

Update on Renovascular Disease

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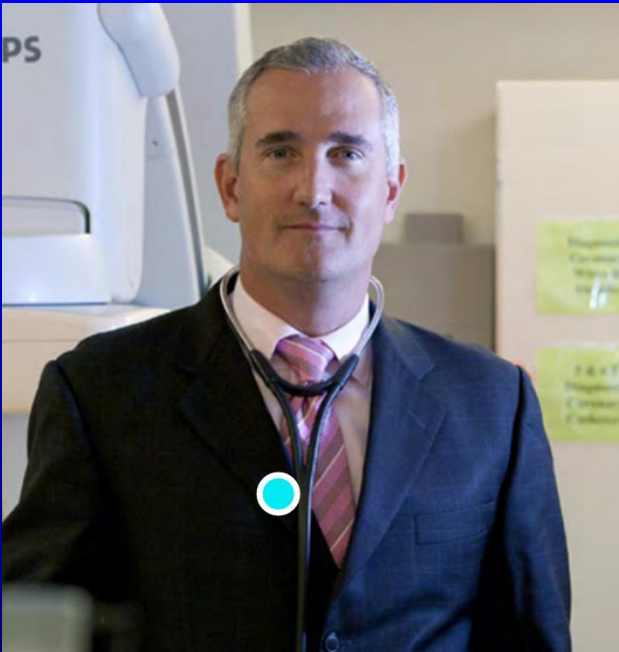
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HARVARD MEDICAL SCHOOL
TEACHING HOSPITAL

Joseph M. Garasic, M.D.



- Boston University School of Medicine
- Internal Medicine Residency - BWH
- Cardiovascular Medicine Fellowship - BWH
- Vascular Medicine & Intervention Fellowship – BWH
- Interventional Cardiology Fellowship – BWH
- Director, Cardiac Catheterization Laboratory – MGH
- Director, Peripheral Vascular Intervention - MGH
- Assistant Professor of Medicine - HMS
 - Clinical focus: Pan Vascular Intervention
 - Research focus: Renal Artery Disease and Denervation

Presenter Disclosure Information

The following relationships exist related to this presentation:

Consultant / Clinical Endpoints Committee – Applied Clinical Intelligence, LLC
Consultant / Clinical Endpoints Committee – Baim Institute for Clinical Research
Consultant / Clinical Endpoints Committee - Boehringer-Ingelheim
Consultant / Clinical Endpoints Committee – Abbott
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Consultant / Clinical Endpoints Committee – Covance
Consultant / Scientific Advisory Board – Recor Medical, Inc.
Equity Interest – Ostial Corporation
Spouse Employee / Shareholder – Vertex Pharmaceuticals

Presentation will include:

Off label use of vascular / biliary stents.
Review of investigational / unapproved devices
and devices with OUS approval.

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Defining the Problem

- RAS is an important cause of secondary hypertension
- Renovascular disease under-appreciated as cause of CRF
- 23% of malignant hypertension is the result of renovascular causes
- Not all patients with RAS are hypertensive as a result
- Not all patients with hypertension have RAS, but the kidney may still be a contributor

Progress in Renovascular Disease

- 1) The disease
- 2) Clinical diagnosis
- 3) Laboratory diagnosis / imaging modalities
- 4) Patient selection: who benefits from intervention?
- 5) Transplant renal artery stenosis
- 6) Limiting restenosis
- 7) RDN (Renal Denervation)

Progress in Renovascular Disease

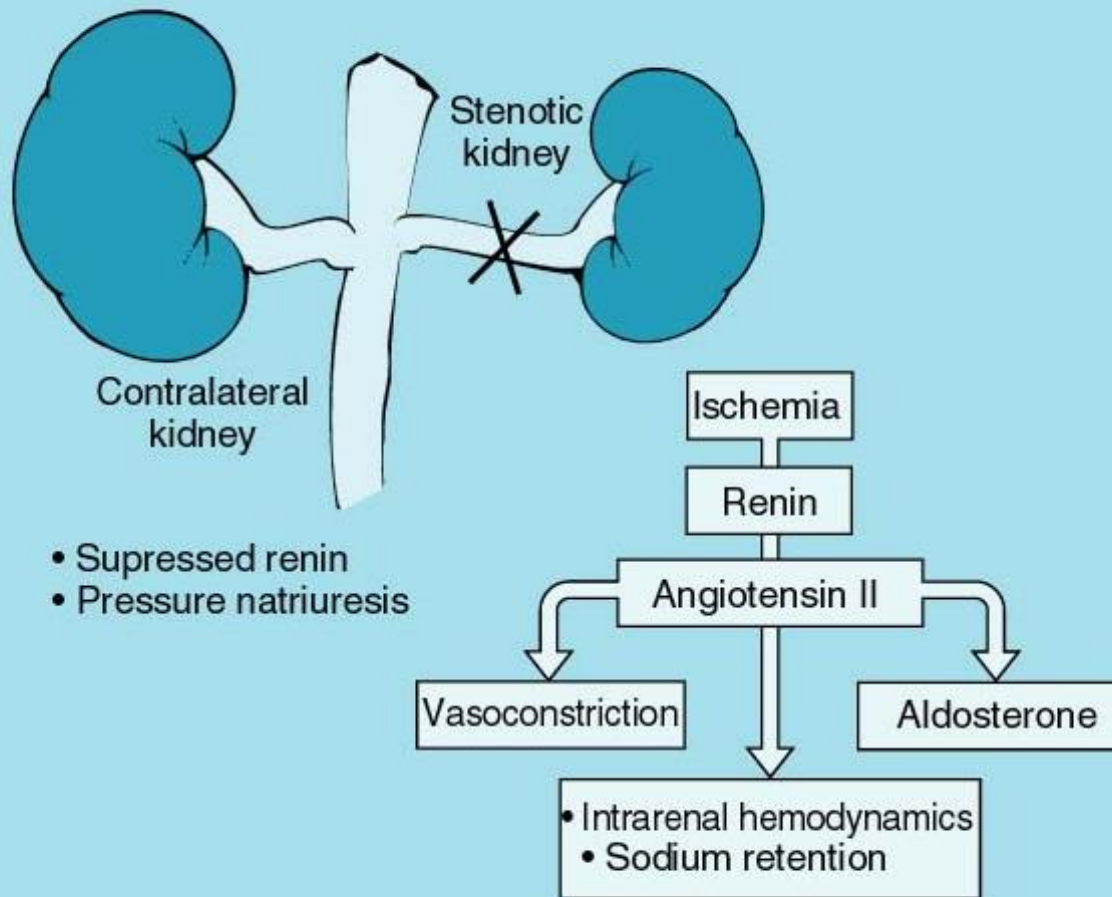
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Etiology of Renal Artery Stenosis

- Atherosclerosis
- Fibromuscular dysplasia
- Polyarteritis Nodosa
- Radiation-induced
- Takayasu's arteritis





Mark A. Pohl

Progress in Renovascular Disease

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Clinical Clues

- Onset of diastolic hypertension after age 55
- Refractory or malignant hypertension
- Development of resistant hypertension in a previously well-controlled patient
- Progressive increase in Creatinine, even if still “normal”
- Presence of atherosclerotic macrovascular disease elsewhere heightens suspicion
- Left heart failure out-of-proportion to LV dysfunction or ischemic burden
- Clinically silent RAS

Progress in Renovascular Disease

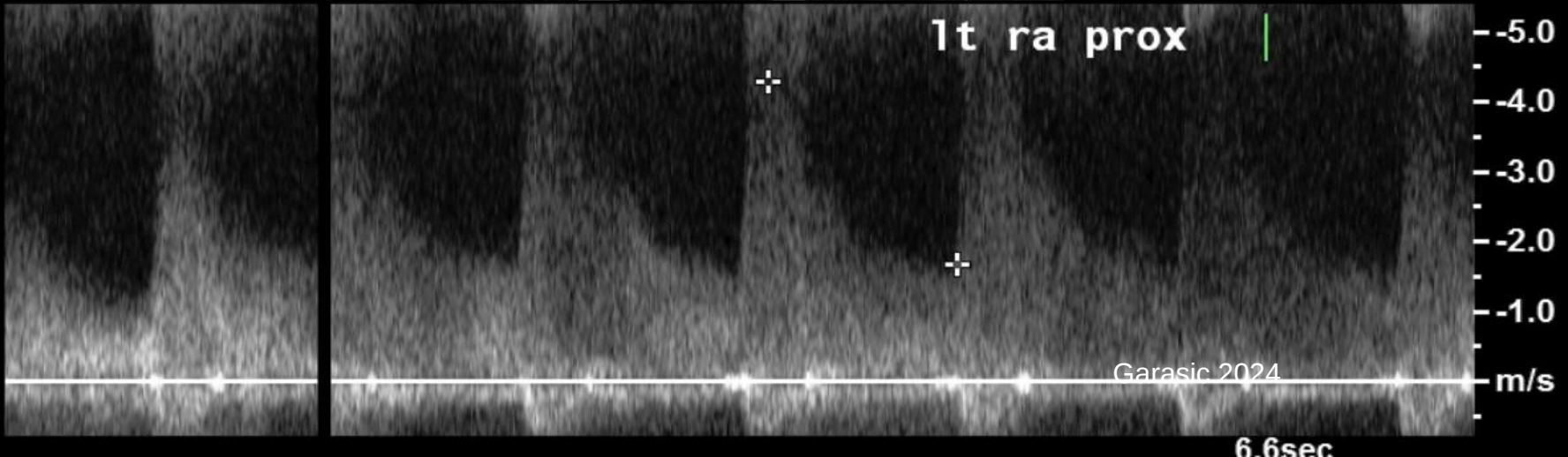
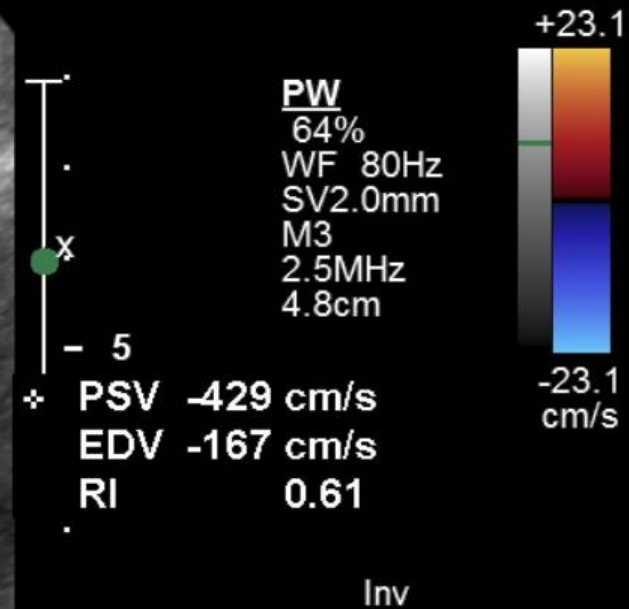
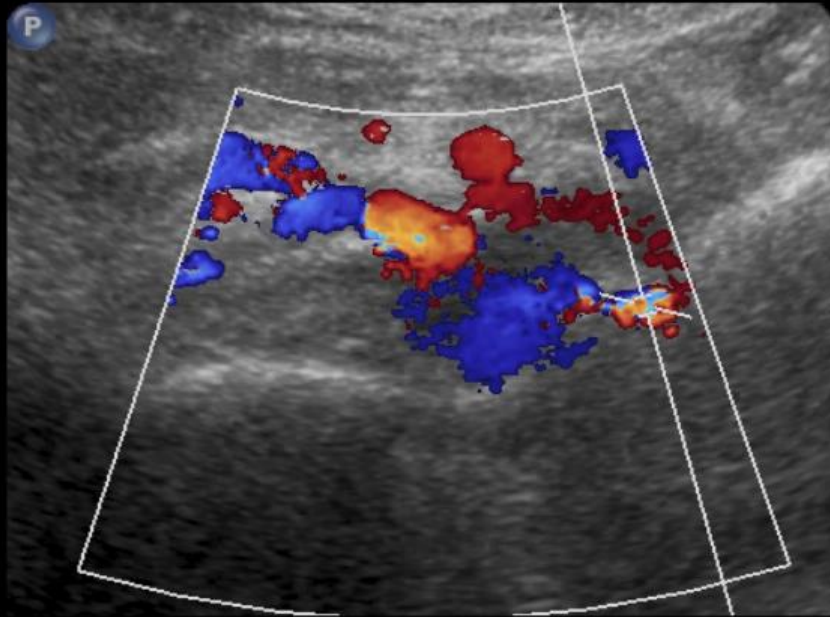
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Screening for Renovascular Disease

- ❖ Clinical syndrome most important in patient selection
- ❖ Various diagnostic modalities:
 - ▢ Serologic markers
 - ▢ Duplex ultrasound - in experienced hands can predict with great accuracy the presence or absence of significant RAS
 - ▢ Captopril renal scan - 10-25% false negative
 - ▢ MR angiography - rare false negatives / common false positives. Equipment/experience dependent
 - ▢ Contrast angiography

What's Old is New: Renal Duplex

R1
Z 2.0
2D
39%
C 55
P Med
Gen
CF
66%
1650Hz
WF 98Hz
Med



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Experimental Data supporting Stenting for Preservation of Renal Function

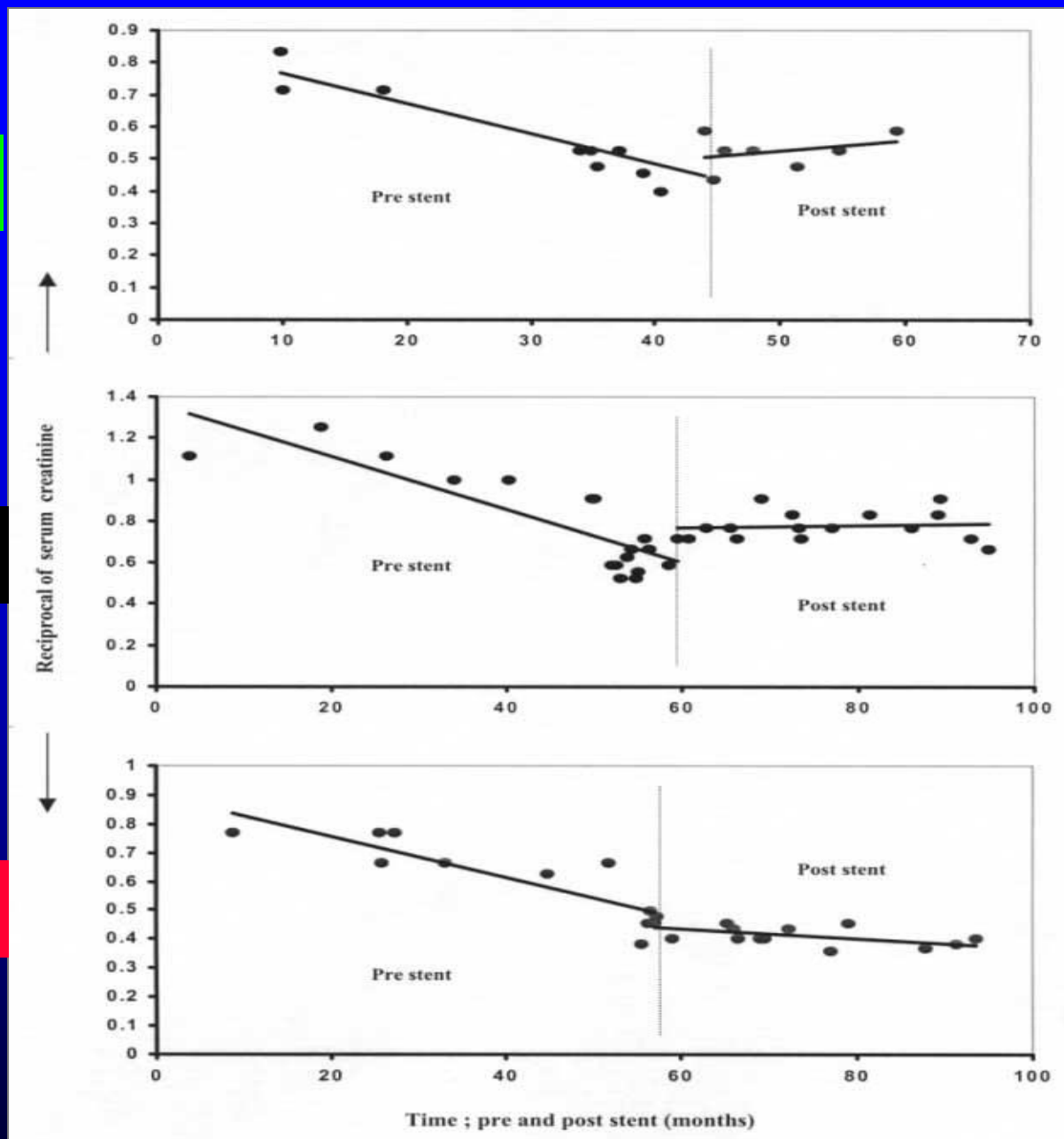
Watson et al. Circulation. 2000; 102:1671-1677.

- 61 vessels in 31 patients with “global” obstructive atherosclerotic renal disease
- All with chronic renal insufficiency (Creat 1.5 – 4.0)
- Stenting with non-articulated Palmaz stents
- Follow-up Renal U/S, Serum Creat , BP measurements:
 - Improvement in reciprocal slope of serum creatinine
 - Improved BP control (SBP from 170 ± 21 Pre-stent vs. 148 ± 15 mmHg Post-stent; $p < 0.001$)
 - Restenosis ($> 50\%$) in only 1 of 61 vessels
 - Stabilization of pole-to-pole renal dimension

IMPROVED

STABLE

ALTERED



Dutch Renal Artery Stenosis Intervention Cooperative Study

N Engl J Med 2000; 342:1007-14

Study Design:

- 106 hypertensive patients with RAS (>50%) and Creat<2.3 mg/dl
- PTA vs. Medical rx with follow-up of BP/meds/ renal fxn at 3&12 mths

Results:

- BP same in both groups
- Fewer meds (2.1 vs. 3.2) in the PTA vs. Medical group
- Renal function similar between groups

Shortcomings:

- Crossover of patients from medical-to-PTA
- No stents
- Is 50% stenosis physiologically significant?
- Pts with elevated creatinine excluded
- Is the goal of renal artery revascularization improvement in BP control?

ASTRAL Trial Schema

Diagnosis of significant ARVD
(Unilateral or Bilateral)
Revascularization not contraindicated

Uncertain whether to revascularize
Randomisation

Revascularization

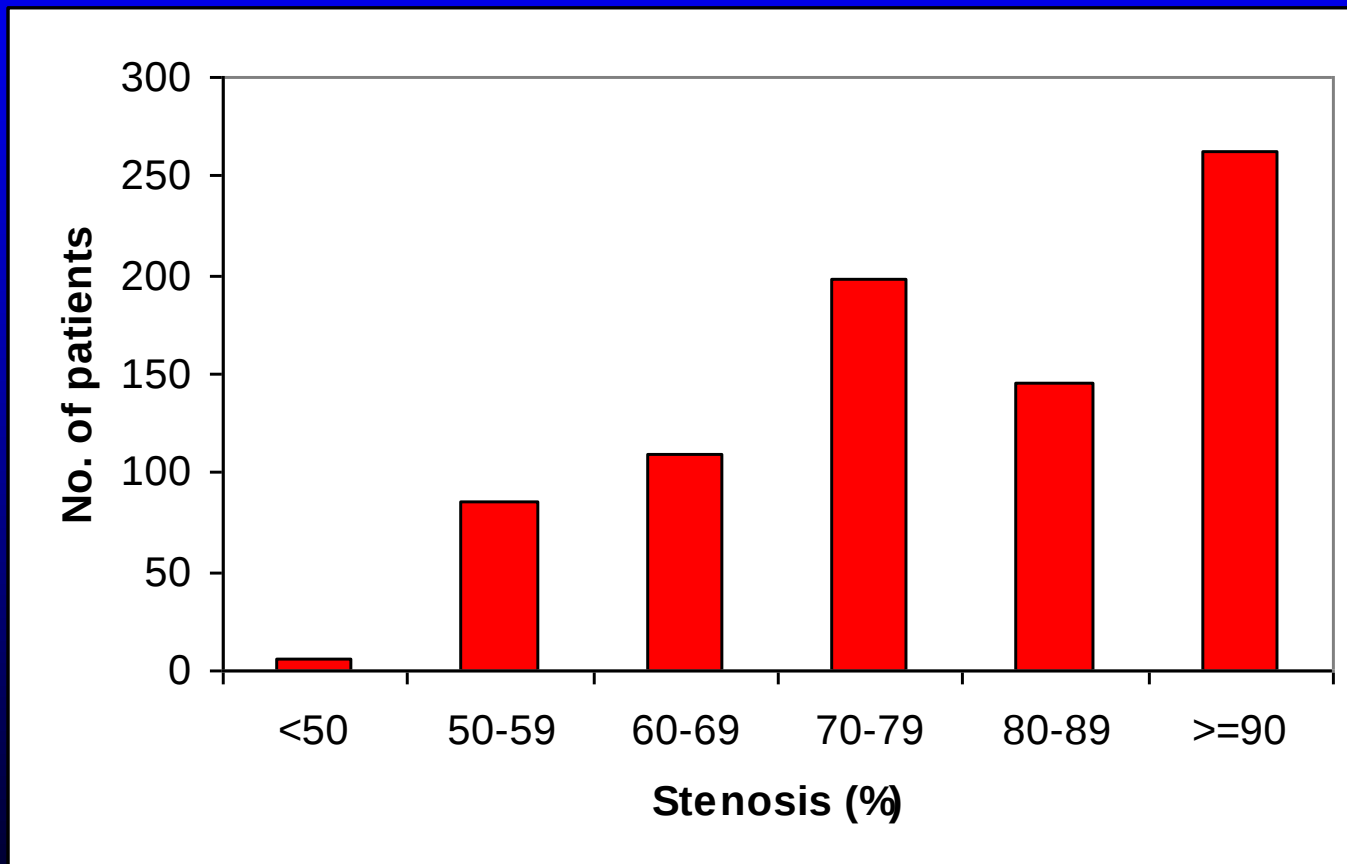
with angioplasty and/or stent
(and medical treatment)

No revascularization

Medical Treatment only

PATIENT CHARACTERISTICS – Percent Stenosis

Mean = 76% (Range: 20% – 100%)



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* 40% of Revascularization patients had no stenosis >70%.

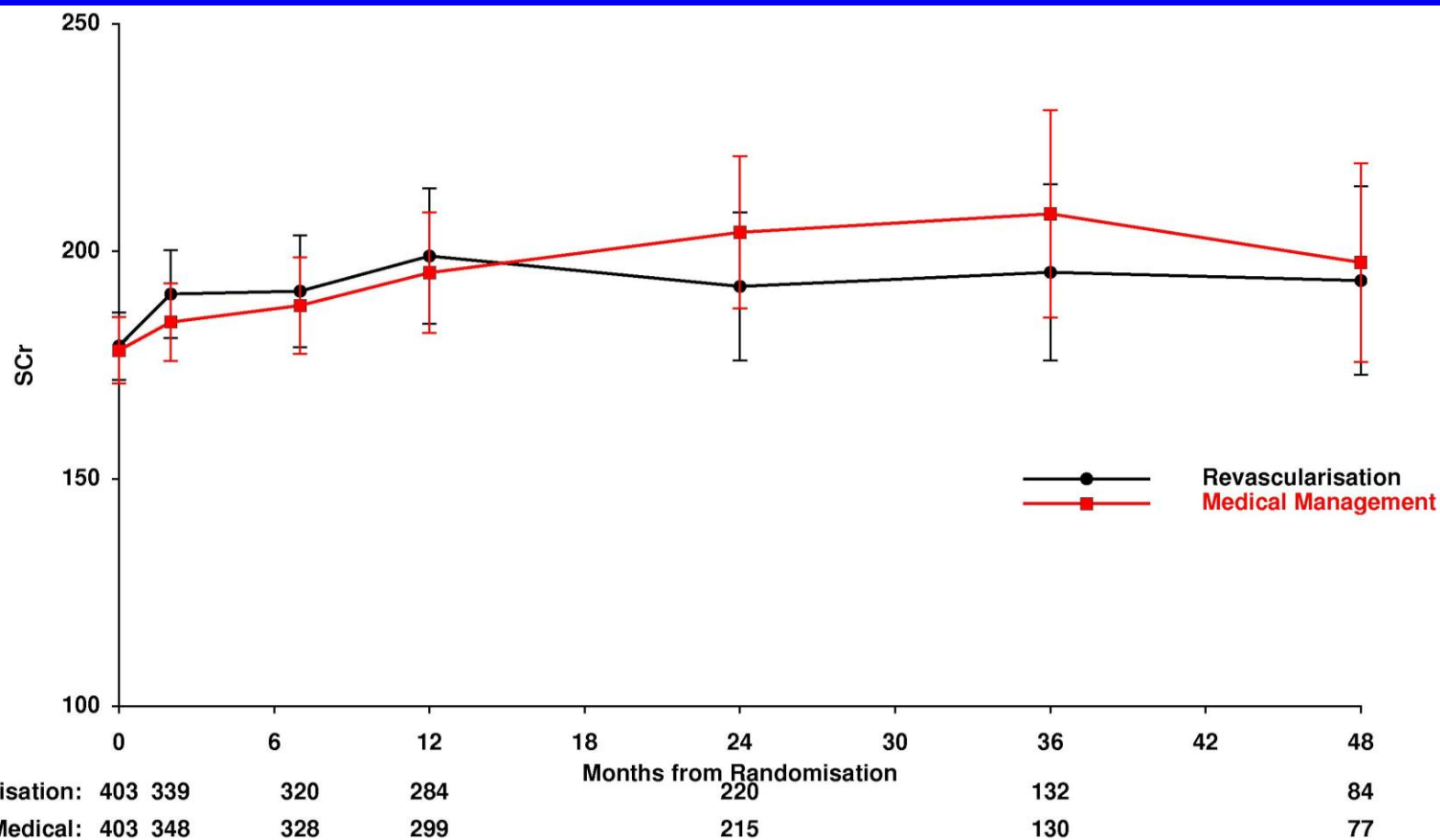


COMPLIANCE WITH RANDOMISED TREATMENT

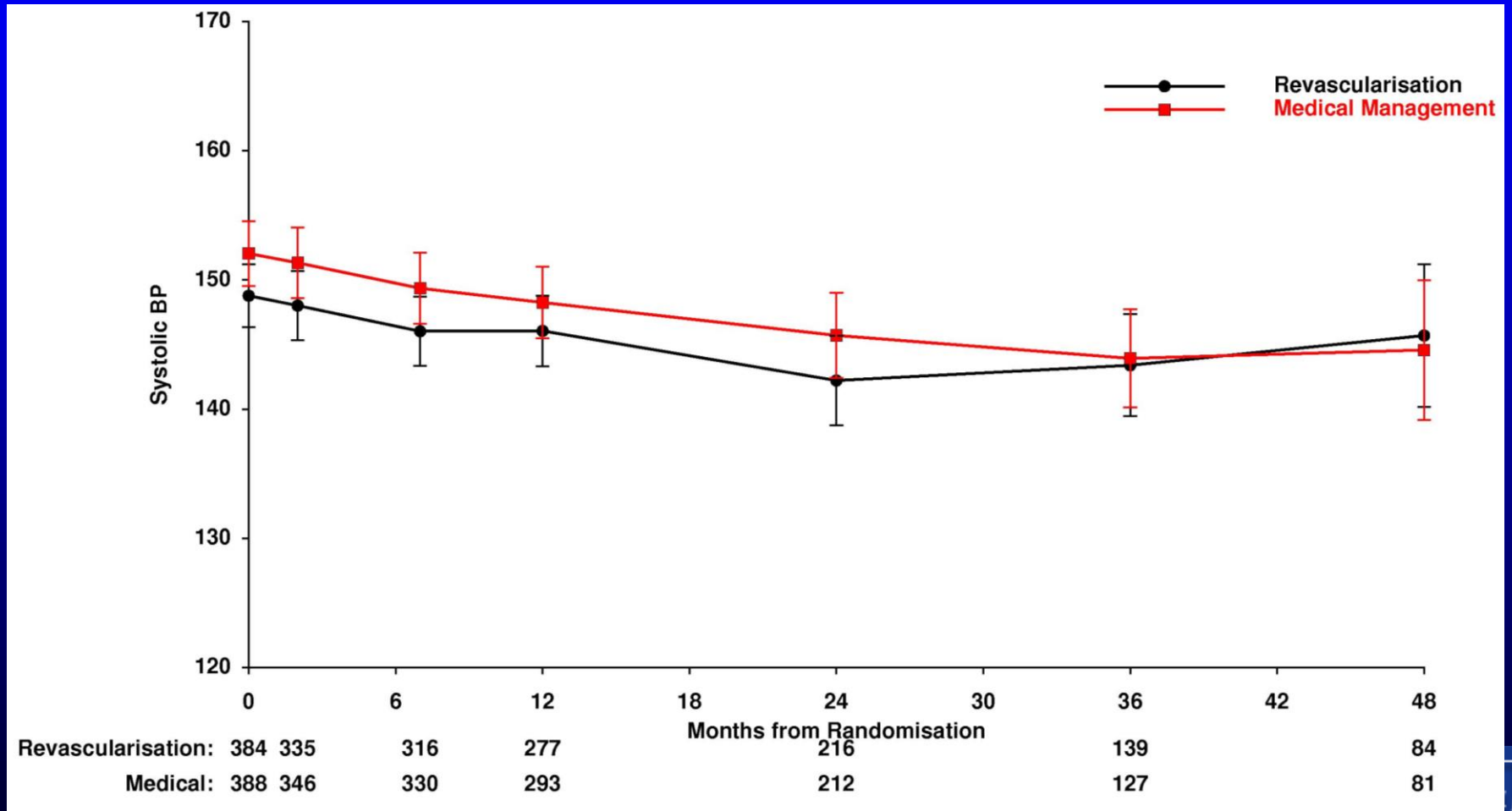
	N		Revasc. Successful	Attempted but Failed	Not Attempted
Revasc.	403		308 (82%)*	17	44
Medical	403		18 (4.4%)	1	1

Complications in Revasc Arm:
5 Renal Embolizations / 4 Renal Artery Occlusions / 4 Renal Artery Perfs

PLOT OF SCr OVER TIME



PLOT OF SYSTOLIC BP OVER TIME



The NEW ENGLAND JOURNAL *of* MEDICINE

ESTABLISHED IN 1812

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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*

Inclusion

- Stenosis could be identified by DUS, MRA, or CTA
- Severe renal artery stenosis
 - $\geq 80\%$ angiographically (core lab adjudicated)
 - OR... $\geq 60\%$ angiographically AND ≥ 20 mmHg gradient
- AND... SBP ≥ 155 while on ≥ 2 anti-HTN meds
- CHANGED after enrollment, but before unblinding data

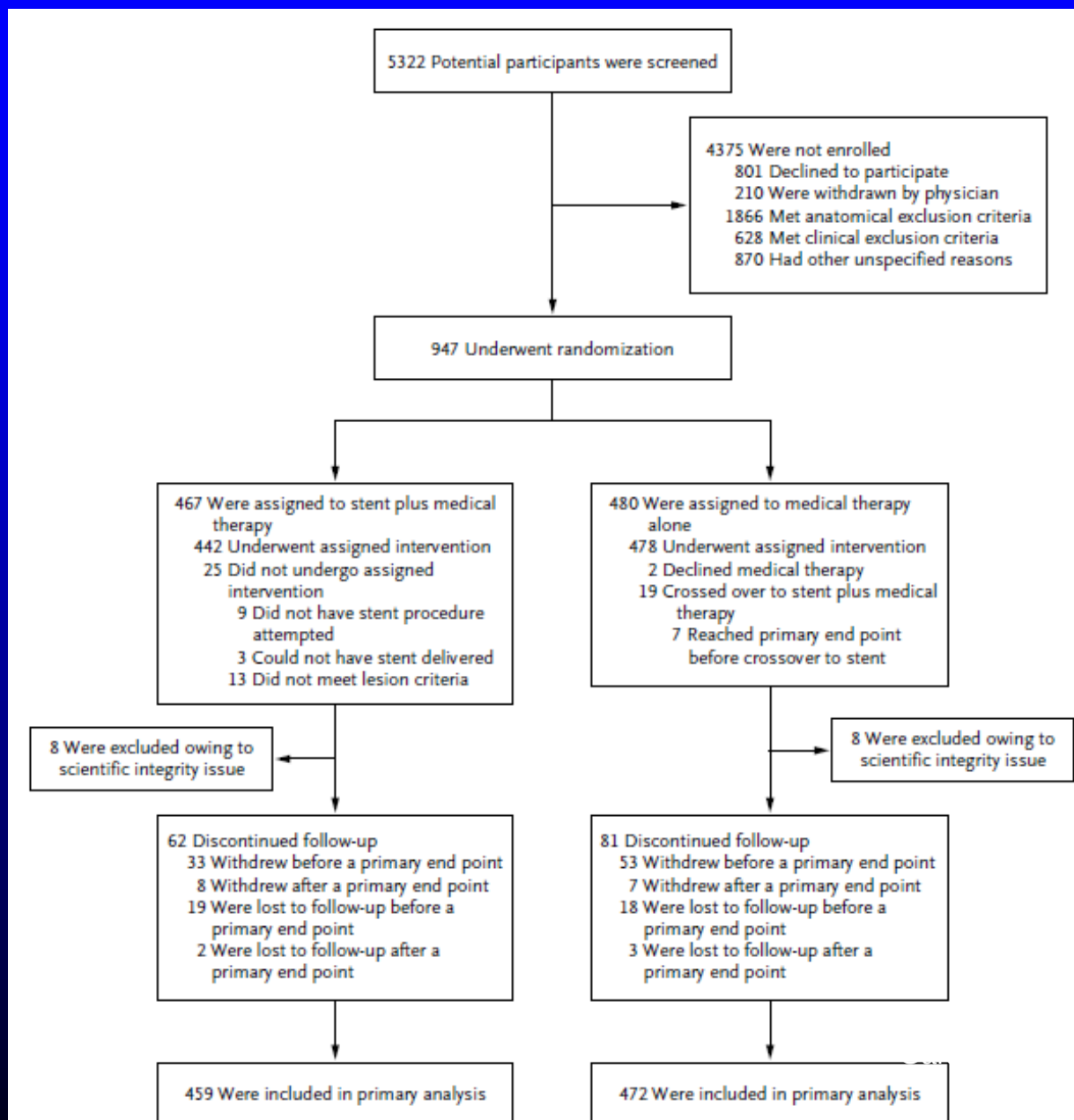
Exclusion

- FMD
- CKD from non ischemic cause
- Cr >4.0 mg/dL
- Kidney length <7cm
- Lesion that could not be treated with single stent

Medical Therapy

- Antiplatelet therapy
- Candesartan – ARB (Atacand, AstraZeneca)
- +/- HCTZ
- Amlodipine-atorvastatin (Caduet, Pfizer)
- BP targets
 - <140/90 mmHg if no co-morbidities
 - <130/80 mmHg if DM or CKD
 - 3 measurements, 2 mins apart → mean of last 2

Patient Randomization



Patient Characteristics

Table 1. Baseline Characteristics of the Study Population, According to Treatment Group.*

Characteristic	Stenting plus Medical Therapy (N = 459)	Medical Therapy Only (N = 472)
Age (yr)	69.3±9.4	69.0±9.0
Male sex (%)	51.0	48.9
Race (%)†		
Black	7.0	7.0
Other	93.0	93.0
Body-mass index‡	28.2±5.3	28.7±5.7
Systolic blood pressure (mm Hg)	149.9±23.2	150.4±23.0
Blood pressure at target level (%)§	29.2	25.3
Estimated GFR (ml/min/1.73 m²)¶	58.0±23.4	57.4±21.7
Stage ≥3 chronic kidney disease (%)	49.6	50.4
Method of identification of stenosis (%)		
Angiography	68.4	68.6
Duplex ultrasonography	25.5	24.2
Computed tomographic angiography	4.4	5.3
Magnetic resonance angiography	1.7	1.9
Medical history and risk factors (%)		
Diabetes	32.4	34.3
Prior myocardial infarction	26.5	30.2
History of heart failure	12.0	15.1
Smoking in past yr	28.0	32.2
Hyperlipidemia	89.4	90.0
Angiographic findings		
% Stenosis, as assessed by core laboratory	67.3±11.4	66.9±11.9
% Stenosis, as assessed by investigator	72.5±14.6	74.3±13.1
Global ischemia (%)**	20.0	16.2
Bilateral disease (%)††	22.0	18.1

- 1) The minority (25/29%) of subjects had target degree of hypertension.
- 2) Many patients enrolled on the basis of CRI, not uncontrolled hypertension.
- 3) Most patients had non-severe RAS with average of 67%
- 4) Most subjects (80% / 84%) did not have global RAS.

Endpoints

- Primary
 - Composite of death from CV or renal causes, stroke, MI, hospitalization for CHF, progressive renal insufficiency ($>30\%$ drop in GFR), or need for CRRT
- Secondary
 - Individual components of primary end point and all-cause mortality
- Endpoints modified in March 2012 (before data unblinded)
- Enrollment from May 2005 to January 2010
- Analyzed according to intention-to-treat

Endpoints

Table 2. Clinical End Points.*

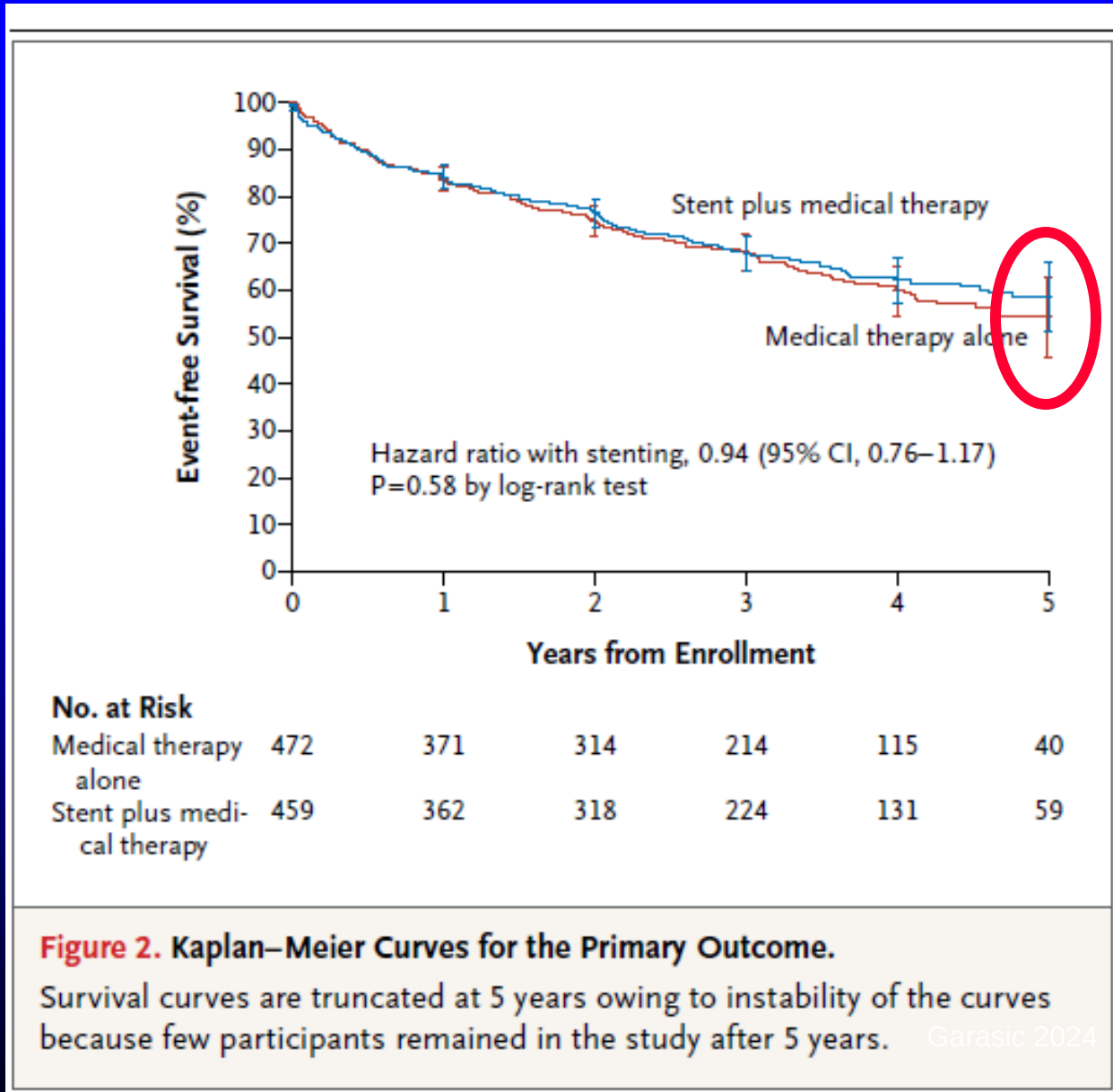
End Point	Stenting plus Medical Therapy (N= 459) no. (%)	Medical Therapy Only (N= 472) no. (%)	Hazard Ratio (95% CI)	P Value
Primary end point: death from cardiovascular or renal causes, stroke, myocardial infarction, hospitalization for congestive heart failure, progressive renal insufficiency, or permanent renal-replacement therapy†	161 (35.1)	169 (35.8)	0.94 (0.76–1.17)	0.58
Components of primary end point‡				
Death from cardiovascular or renal causes	20 (4.4)	20 (4.2)		
Stroke	12 (2.6)	16 (3.4)		
Myocardial infarction	30 (6.5)	27 (5.7)		
Hospitalization for congestive heart failure	27 (5.9)	26 (5.5)		
Progressive renal insufficiency	68 (14.8)	77 (16.3)		
Permanent renal-replacement therapy	4 (0.9)	3 (0.6)		
Secondary clinical end points§				
Death from any cause	63 (13.7)	76 (16.1)	0.80 (0.58–1.12)	0.20
Death from cardiovascular causes	41 (8.9)	45 (9.5)	0.89 (0.58–1.36)	0.60
Death from renal causes	2 (0.4)	1 (0.2)	1.89 (0.17–20.85)	0.60
Stroke	16 (3.5)	23 (4.9)	0.68 (0.36–1.28)	0.23
Myocardial infarction	40 (8.7)	37 (7.8)	1.09 (0.70–1.71)	0.70
Hospitalization for congestive heart failure	39 (8.5)	39 (8.3)	1.00 (0.64–1.56)	0.99
Progressive renal insufficiency	77 (16.8)	89 (18.9)	0.86 (0.64–1.17)	0.34
Permanent renal-replacement therapy	16 (3.5)	8 (1.7)	1.98 (0.85–4.62)	0.11

BP and Meds

	No of Meds (Pre)	No of Meds (Post)	SBP Change (mmHg)
Medical Therapy	2.1 +/- 1.6	3.5 +/- 1.4	-15.6 +/- 25.8
Intervention	2.1 +/- 1.6	3.3 +/- 1.5	-16.6 +/- 21.2
		p = 0.24	

- In longitudinal analysis, SBP was modestly lower in stent group (-2.3 mmHg; 95%CI -4.4 to -0.2 mmHg; p = 0.03), but this difference did not translate to clinical benefits
- Was this maximal medical therapy at enrollment?

Kaplan-Meier Curves



Is 5 years follow-up adequate?

CORAL Conclusions:

- Most CORAL subjects had non-severe RAS
- Extrapolating from sub-group analysis is difficult post hoc
- Most subjects did not have severe, multi-drug resistant uncontrolled hypertension
- We know nothing about the trajectory of renal failure or relative contribution of other factors
- Vast majority (>80%) of screened patients not enrolled. Courage effect?
- The primary outcome curves began to diverge from years 3-5 post randomization. Do outcomes such as MI / CHF /Stroke / Death require longer term follow-up?
- If you can't save a life with a coronary intervention, is it reasonable to expect such profound outcomes post renal intervention?
- CORAL likely demonstrates that multifactorial medical therapy alone was equivalent to medical therapy plus stenting in patients with essential hypertension and non-obstructive atherosclerotic RAS

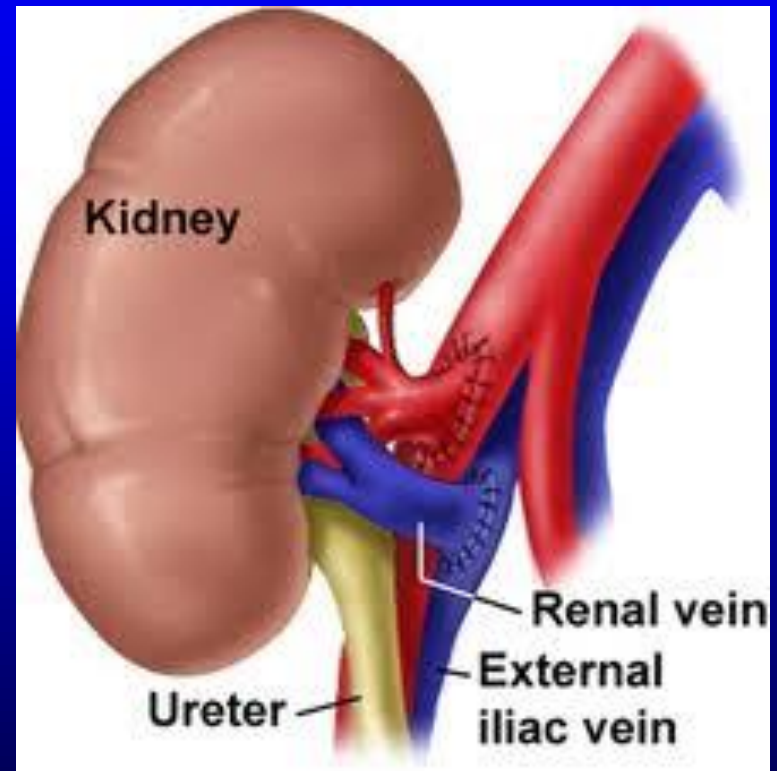
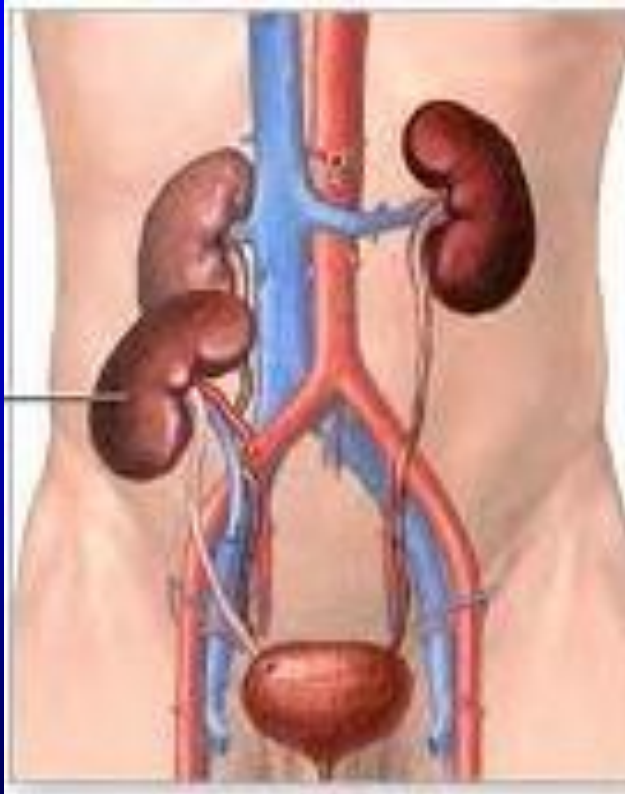
Who should still have their RAS treated?

- Patients with true multi-drug (≥ 3) resistant hypertension
- Patients who have failed initial attempts at aggressive medical therapy
- Patients with progressive renal failure and bilateral severe RAS (with trans-lesional gradients if necessary)
- Patients with recurrent pulmonary edema out of proportion to LV function / ischemic burden and with severe bilateral RAS
- Patients with FMD and hypertension where PTA is often curative
- Patients with severe transplant RAS and associated syndrome

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Transplant RAS- Background



STUDIES ON EXPERIMENTAL HYPERTENSION

I. THE PRODUCTION OF PERSISTENT ELEVATION OF SYSTOLIC BLOOD PRESSURE BY MEANS OF RENAL ISCHEMIA*†

BY HARRY GOLDBLATT, M.D., JAMES LYNCH, M.D., RAMON F. HANZAL, PH.D., AND WARD W. SUMMERVILLE, M.D.

(From the Institute of Pathology, Western Reserve University, Cleveland)

PLATES 23 AND 24

(Received for publication, December 1, 1933)

The production of elevated blood pressure in animals has been attempted (1-16) by various methods involving injury to the kidneys.

Goldblatt, H., J. Lynch, R.F. Hanzel, and W.W. Summerville. 1934. J. Exp. Med. 59:347-379

Goldblatt / TRAS Physiology

- 2 kidneys / 1 clip:
 - Hypertension but minimal edema or congestion due “pressure natriuresis” in unaffected kidney
- 1 kidney / 1 clip
 - Hypertension with edema and congestion
 - Renal function is sensitive to diuretic and ACE/ARB
 - Transplant situation; bilateral RAS
- Renal / graft function may be reasonably preserved

Non-contrast MRA of TRAS



- Severe stenoses of two renal arteries near iliac anastomotic site
- Patent iliac system

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Deep Arterial Injury: What Vascular Biology Tells Us

Pathobiology of In-stent Restenosis



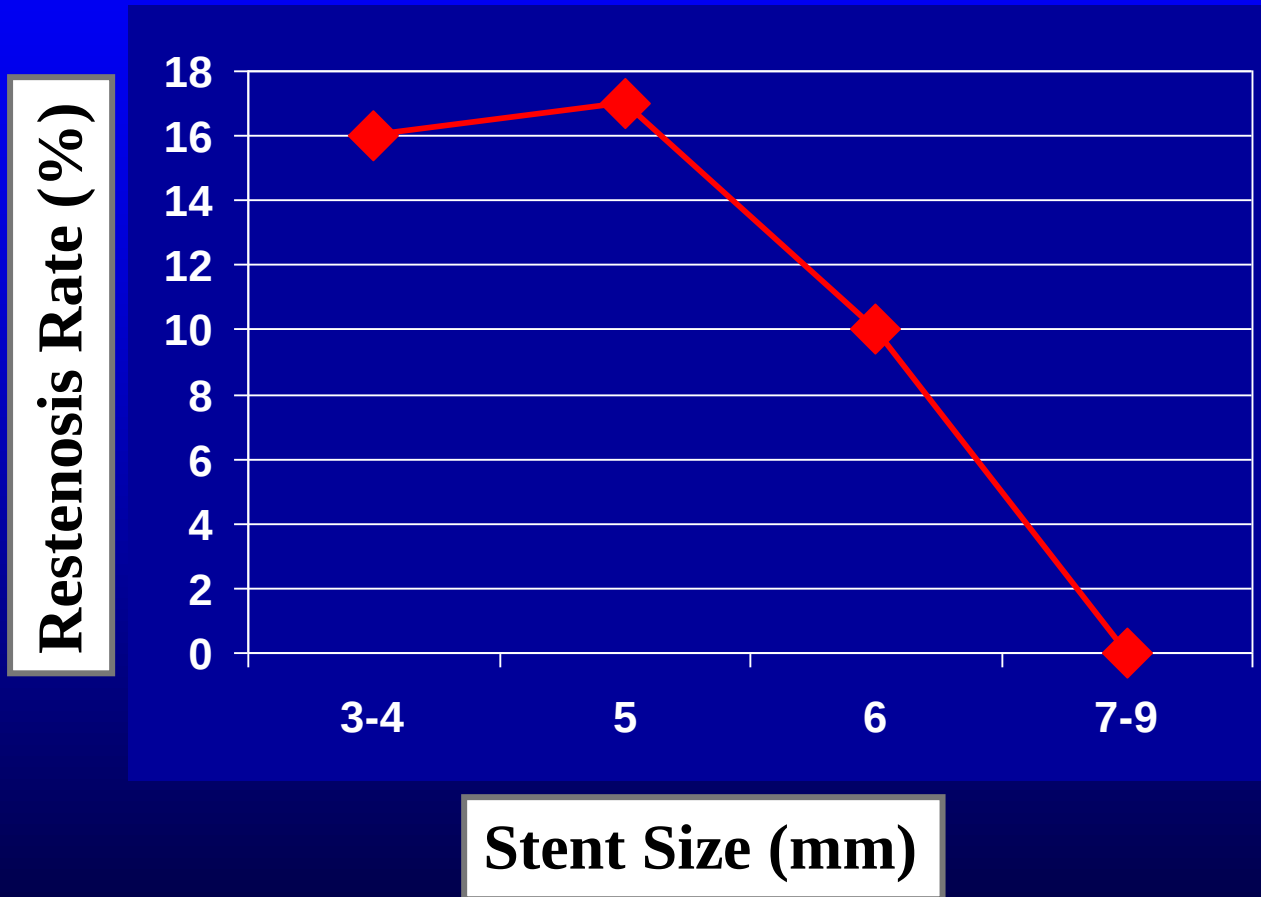
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RA Stenting: Restenosis

Study series	# of Arteries	Arteries evaluated (%original total arteries)	Ostial lesion (%)	Stent type	Method of evaluation	Average time to evaluation (month)	Restenosis (of artery evaluated)
van de Ven, 1999	52	50 (95%)	100	Palmaz	angio*	6	21%
Rocha-Singh, 1999	180	158 (88%)	43	Palmaz	duplex + angio	13	12%
Tuttle, 1998	148	49 (33%)	100	Palmaz	angio	8	14%
Rundback, 1998	54	28 (52%)	NA	Palmaz	angio* + spiral CT	12	26%
White, 1997	133	80 (60%)	81	Palmaz	angio*	9	19%
Harden, 1997	32	24 (75%)	75	Palmaz	angio*	6	12%
Blum, 1997	74	74 (100%)	100	Palmaz	angio*	24	11%
Henry, 1996	64	54 (84%)	53	Palmaz	angio*	14	9%
Iannone, 1996	83	69 (85%)	78	Palmaz	duplex	11	14%
Dorros, 1995 [30]	92	56 (61%)	100	Palmaz	angio*	7	25%
Hennequin, 1994	21	20 (95%)	33	Wallstent	angio*	29	20%
Rees, 1994	296	150 (51%)	100	Palmaz	angio*	7	33%
<i>weighted average</i>						10	~20%

angio* = protocol-specified angiographic follow-up

Restenosis: Is it a problem in the Renal Arteries?



Zeller et al. Catheter Cardiovasc Interv 2003; 60: 1-6.

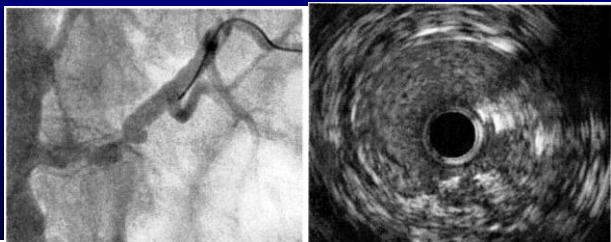
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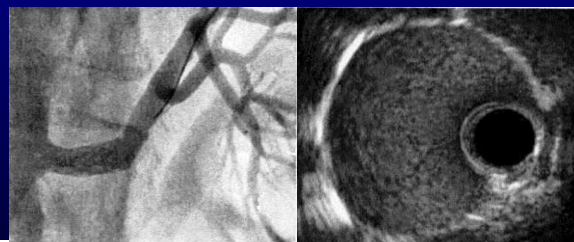
The Utilization of PTFE-Covered Stents For The Treatment of Renal Artery In-Stent Restenosis

- Ten men and 16 women (mean age of 70 +/- 11 years).
- Twelve (46%) of the patients had DM, 100% had HTN, 100% had hypercholesterolemia, 16 (62%) were current or former smokers and all had peripheral arterial disease.
- Mean pre-procedure creatinine was 1.58 +/- 0.72 mg/dl (5 patients had a solitary functioning kidney).
- The average RA-ISR by angiography prior to intervention was 84 +/- 1.8 %.
- There was 100% procedural success without any recorded procedural complications.
 - Median stent diameter was 6 mm.
 - Median stent length was 16 mm.
 - Post-dilation was performed in all patients, median balloon diameter of 7 mm.
- Mean follow-up of 10.2 +/- 4.7 months, 0% of patients who received a PTFE-covered stent for RA-ISR had a severe enough renarrowing to require repeat intervention.

Pre



Post



Nicholas J. Ruggiero, II, Joseph Garasic, Michael R. Jaff, Andrew B. McCann, Thomas J. Kiernan, Brian G. Hynes, Douglas E. Drachman, Robert Schainfeld, Kenneth Rosenfield, Gary M. Ansel. ACC 2010.

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Early Renal Denervation

- Surgical denervation of splanchnic / renal nerves documented in 1940's / 1950s for treatment of essential hypertension with improved patient outcomes
- Developing guidelines for improved BP control, relationship to improved clinical outcomes, and common cases of med intolerance, multi-drug resistant hypertension created need for an alternative to medical therapy
- Developing catheter based technologies in coronary and peripheral vascular intervention led to the development of catheter-based techniques for renal denervation and investigation of their efficacy in the treatment of resistant htn

Smithwick RH. Surgical treatment of hypertension. *Am J Med* 1948;4:744–759..

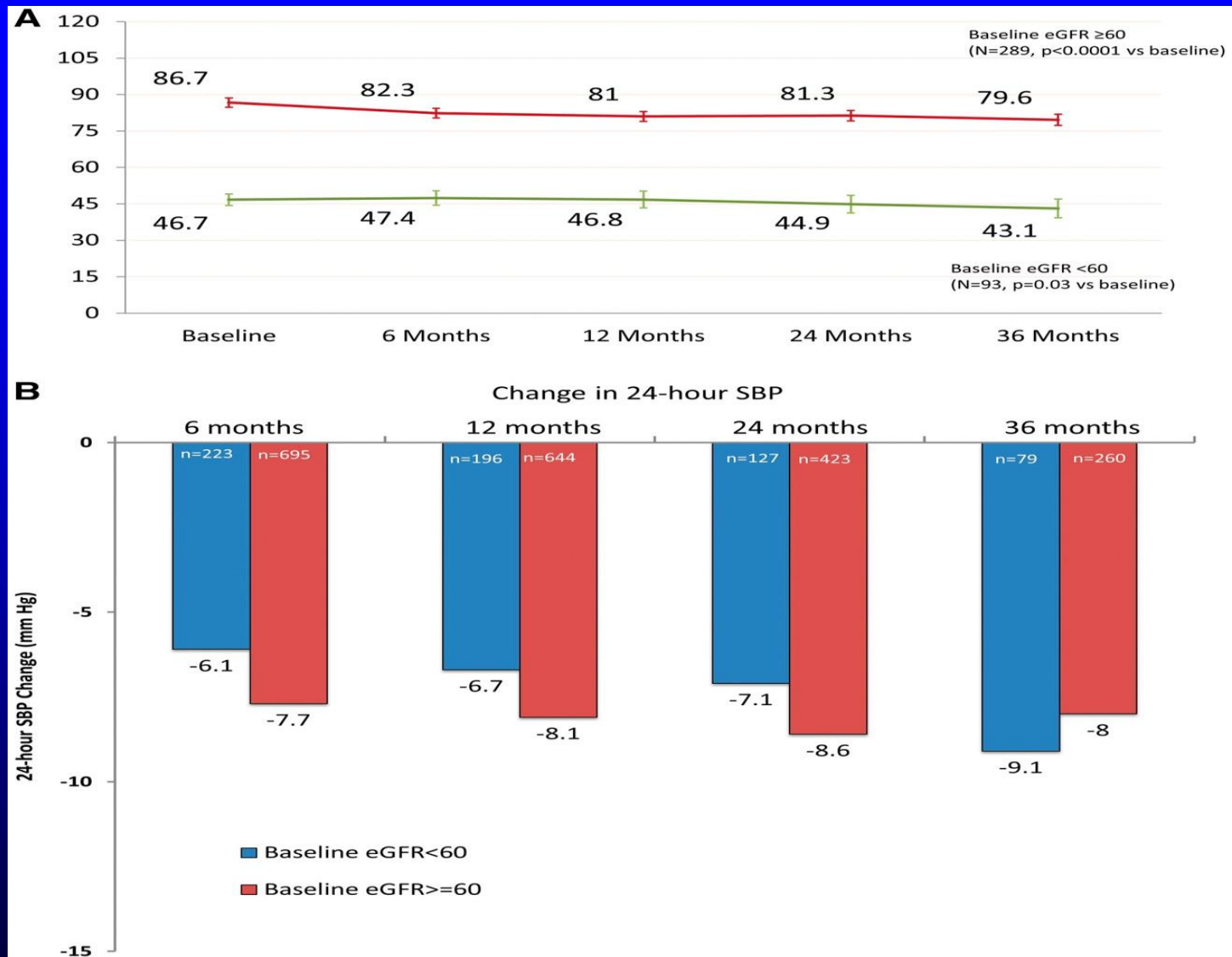
Smithwick RH, Thompson JE. Splanchnicectomy for essential hypertension; results in 1,266 cases. *J Am Med Assoc* 1953;152:1501–1504.

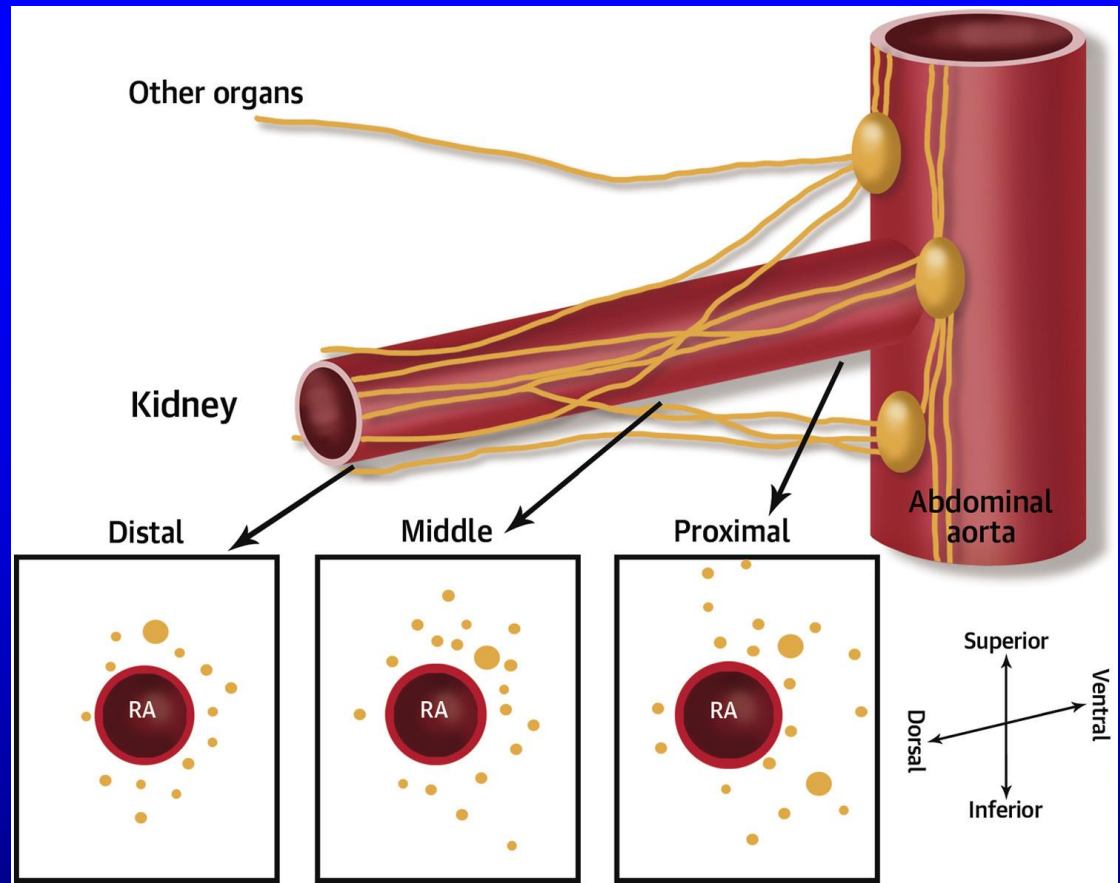
Catheter-Based RDN: Early Trials

- Multiple technologies developed
- First used radiofrequency technology (RFA)
- Later ultrasound and neurotoxin injection to adventitia of renal artery where afferent / efferent nerves reside
- Non randomized Simplicity HTN-1 and HTN-2 studies showed significant improvements in office BP
- Randomized, sham-controlled Simplicity HTN-3 negative study due to:
 - ?Ineffective technology
 - ?4 Quadrant-Circumferential Ablation
 - Med changes
 - Accessory renal artery rx
 - Proximal vs distal rx
 - ?Less efficacy in low renin htn subjects
 - Hawthorne effect
 - Ambulatory > Office BP effect
- However, renal denervation produced a larger decrease in ambulatory systolic blood pressure at 12 months (-7.5 vs -0.1 mmHg) and 36 months (-15.6 vs -0.3 mmHg). There were no differences in the incidence of serious adverse events.

Bhatt DL, Kandzari DE, O'Neill WW, D'Agostino R, Flack JM, Katzen BT, Leon MB, Liu M, Mauri L, Negoita M, Cohen SA, Oparil S, Rocha-Singh K, Townsend RR, Bakris GL. A controlled trial of renal denervation for resistant hypertension. *N Eng J Med* 2014;370:1393-1401.

Global Symplectivity Registry @ 36-Months



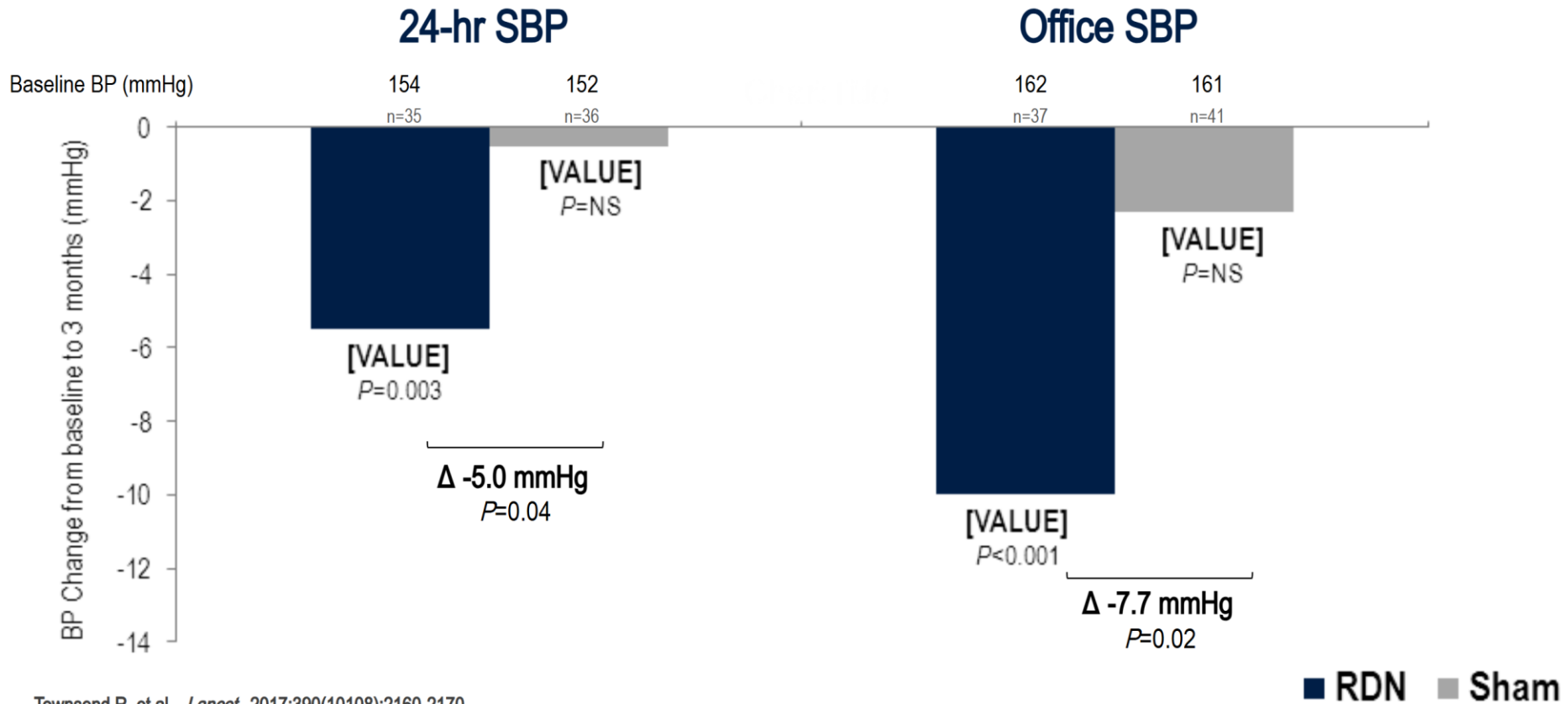


Spyral RDN Catheter (Medtronic)

Sakakura et al. Anatomic Assessment of Sympathetic Peri-Arterial Renal Nerves In Man. *JACC* 2014;64 (7):635-643.

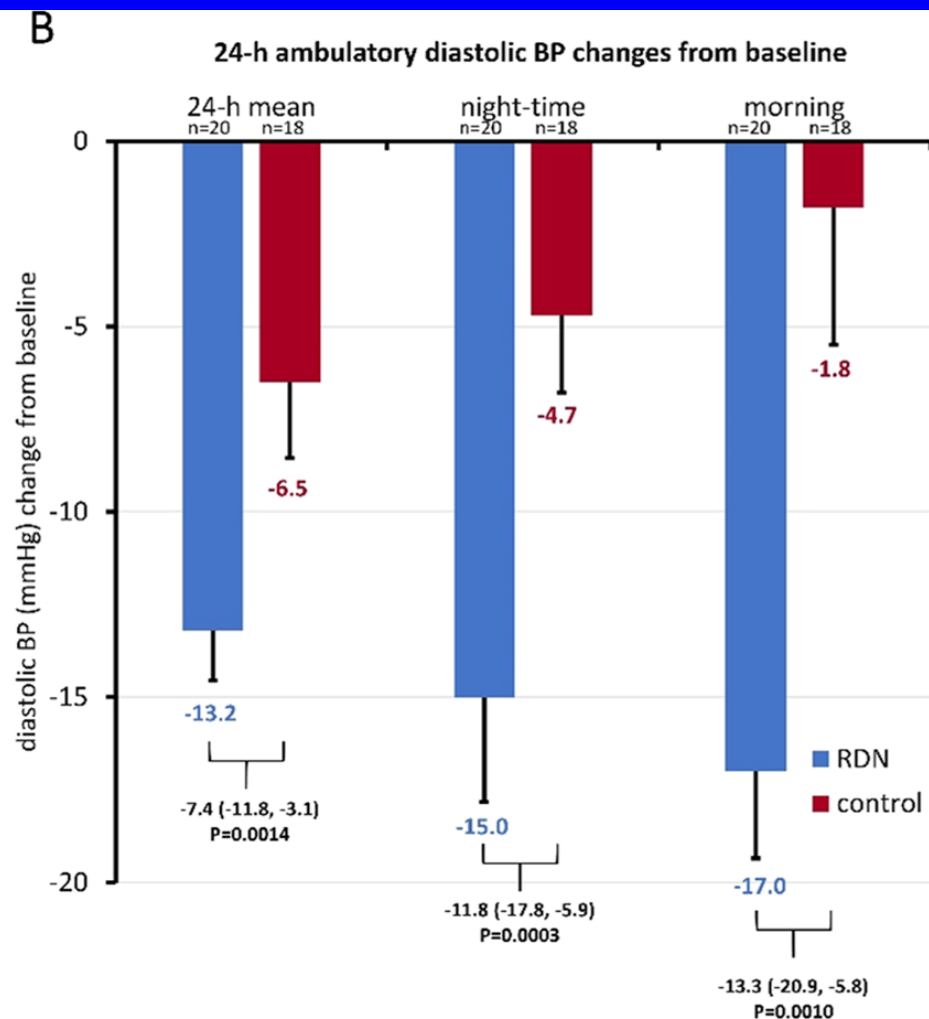
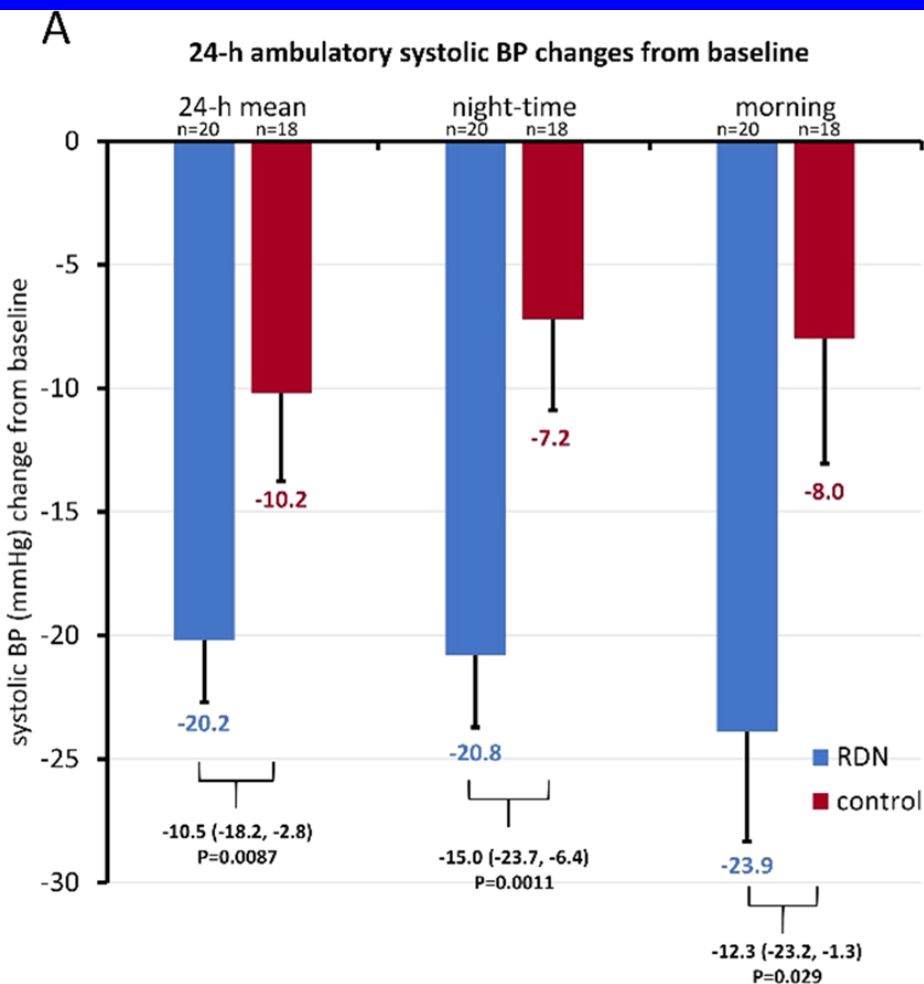
Spyral HTN Off-Med @ 3-Months

Trial Description: Patients with uncontrolled hypertension not on antihypertensive therapy were randomized to renal denervation vs. sham.



Townsend R, et al. *Lancet*. 2017;390(10108):2160-2170.

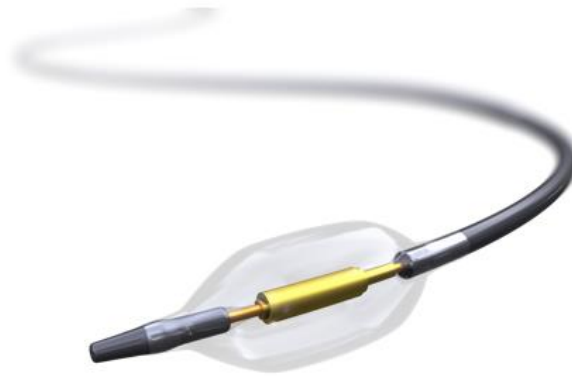
Spyral HTN On-Med @ 36-Months



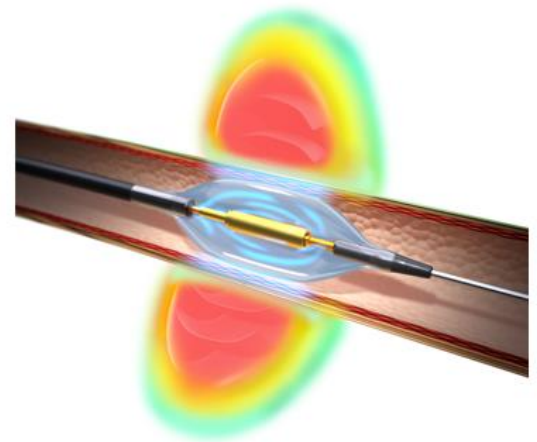
Paradise™ Ultrasound Renal Denervation System



Generator



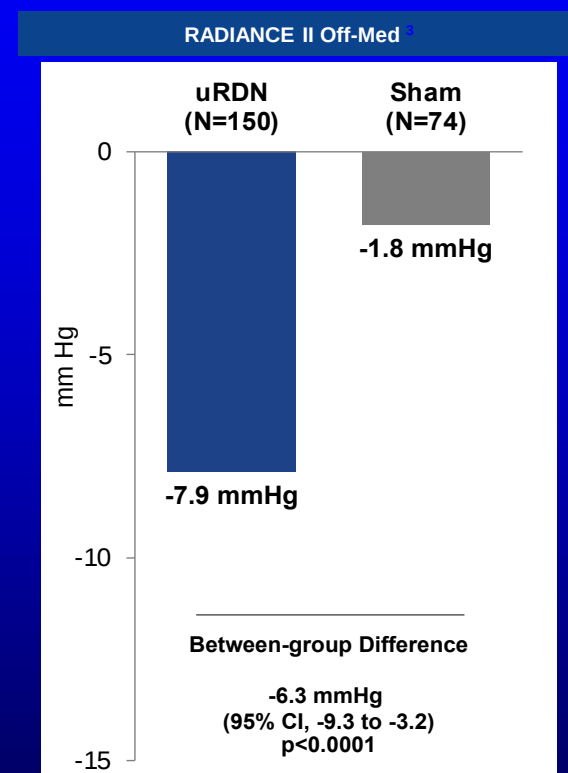
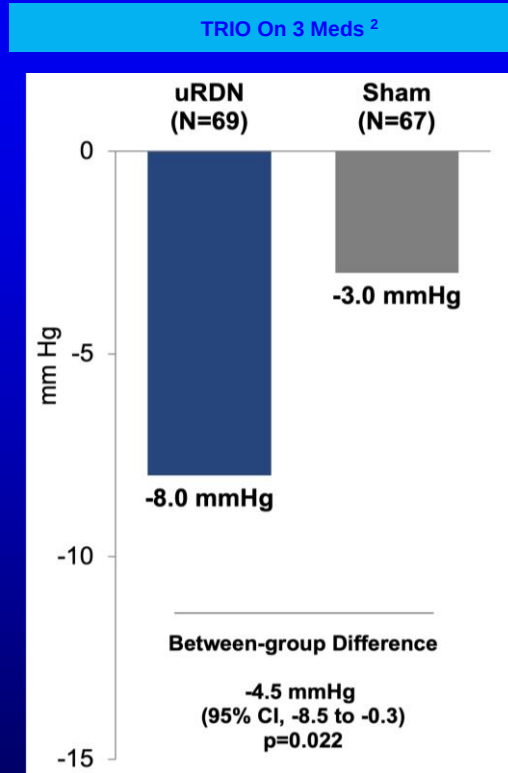
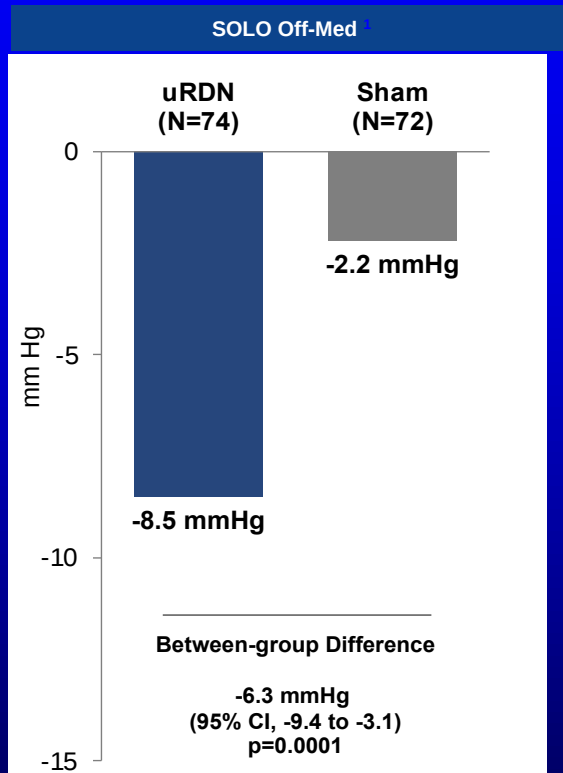
Ultrasound
Catheter



Sonication Area

Paradise uRDN System: SOLO, TRIO, RADIANCE II: Primary Endpoint

Change in Daytime Ambulatory Systolic BP (mmHg) at 2 Months



1. Azizi *et al. Lancet.* 2018; 391(10137):2335-2345

2. Azizi *et al. Lancet.* 2021; 397:2476-2486

3. Azizi *et al. JAMA.* 2023; 329(8): 651-661

In Whom to Avoid RDN:

- kidney transplant recipients
- patients with severely impaired kidney function (KDIGO stage G4 and G5);
- patients requiring haemodialysis;
- patients with fibromuscular dysplasia;
- patients with untreated secondary HTN

(RAS / Untreated OSA / Hyperaldosteronism / Coarctation AO / Cushing Syndrome)

- patients with a single functioning kidney.

Consider RDN in Patients:

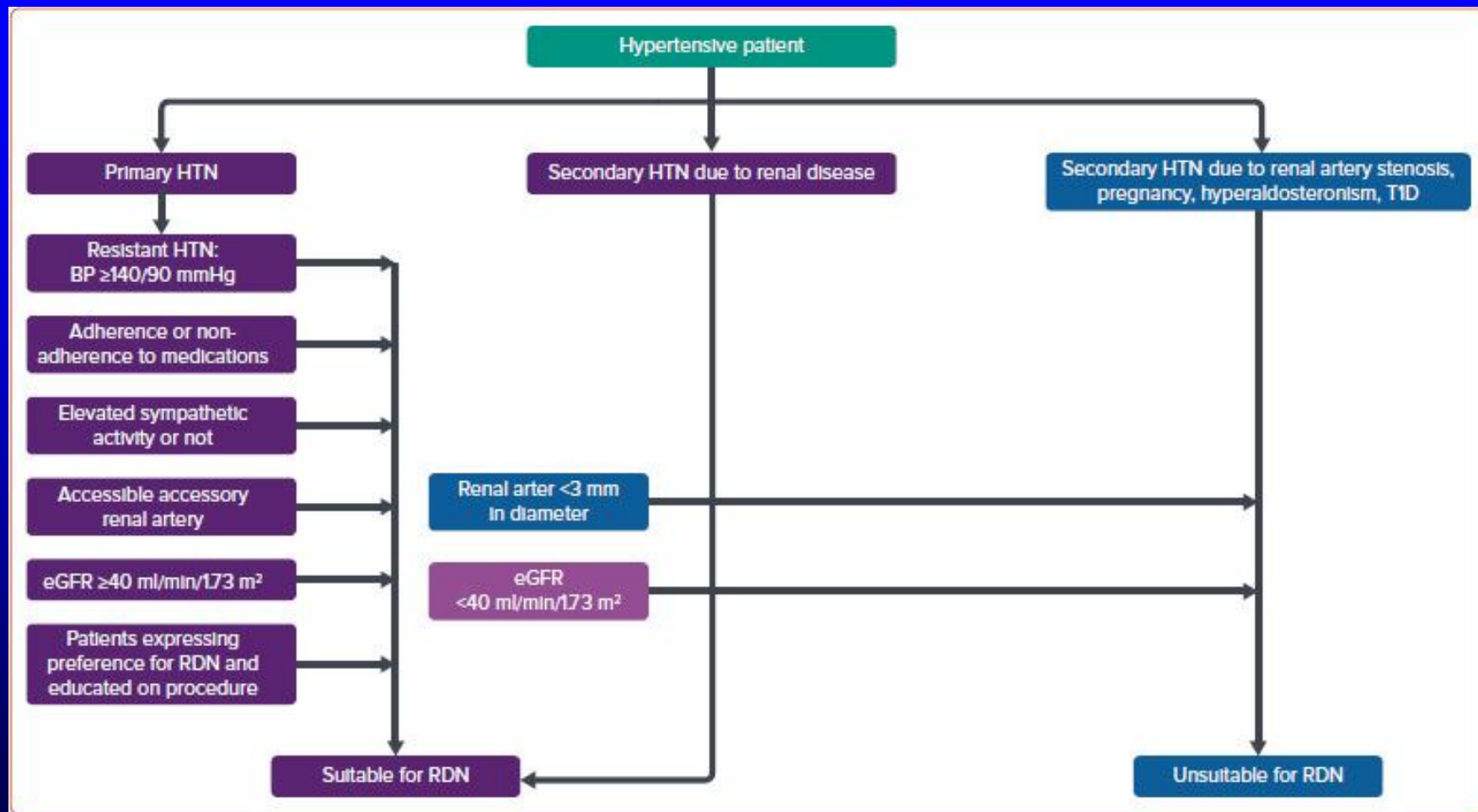
- for whom BP remains high or above target despite full adherence with the maximum appropriate combination of pharmacological agents that can be tolerated;
- with resistant HTN;
- with a history of repeated non-adherence despite numerous counselling sessions;
- on polypharmacy for multiple comorbidities;
- with multiple end-organ damage, with high CV risk;
- unwilling to take long-term pharmacotherapy; and
- with an intolerance to antihypertensive medications.

Chia YC, Ahmad WAW, Fong AYY et al. 2022 Malaysian Working Group consensus statement on renal denervation for management of arterial hypertension. *Hypertens Res.* 2022;45:1111–22. doi: 10.1038/s41440-022-00937-w.

Renal denervation in the management of hypertension in adults. A clinical consensus statement of the ESC Council on Hypertension and the European Association of Percutaneous Cardiovascular Interventions (EAPCI) *EuroIntervention.* 2023;18 doi: 10.4244/EIJ-D-22-00723.



How to Evaluate for RDN Candidacy:



RDN Take Home Messages

- Renal Artery Denervation proof-of-concept originated in surgical denervation
- Randomized, sham-controlled data confirms the efficacy of RDN in provoking modest decreases in systolic and diastolic BP in mild to moderate and resistant hypertensive patients
- Complications (dissection / perforation / stenosis / vascular) were rare
- There may be a differential response related to technology used, but data here is TBD (uRDN vs RF vs toxin)
- Data supports sustained effect out to 36 months
- Patients with the worst hypertension experience the greatest decrease in BP with RDN
- It is reasonable to rule out secondary causes of hypertension and reach maximal tolerated medical therapy before considering RDN in refractory and intolerant patients

In Summary

- There is much progress in the treatment of renovascular disease
- More randomized data is necessary but most recent data from CORAL is non-enlightening
- The growth of renal transplantation has resulted in the advent of a new type of renal intervention
- Restenosis is a significant problem in the management of RAS and optimal management has not been defined
- The advent of renal artery denervation has provided a new arrow in our quiver of therapies against hypertension and resultant CV risk
- Renovascular disease is an opportunity for multi-specialty collaboration: cardiology / vascular medicine / nephrology / interventional radiology / hypertensivist / internal medicine / vascular surgery / electrophysiology / heart failure / transplant surgery

Presenter Disclosure Information

The following relationships exist related to this presentation:

Consultant / Clinical Endpoints Committee – Applied Clinical Intelligence, LLC
Consultant / Clinical Endpoints Committee – Baim Institute for Clinical Research
Consultant / Clinical Endpoints Committee - Boehringer-Ingelheim
Consultant / Clinical Endpoints Committee – Abbott
Consultant / Clinical Endpoints Committee – Merck
Consultant / Clinical Endpoints Committee – Bayer
Consultant / Clinical Endpoints Committee – AbbVie
Consultant / Clinical Endpoints Committee – Siemens
Consultant / Clinical Endpoints Committee – Covance
Consultant / Scientific Advisory Board – Recor Medical, Inc.
Equity Interest – Ostial Corporation
Spouse Employee / Shareholder – Vertex Pharmaceuticals

Presentation will include:

Off label use of vascular / biliary stents.
Review of investigational / unapproved devices
and devices with OUS approval.

Garasic 2024



Selected References

- 1) Cooper et al. Stenting and Medical Therapy for Atherosclerotic Renal-artery Stenosis. N Engl J Med. 2014 Jan 2; 370(1):13-22.
- 2) White et al. Indications for renal arteriography at the time of coronary angiography: A scientific advisory from the American Heart Association Committee on Diagnostic and Interventional Cardiac Catheterization, Council on Clinical Cardiology, and the Councils on Cardiovascular Radiology and Intervention and on Kidney in Cardiovascular Disease. Circulation 2006; 114:1892-95.
- 3) Sirolimus-eluting versus bare-metal low-profile stent for renal artery treatment (GREAT Trial): angiographic follow-up after 6 months and clinical outcome up to Two years. J Endovasc Ther. 2007 Aug; 14(4): 460-8.
- 4) Radermacher J et al. Use of Doppler ultrasonography to predict outcome of therapy for renal-artery stenosis. N Engl J Med 2001; 344:410-17.
- 5) The ASTRAL Investigators. Revascularization versus Medical Therapy for Renal-Artery Stenosis. N Engl J Med 2009; 361: 1953-1962.
- 6) Swaminathan et al. SCAI Position Statement on Renal Denervation for Hypertension: Patient Selection, Operator Competence, Training and Techniques, and Organizational Recommendations. [Journal of the Society for Cardiovascular Angiography & Interventions](#). Volume 2, Issue 6, Part A, November–December 2023, 101121.



Failure of renal function to improve after renal intervention may be predicted by:

- A) Significant proteinuria
- B) Recent onset or worsening of hypertension
- C) Preserved renal span
- D) Severe ostial stenosis
- E) Creatinine clearance >40 ml/min

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may be predicted by:

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Which of the following statements regarding Renovascular disease is false:

- A) The rate of renal artery restenosis is ~20%
- B) Renal intervention is curative of hypertension in most cases of bilateral severe RAS
- C) A low resistive index is associated with improved outcomes after renal intervention.
- D) The majority of revascularized patients in the Astral and Coral trials had unilateral RAS
- E) Fibromuscular dysplasia affecting the renal arteries most typically does not result in a loss of renal span

Which of the following statements regarding Renovascular disease is false:

B) Renal intervention is curative of hypertension in most cases of bilateral severe RAS

Which is true of MR Angiography in evaluating Renovascular disease:

- A) MRA is the modality of choice in the HD patient
- B) False negatives are common, but false positives are rare
- C) Renal duplex provides greater data for plotting intervention
- D) MRA is likely preferable to u/s in the obese patient
- E) Pathology involving the mid renal artery such as FMD is difficult to image by MRA

Which is true of MR Angiography in evaluating Renovascular disease:

D) MRA is likely preferable to u/s in the obese patient

Which is a true statement as relates to the utility of RDN in the management of hypertension:

- A) The response to therapy in RDN is equivalent across varying degrees of hypertension
- B) The presence of a previously placed renal stent improves efficacy after RDN
- C) All modalities of RDN are known to have comparable clinical outcomes
- D) A 10mmHg reduction in BP is associated with a 20% reduction in CV events (fatal & non-fatal MI / SCD / CVA / heart failure) and a 17% reduction in mortality
- E) There are no non-responders in RDN

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Take Home Message: Renal Artery Stenosis

- Most renovascular disease is atheromatous
- Clinical suspicion and the presence of other macrovascular disease should prompt screening for RAS
- Duplex ultrasound, CTA, MRA, and contrast angiography all may be used in making the diagnosis
- RAS may be followed clinically in patients responsive to medical therapy
- Pts who fail medical therapy and are candidates for invasive evaluation may benefit from renal revascularization
- The renal artery is now the target for denervation procedures, in efforts to treat hypertension, atrial fibrillation, and other diverse conditions.
- Renal artery denervation provides a modest and variable improvement in systolic blood pressure control in patients with uncontrolled systolic hypertension.