, MD; Ton J. Rabelink, MD, PhD; Pierre-François Plouin, MD; Alain Raynaud, MD; Gert A. van Montfrans, MD, PhD; Jim A. Reekers, MD, PhD; Anton H. van den Meiracker, MD, PhD; Peter M.T. Pattynama, MD, PhD; Peter J.G. van de Ven, MD, PhD; Dammis Vroegindeweij, MD, PhD; Abraham A. Kroon, MD, PhD; Michiel W. de Haan, MD, PhD; Cornelis T. Postma, MD, PhD; and Jaap J. Beutler, MD, PhD*

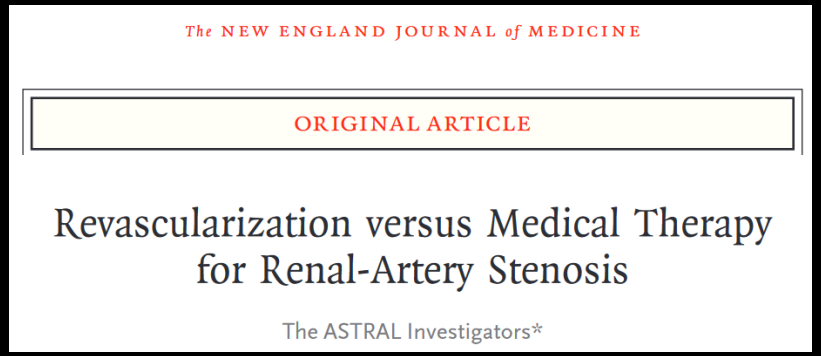


The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JANUARY 2, 2014 VOL. 370 NO. 1

Stenting and Medical Therapy for Atherosclerotic Renal-Artery Stenosis

Christopher J. Cooper, M.D., Timothy P. Murphy, M.D., Donald E. Cutlip, M.D., Kenneth Jamerson, M.D., William Henrich, M.D., Diane M. Reid, M.D., David J. Cohen, M.D., Alan H. Matsumoto, M.D., Michael Steffes, M.D., Michael R. Jaff, D.O., Martin R. Prince, M.D., Ph.D., Eldrin F. Lewis, M.D., Katherine R. Tuttle, M.D., Joseph I. Shapiro, M.D., M.P.H., John H. Rundback, M.D., Joseph M. Massaro, Ph.D., Ralph B. D'Agostino, Sr., Ph.D., and Lance D. Dworkin, M.D., for the CORAL Investigators*



The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Revascularization versus Medical Therapy for Renal-Artery Stenosis

The ASTRAL Investigators*

References: Bax L et al. Ann Intern Med 2009;150:840–848; W150-841.
Wheatley K et al. N Engl J Med 2009; 361:1953–1962.
Cooper CJ et al. N Engl J Med 2014; 370:13–22.

Future

treat earlier?*

identify “salvageable” kidneys†
- only treatment for functional relevant stenosis

treat microvasculature‡

References: *: de Leeuw PW et al. Curr Hypertens Rep. 2018 Apr 10;20(4):35.
†: Abumoawad A et al. Kidney Int. 2019 Apr;95(4):948-957.
‡: Chen XJ et al. J Hypertens. 2019 Oct;37(10):2074-2082.

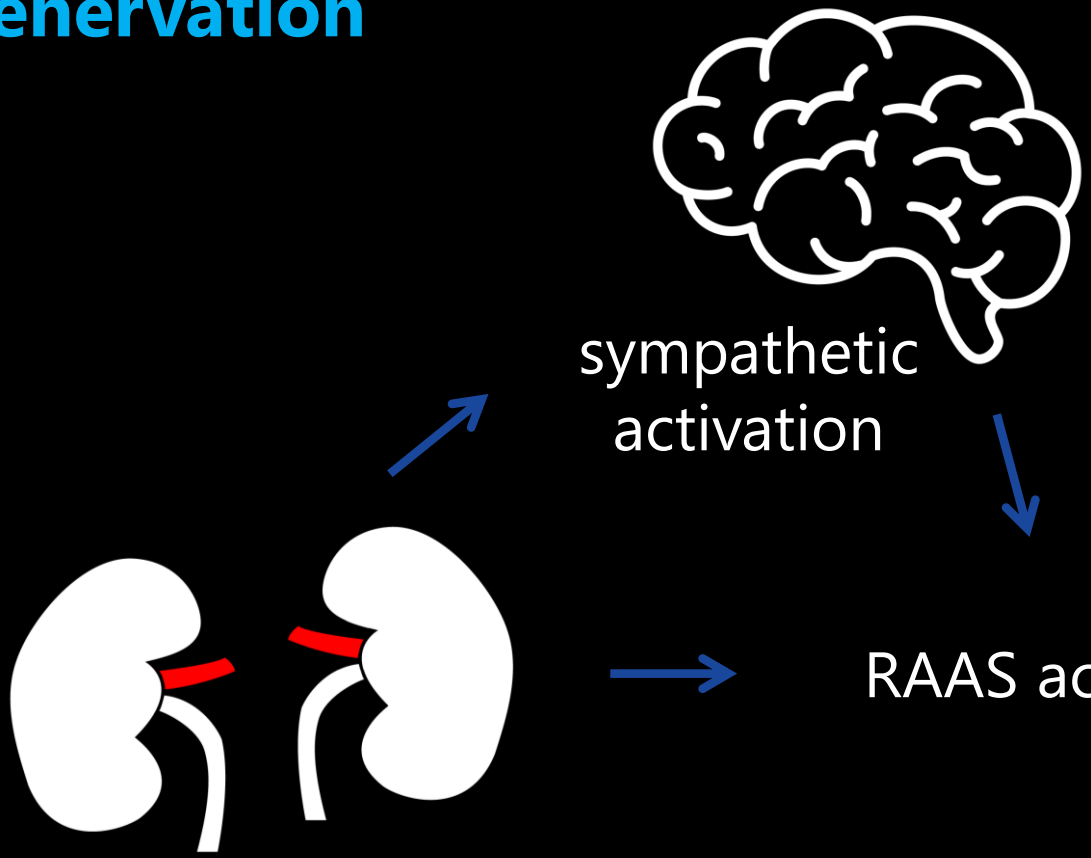
Why imaging the renal arteries?

renovascular hypertension

renal denervation

renal transplantation

Renal denervation



Why imaging the renal arteries?

renovascular hypertension

renal denervation

renal transplantation

US

CT

TOF MRA

Image: Blankholm AD et al. Acta Radiol. 2015 Dec;56(12):1527-33.

preoperative planning

- receiver*
- donor†

postoperative evaluation‡

References: *: Blankholm AD et al. Acta Radiol. 2015 Dec;56(12):1527-33.
†: Blankholm AD et al. Acad Radiol. 2015 Nov;22(11):1368-75.
‡: Gondalia R et al. Abdom Radiol (NY). 2018 Oct;43(10):2589-2596.

Imaging techniques

MRA vs other techniques

contrast enhanced MRA

non-contrast enhanced MRA

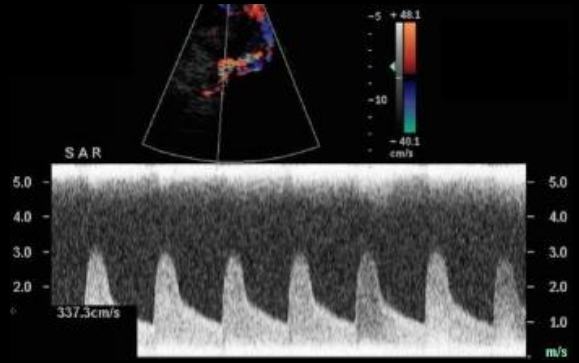
Imaging techniques

MRA vs other techniques

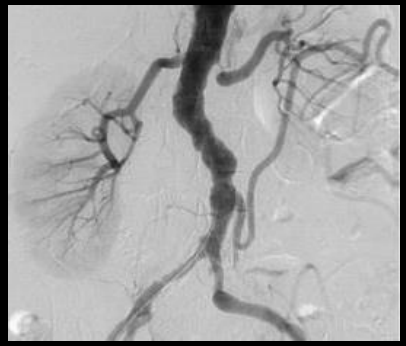
contrast enhanced MRA

non-contrast enhanced MRA

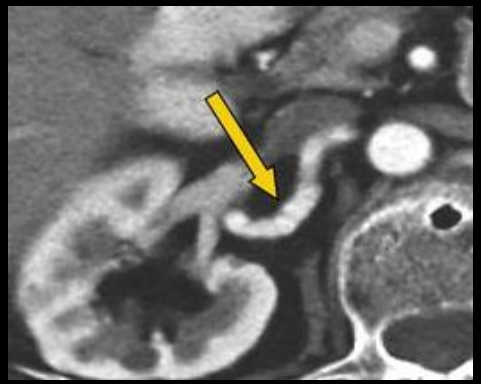
hand-held ultrasound



digital subtraction angiography



computed tomography angiography



magnetic resonance angiography

How to image the renal arteries?

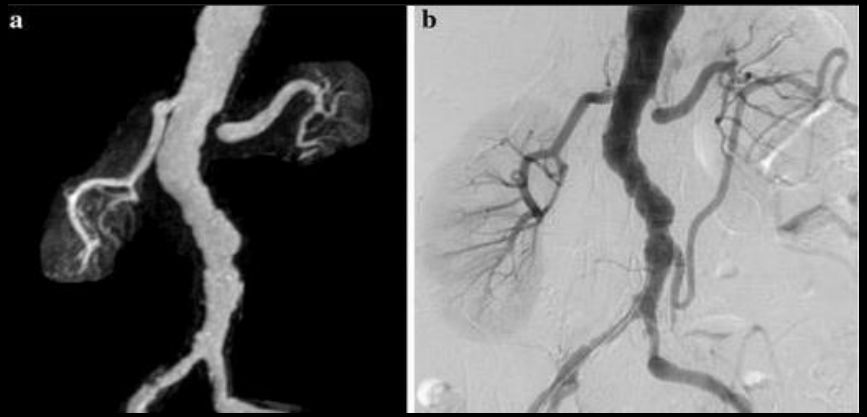
MRA vs CT vs DSA vs ultrasound

contrast enhanced MRA

non-contrast enhanced MRA

CE MRA vs CTA in native kidneys

atherosclerotic stenosis

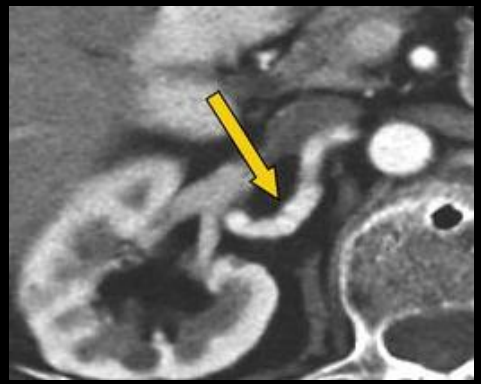


CE MRA DSA

fibromuscular dysplasia

CE MRA

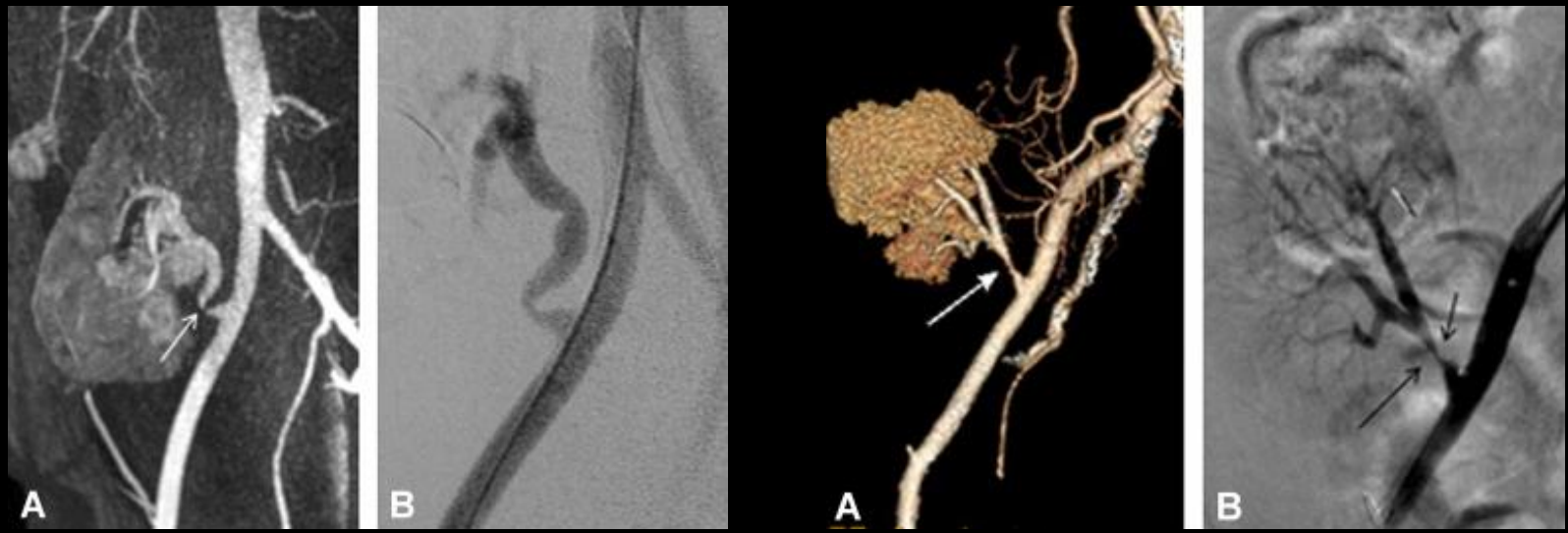
CTA



Images: Glockner JF, Vrtiska TJ. Abdom Imaging. 2007 May-Jun;32(3):407-20.

CE MRA vs CTA in renal transplants

CE MRA DSA CTA DSA



Images: Gaddikeri S et al. Curr Probl Diagn Radiol. 2014 Jul-Aug;43(4):162-8.

Ferumoxytol as MR contrast agent

Fananapazir G et al. J Magn Reson Imaging. 2017 Mar;45(3):779-785.

Ferumoxytol as MR contrast agent

www.kidney-international.org review

Current and potential imaging applications of ferumoxytol for magnetic resonance imaging

Gerda B. Toth[1,21], Csanad G. Varallyay[2,21], Andrea Horvath[1,21], Mustafa R. Bashir[3,4], Peter L. Choyke[5], Heike E. Daldrup-Link[6], Edit Dosa[7], John Paul Finn[8], Seymur Gahramanov[9], Mukesh Harisinghani[10], Iain Macdougall[11], Alexander Neuwelt[12], Shreyas S. Vasanawala[13], Prakash Ambady[1], Ramon Barajas[2], Justin S. Cetas[14], Jeremy Ciporen[14], Thomas J. DeLoughery[15], Nancy D. Doolittle[1], Rongwei Fu[16,17], John Grinstead[18], Alexander R. Guimaraes[2], Bronwyn E. Hamilton[2], Xin Li[19], Heather L. McConnell[1], Leslie L. Muldoon[1], Gary Nesbit[2], Joao P. Netto[1,2], David Petterson[2], William D. Rooney[19], Daniel Schwartz[1,19], Laszlo Szidonya[1] and Edward A. Neuwelt[1,14,20]

Toth et al. Kidney Int. 2017 Jul;92(1):47-66.

How to image the renal arteries?

MRA vs CT vs DSA vs ultrasound

contrast enhanced MRA

non-contrast enhanced MRA

Why non-contrast?

REVIEW ARTICLE

Noncontrast MR Angiography: An Update

Robert R. Edelman, MD,[1,2*] and Ioannis Koktzoglou, PhD[1,3]

Edelman RR, Koktzoglou I. J Magn Reson Imaging. 2019 Feb;49(2):355-373.

Why non-contrast MRA?

no risk of NSF or gadolinium retention

reduce risk of mistiming

no background contamination

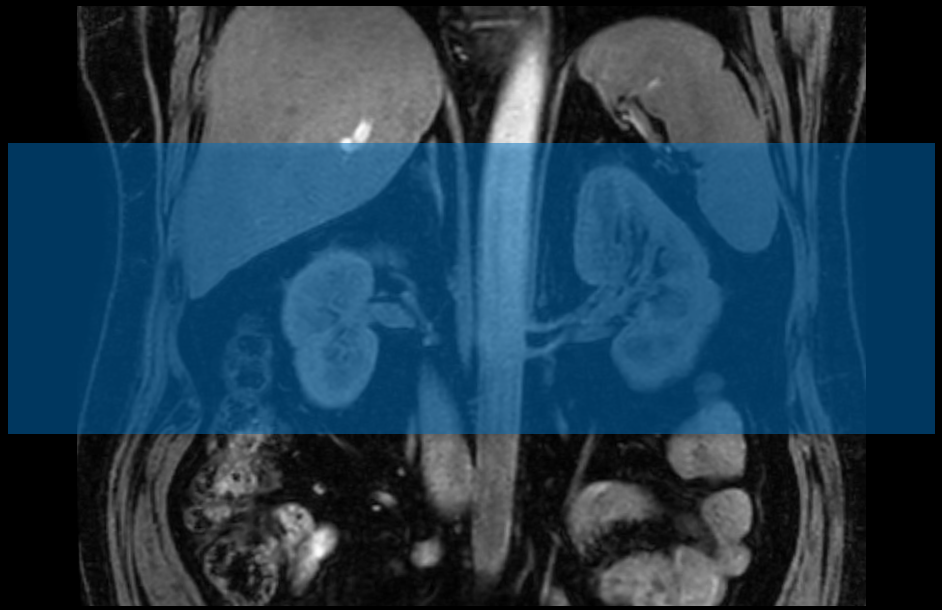
shorter patient preparation

avoid added costs of GBCA administration

Edelman RR, Koktzoglou I. J Magn Reson Imaging. 2019 Feb;49(2):355-373.

Time-of-flight MRA

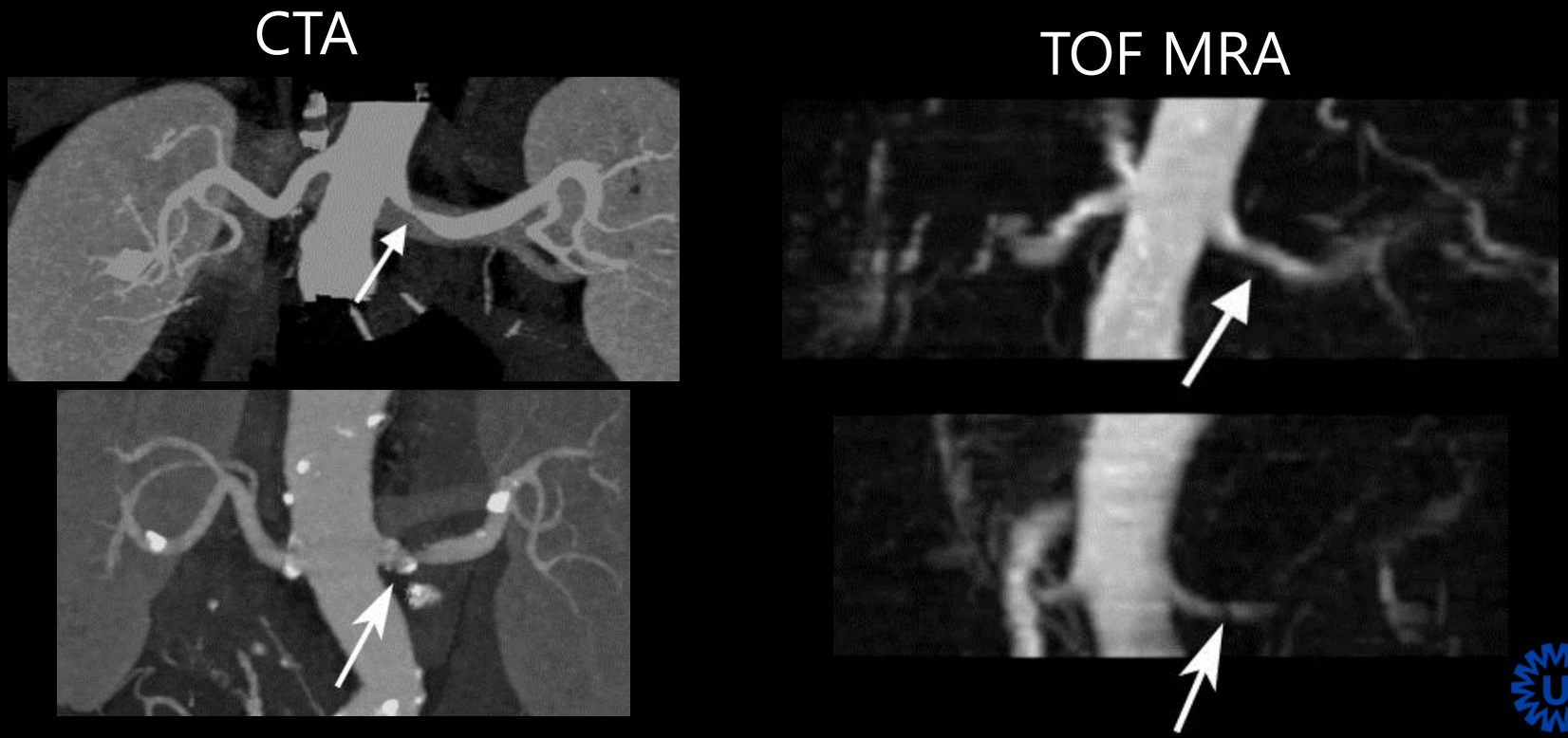
repeated RF pulses



tissue within slab becomes saturated

tissue outside slab remains fully magnetized

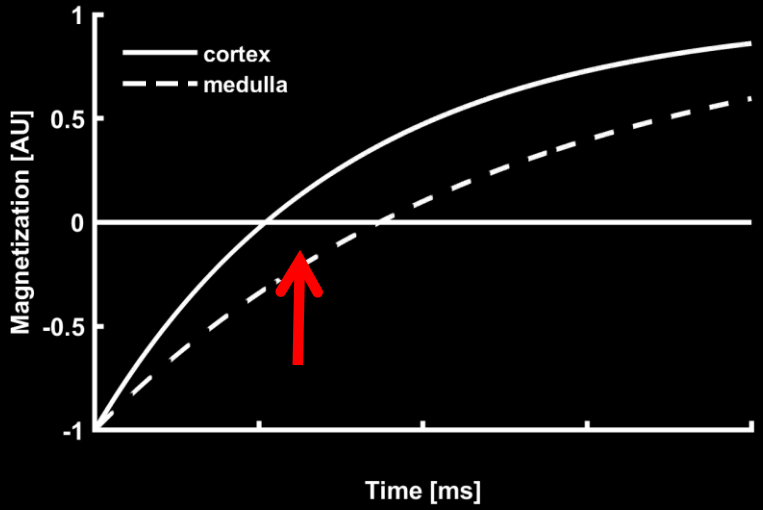
Time-of-flight MRA

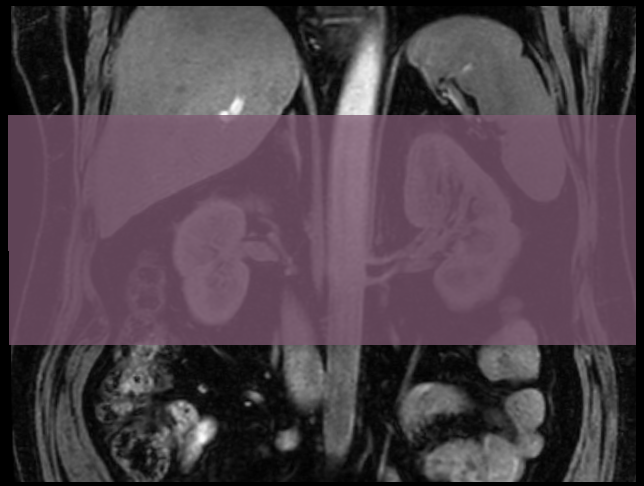


Images: Fabrega-Foster KE et al. J Magn Reson Imaging. 2018 Feb;47(2):572-581.

Inflow dependent inversion recovery

180° inversion pulse



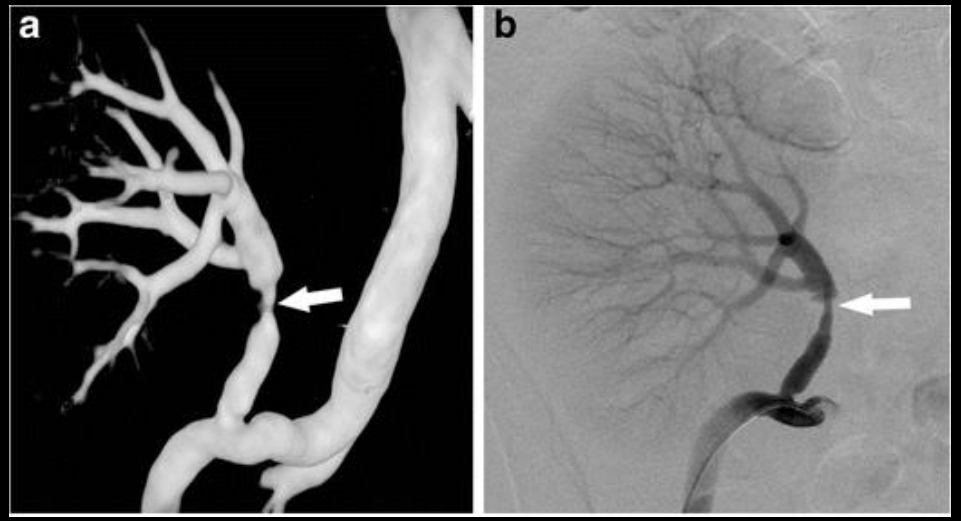


invert magnetization within slab

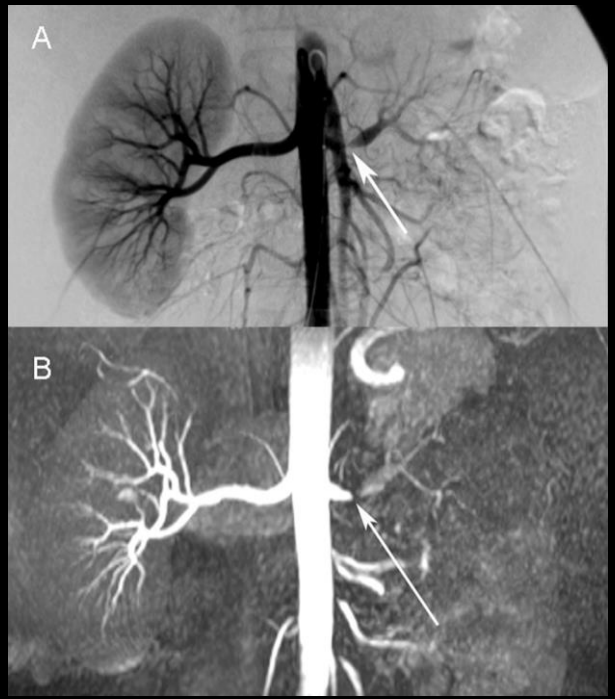
tissue outside slab remains fully magnetized

Inflow dependent inversion recovery

Zhang LJ et al. Eur Radiol. 2018 Oct;28(10):4195-4204.



Inflow dependent inversion recovery

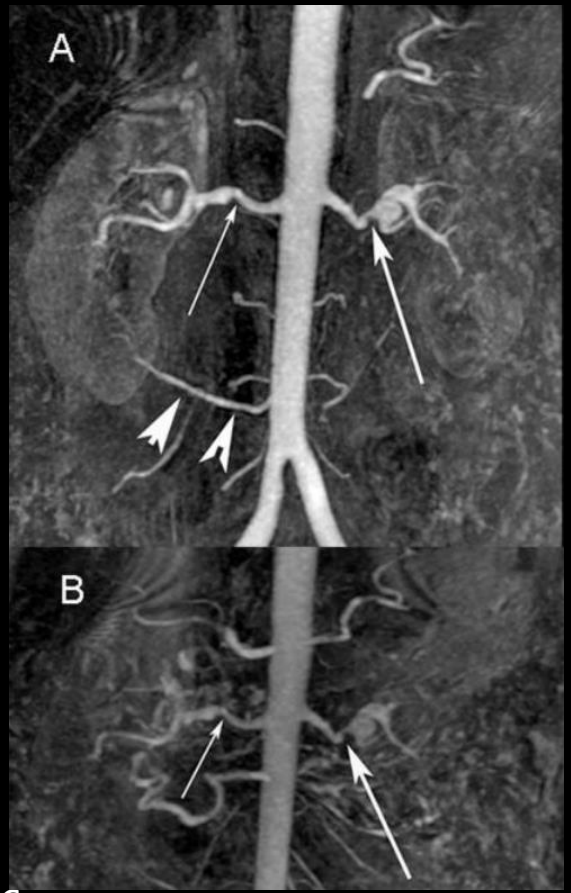


DSA

IFDIR

CE MRA

IFDIR



Images: Sebastià C et al. Eur J Radiol Open. 2016 Aug 4;3:200-6.

Inflow dependent inversion recovery

compared to DSA

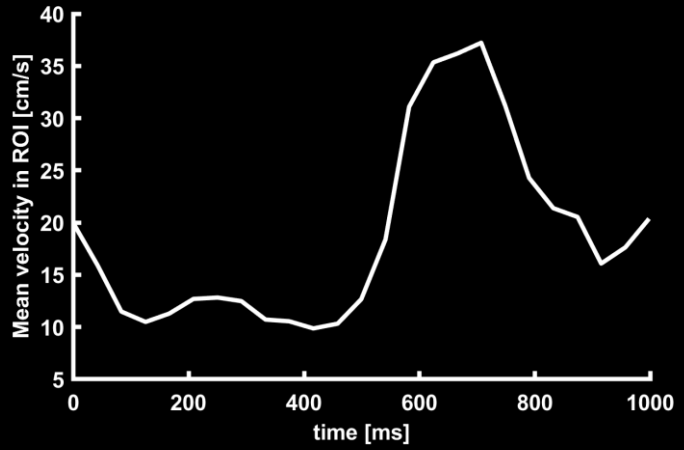
- sensitivity 93-100%*
- specificity 86-94%*

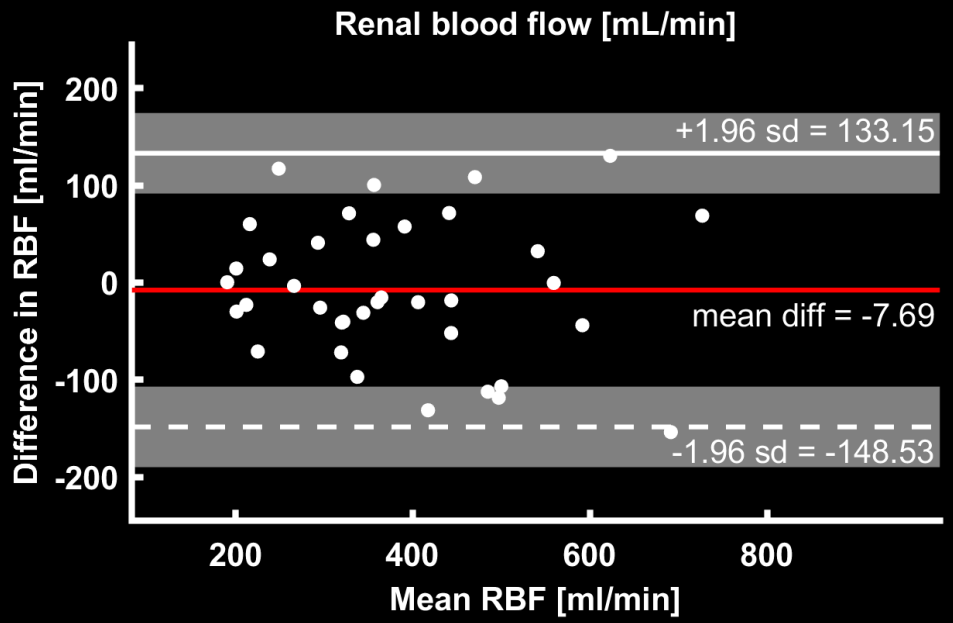
less accurate in fibromuscular dysplasia†

References: *: Coenegrachts KL et al. Radiology. 2004 Apr;231(1):237-42.
*: Parienty I et al. Radiology 2011;259:592–601.
*: Liang KW et al. J Comput Assist Tomogr. 2017 Jul/Aug;41(4):619-627.
*: Zhang LJ et al. Eur Radiol. 2018 Oct;28(10):4195-4204.
†: Sebastià C et al. Eur J Radiol Open. 2016 Aug 4;3:200-6.

2D phase contrast

Coefficient of variation 13%





References: Unpublished data, de Boer et al.

4D flow MRI

ORIGINAL RESEARCH

Four-Dimensional Phase-Contrast Vastly Undersampled Isotropic Projection Reconstruction (4D PC-VIPR) MR Evaluation of the Renal Arteries in Transplant Recipients: Preliminary Results

Daisuke Motoyama, MD,[1] Yasuo Ishii, MD, PhD,[2] Yasuo Takehara, MD, DMSc,[3]*
Masataka Sugiyama, MD,[4] Wang Yang, MD,[4] Hatsuko Nasu, MD, PhD,[4]
Takasuke Ushio, MD,[4] Yuko Hirose, MD,[4] Naoki Ohishi, RT,[5]
Tetsuya Wakayama, PhD,[6] Hiroyuki Kabasawa, BS,[7] Kevin Johnson, PhD,[7]
Oliver Wieben, PhD,[7] Harumi Sakahara, MD, PhD,[4] and Seiichiro Ozono, MD, PhD[1]

4D flow MRI

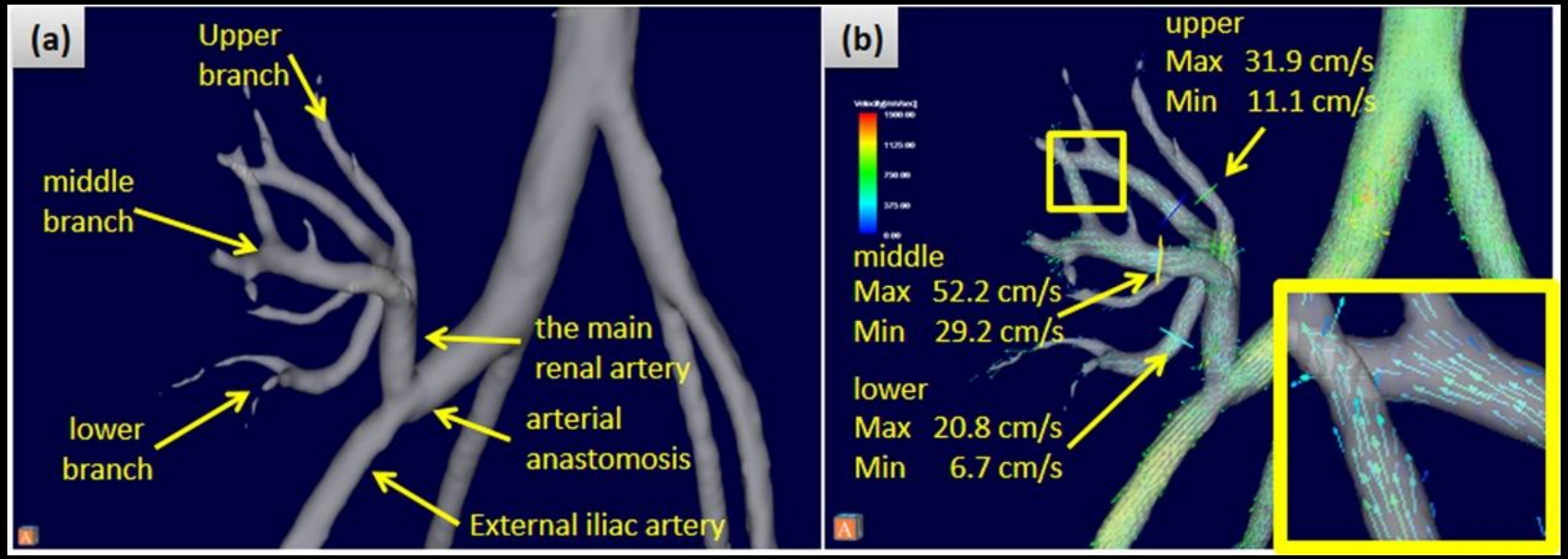


Image: Motoyama D et al. J Magn Reson Imaging. 2017 Aug;46(2):595-603.

Conclusion

contrast free MRA can provide the same information as contrast-enhanced alternatives

exciting new techniques offer improved anatomical but also functional evaluation of renal artery pathologies

Acknowledgments

Tim Leiner, Peter Blankestijn
Hans Hoogduin, Jaap Joles,
Marianne Verhaar
And all colleagues of the 7T group