Budapest Nephrology School
Secondary Hypertension

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August 2011

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Objectives

- Define Secondary Hypertension
- Incidence of secondary HTN
- Renal Artery Stenosis
- Primary Hyperaldosteronism
- Pheochromocytoma
- Determine who to work up for secondary HTN
- Best Screening tests for secondary hypertension

Secondary Hypertension

- 90% of patients have **essential** or primary hypertension
- These patients usually have **positive family history** of hypertension

- **Secondary hypertension** is when an underlying physiological or anatomical cause of hypertension is found

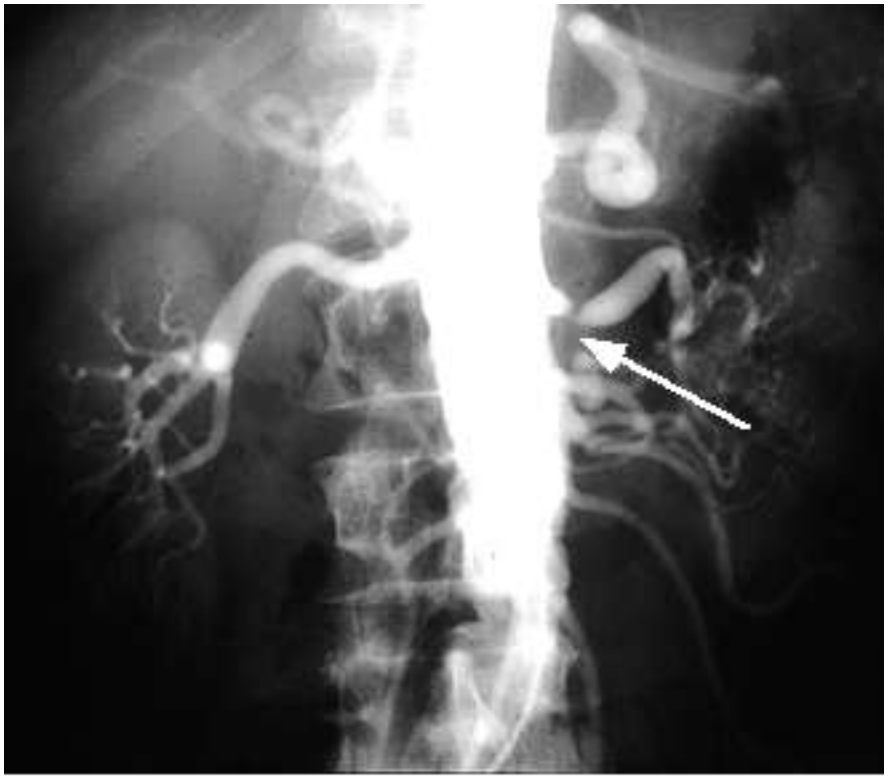
More common causes of Secondary Hypertension

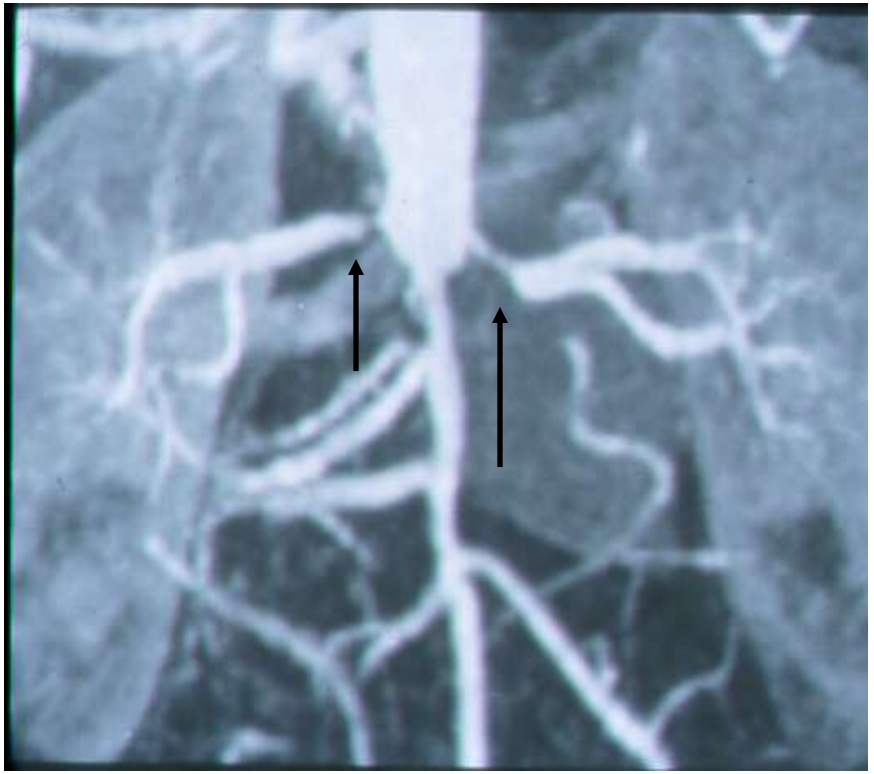
- Renal Disease
- Renal Artery Stenosis
- Primary Hyperaldosteronism
- Pheochromocytoma

CLASSIFICATION OF RENAL ARTERY DISEASE

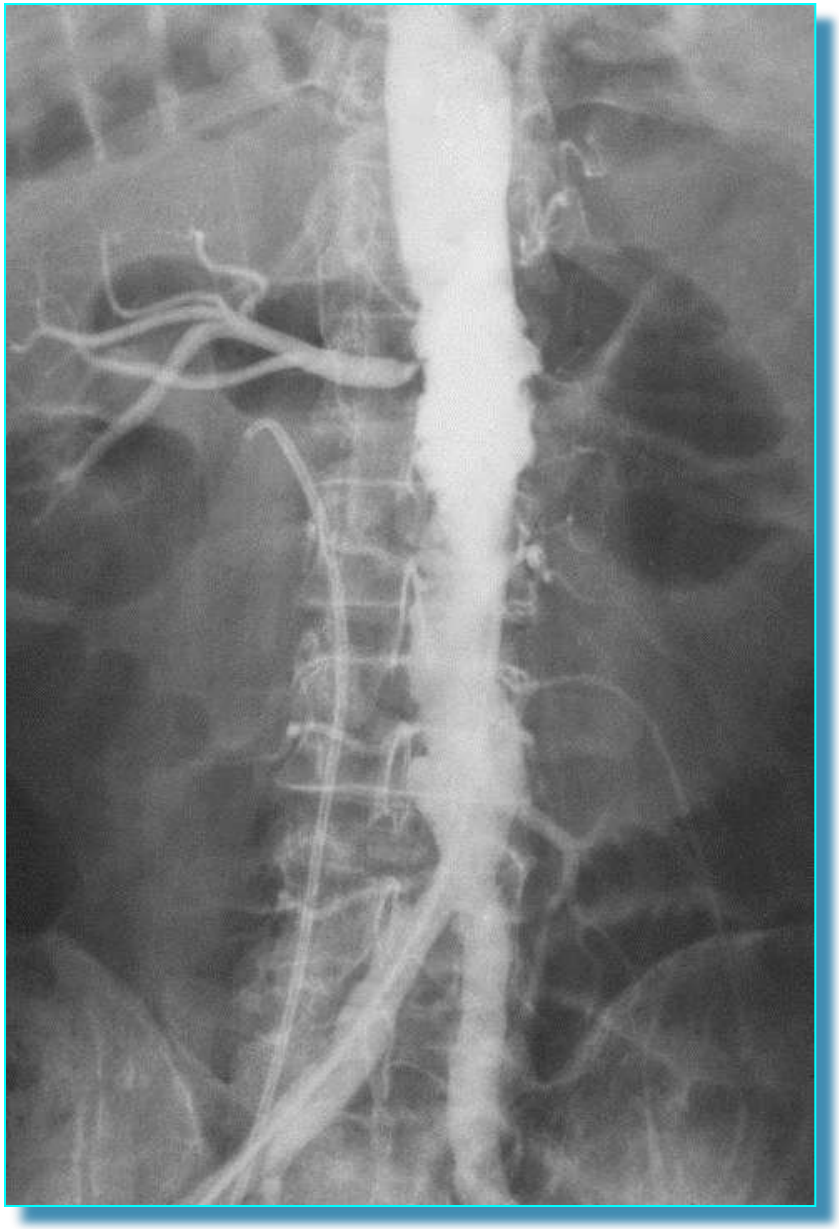
Disease	Incidence
Atherosclerosis	60% - 80%
Fibrous dysplasia	20% - 40%
Medial (30%)	
Perimedial (5%)	
Intimal (5%)	
Arterial aneurysm	<5%
A-V malformation	<1%

Atherosclerotic RAS

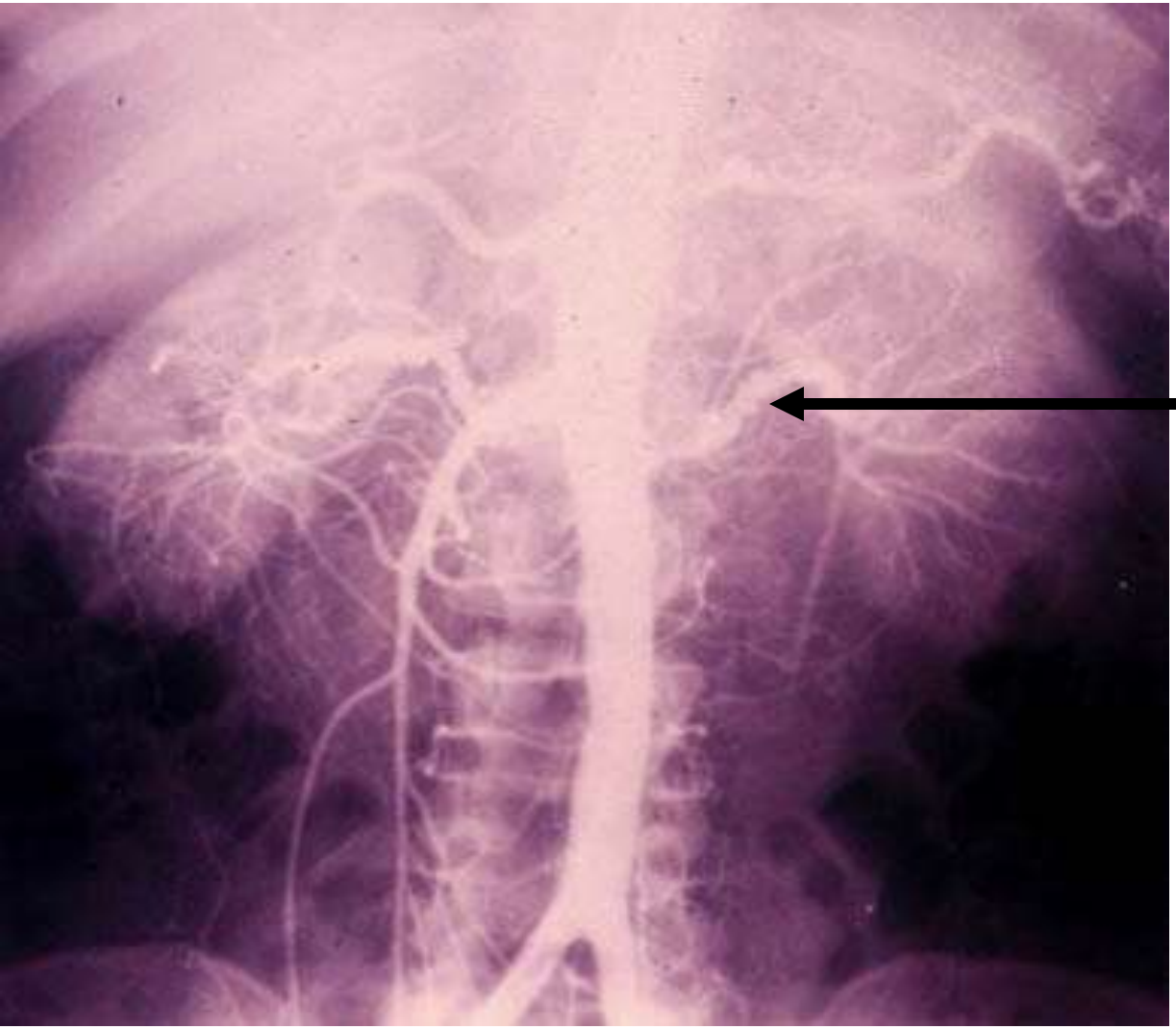




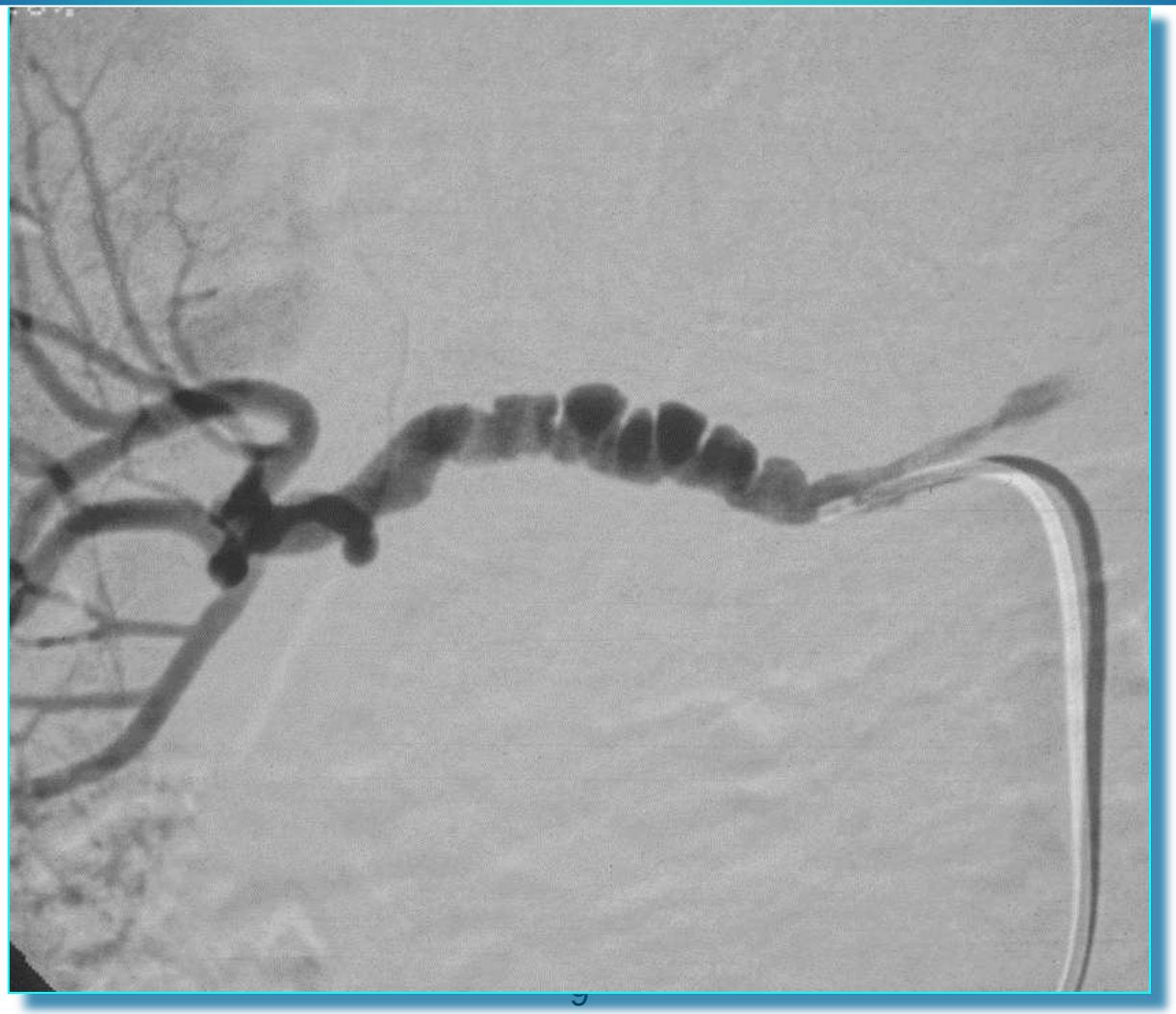
Atherosclerotic Renal Artery Disease



FMD: Renal Arteriogram



Medial Fibromuscular Dysplasia



Atherosclerotic VS FMD

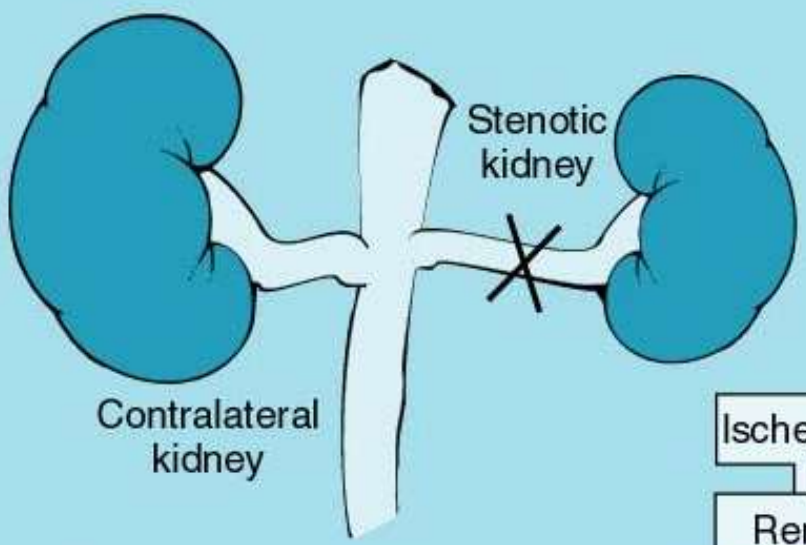
Atherosclerotic RAD	Fibrous RAD
Men and women	Women
Age >50 – 55 years	Age 20 – 55 years
Total occlusion common	Total occlusion rare
Ischemic atrophy common	Ischemic atrophy rare
Surgical intervention or PTRA ⇨ mediocre cure rates of the hypertension	Surgical intervention or PTRA ⇨ good cure rates of the hypertension
Less amenable to PTRA	More amenable to PTRA

***Common features: Propensity to cause hypertension**

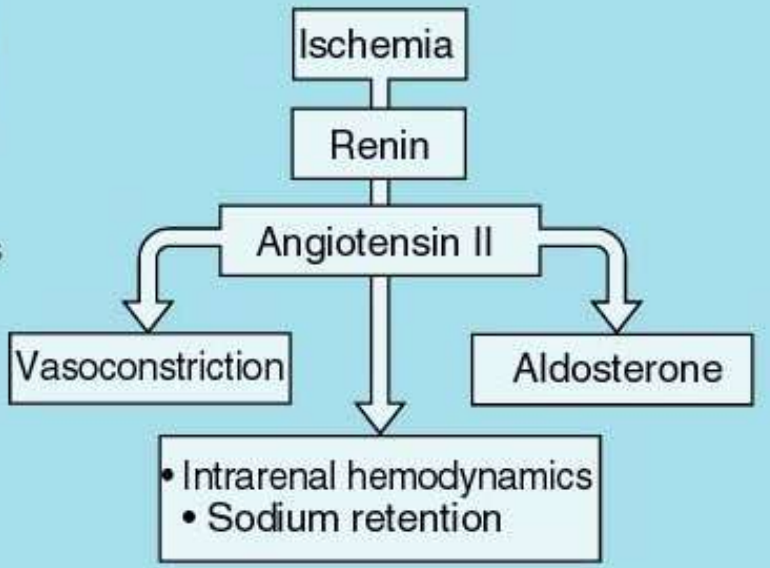
Occur bilaterally in 30-40% of patients

Natural History of FMD

Lesion	Frequency*	Risk of progression	Threat to renal function
Medial fibroplasia	65 - 85%	++	- -
Perimedial fibroplasia†	15%	++++	++++
Intimal fibroplasia and medial hyperplasia†	5 - 10%	++++	+++

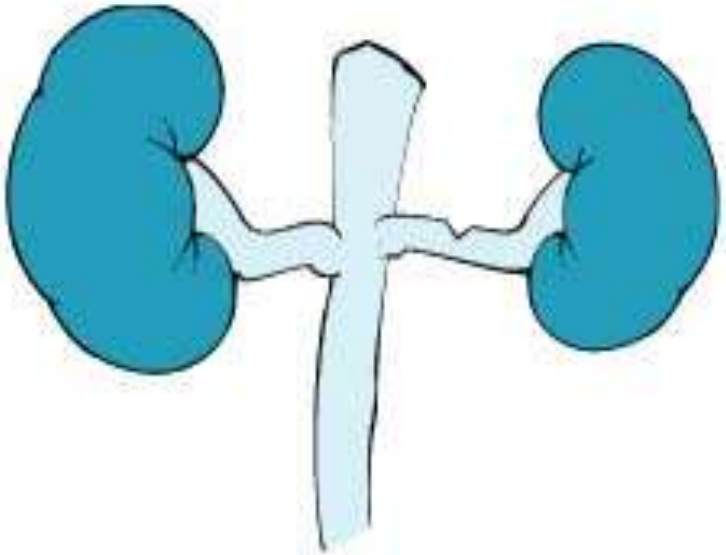


- Supressed renin
- Pressure natriuresis



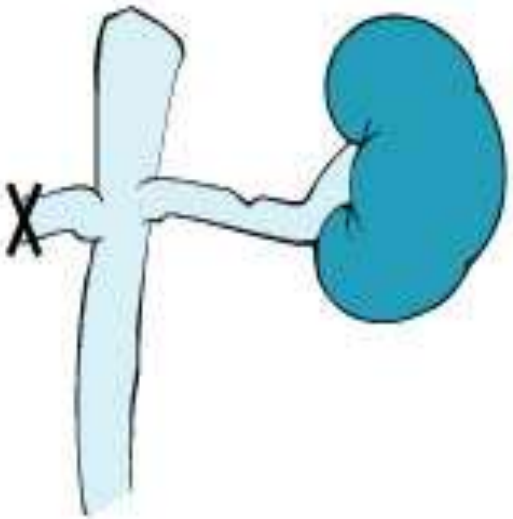
Pathophysiology of RAS: 1 vs 2

Two-kidney hypertension



Blood pressure	Renin	Volume
↑	High	Normal

One-kidney hypertension



Blood pressure	Renin	Volume
↑	Normal	High

Ischemic Nephropathy

- Unilateral
  - Hypertension is ***driven by renin release***
  - The renin release continues until the pressure increases flow to the stenotic side
  - Sodium excretion by the contralateral kidney is increased
- Bilateral
  - The hypertension is largely ***volume–related*** and not as much driven by renin
  - There is no contralateral ‘non stenotic’ kidney so volume cannot be reduced by pressure natriuresis on the unobstructed side

Ischemic Nephropathy

- Unilateral
  - Blood pressure usually responds to ACE-inhibitors or ARBs
  - Creatinine usually remains stable during therapy
  - Overall kidney function depends on the degree of damage to the contralateral kidney
- Bilateral
  - Usually need a diuretic to deal with the volume issue
  - Creatinine may increase when an ACE-inhibitor or ARB is used
  - Kidney function is often impaired, and the relative contribution of stenosis (vs parenchymal disease) is difficult to predict

Clinical Diagnosis of RAS

- Age at onset of HTN <30 years or >55 years
- Well-documented, abrupt onset of hypertension
- Acceleration of previously stable and well-controlled BP
- HTN refractory to an appropriate 3-drug regimen
- Accelerated retinopathy
- Malignant hypertension
- Systolic-diastolic abdominal bruit
- Flash pulmonary edema
- Evidence of generalized atherosclerosis
- Acute renal failure with ACE or ARB

Diagnosis of RAS

- **Duplex ultrasonography**
- **Magnetic resonance angiography**
- **Spiral CT angiography**
- **Captopril renography**
- Captopril provocation test
- Radionuclide renography
- Rapid-sequence intravenous pyelography
- CO_2 angiography
- **Conventional arteriography**

Duplex Ultrasonography (U/S)

ADVANTAGE

- Noninvasive

DISADVANTAGES

- Requires an experienced technician; operator-dependent
- Limited by obesity or bowel gas

Magnetic Resonance Angiography (MRA)

ADVANTAGE

- Noninvasive

DISADVANTAGES

- Risk of nephrogenic systemic fibrosis among patients with advanced CKD
- ? other metal in the body
- May not detect distal disease in FMD

Computed Tomographic (CT) Angiography

ADVANTAGE

- Noninvasive

DISADVANTAGES

- Risk of contrast nephropathy among patients with chronic kidney disease (CKD)
- Radiation exposure

Intraarterial Digital-Subtraction Angiography (Ia-DSA)

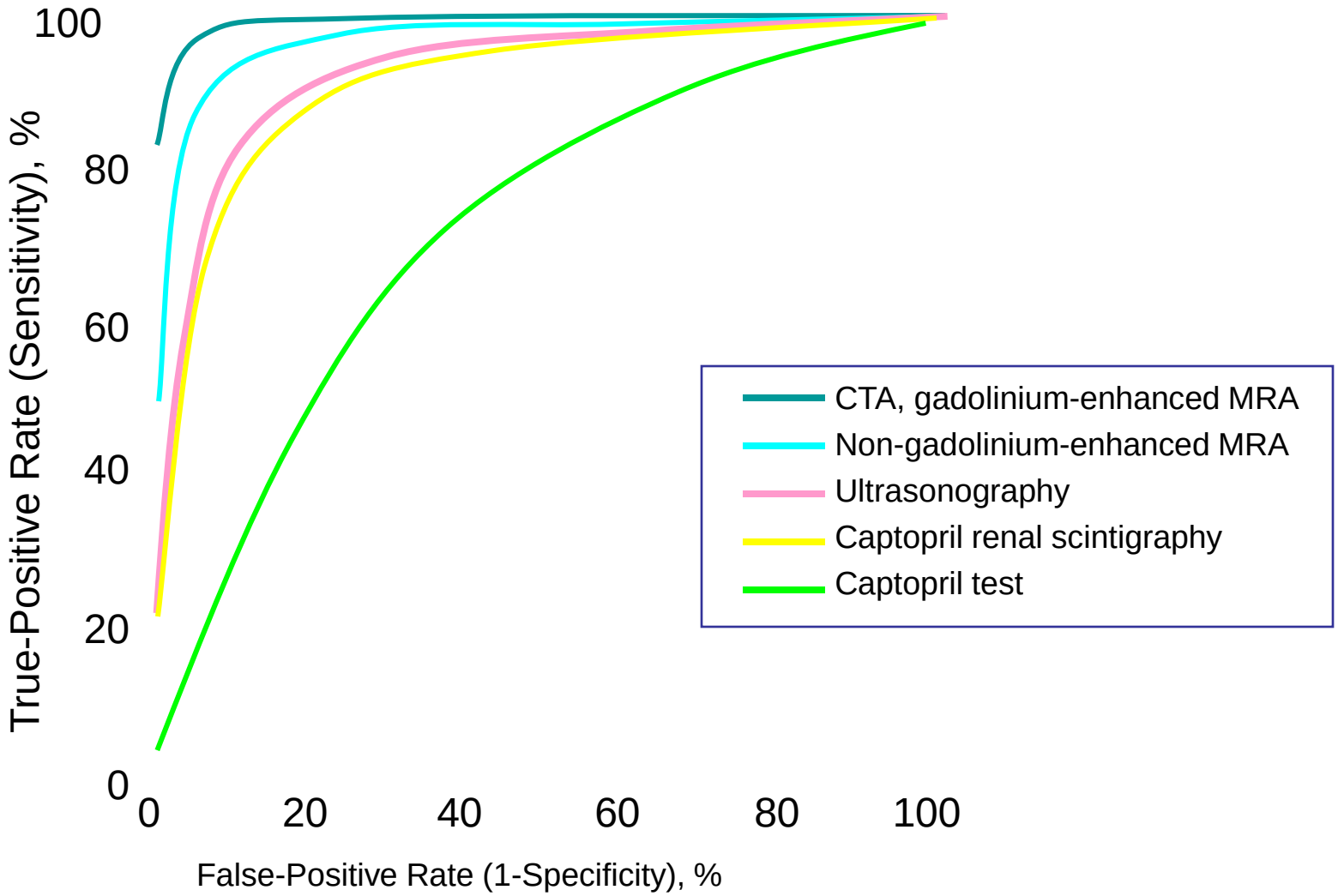
ADVANTAGES

- Best image quality
- Best anatomical information

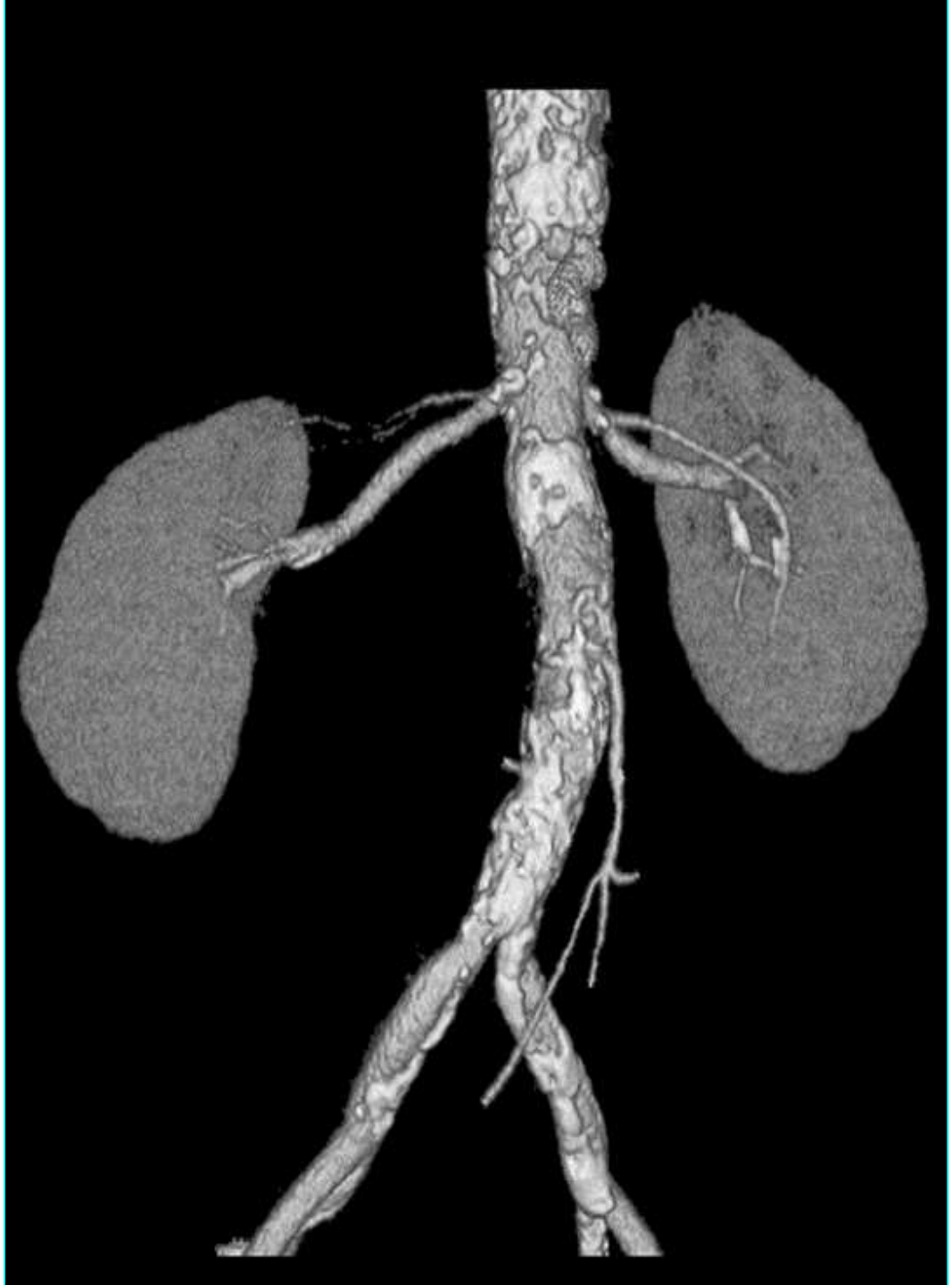
DISADVANTAGES

- Invasive
- Risk of contrast nephropathy among patients with CKD
- Risk of atheroembolic events
- Risk of vascular complications at puncture site
- Radiation exposure

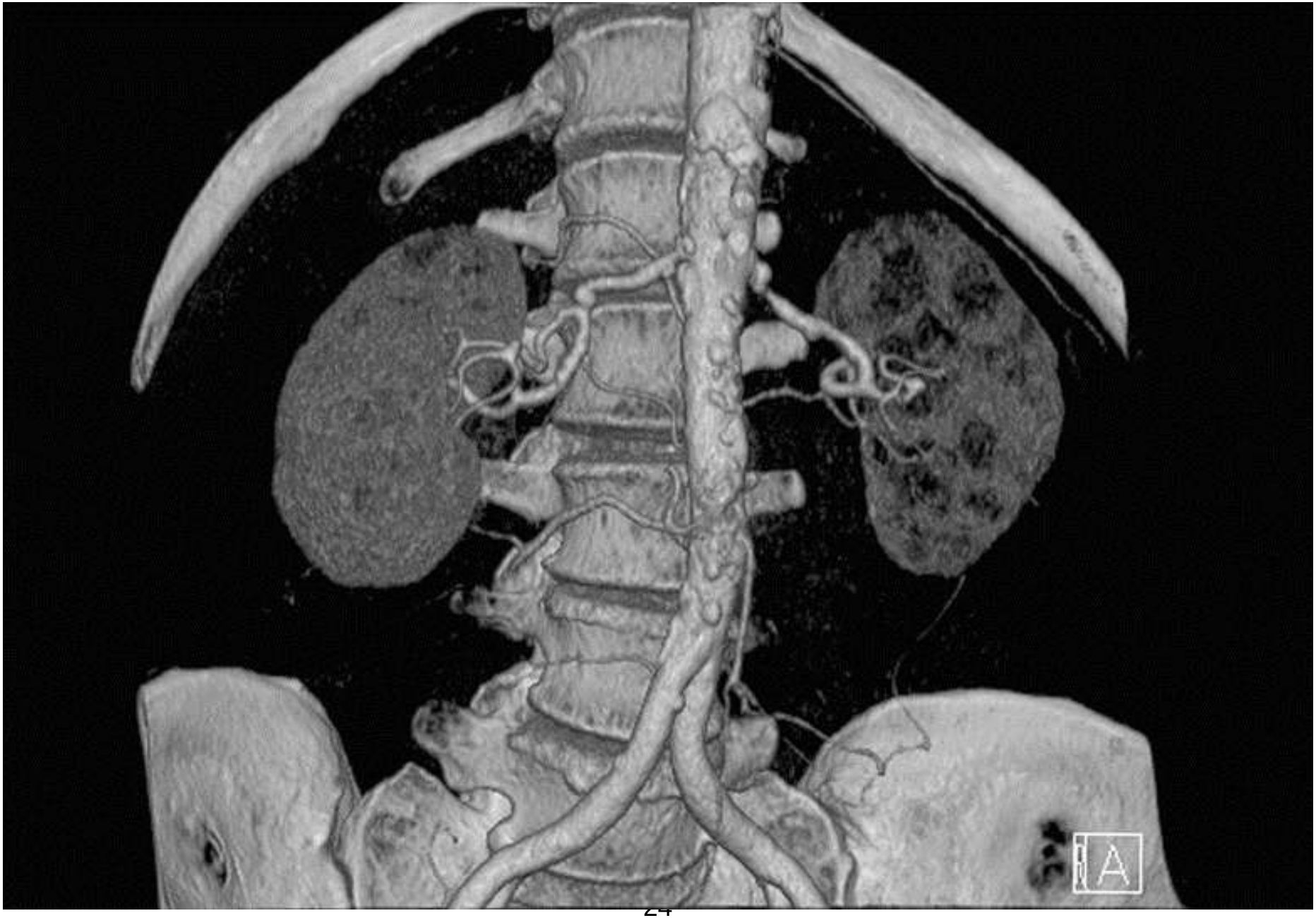
Meta-Analysis: Comparison of Non-invasive Tests for Renal Artery Stenosis with Renal Angiography (55 studies)



Boudewijn G et al. *Ann Intern Med* 2001;135:401-11



CT
Angiography



Courtesy of Steve Textor, MD, Mayo Clinic

Natural History of ARAS

1. Overall progressive renal artery obstruction in 44%
2. Progression to total occlusion in 39% of high-grade (> 75%) stenotic lesions
3. Progression usually within 2 years of initial diagnosis
4. Progressive obstruction associated with loss of renal function

Schreiber MJ, Pohl MA, Novick AC: *Urol Clin No Am* 1984

Natural History of ARAS Revisited

- Early data based on retrospective series
- Many, perhaps most, lesions do **NOT** progress rapidly
- Rates of progression may be changing:
  - Smoking cessation
  - Improved BP control
  - Lipid management
  - Vascular effects of antihypertensive agents
  - Other factors: lifestyle modifications

Progression of ARAS

- 76 patients, 132 arteries, mean f/u 32 months
- cumulative incidence of progression:
- normal to 60% stenosis: 0% at 1 yr, 0% at 2 yrs, 8% at 3yr
- ≥60%: 30% at 1 yr, 44% at 2 yrs, 48% at 3 yrs
- **Progression to occlusion occurred only in arteries with a baseline stenosis ≥ 60%**
- **Cumulative incidence of progression to occlusion: 4% at 1 yr, 4% at 2 yrs, 7% at 3 yrs**
- BP control and serum creatinine **were not** predictive of progression

Zierler et al (AJH, 1996)

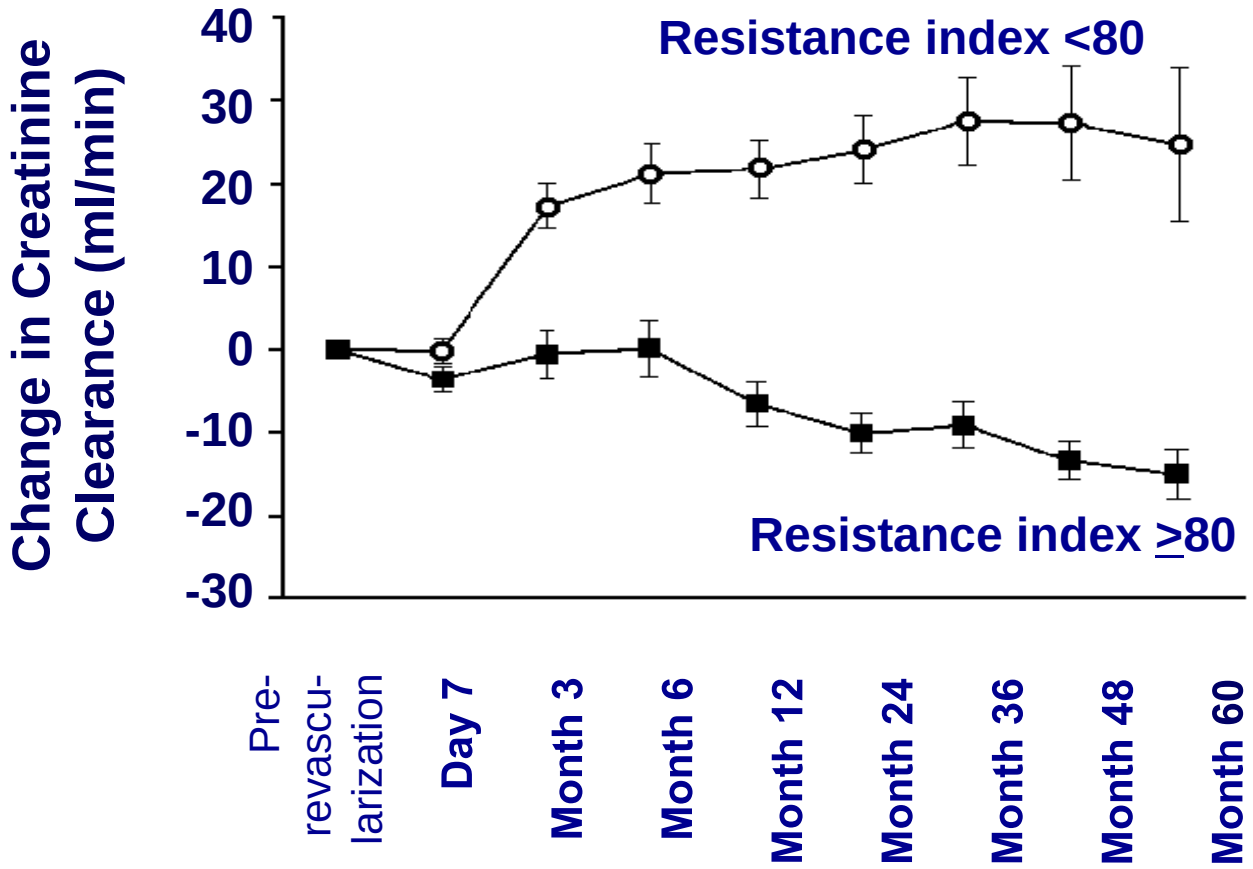
Anatomic Indications for Renal Revascularization

- Chronic total renal artery occlusion bilaterally or in a solitary kidney
- High-grade (>75%) arterial stenosis in a solitary kidney
- High-grade (>75%) bilateral renal artery stenosis

Clinical Indications for Renal Revascularization

- Uncontrolled BP on 3 to 5 drugs
- Progressive decline in GFR (assuming no other cause identified)
- Significant increase in serum creatinine (↓ in GFR) with SBP lowering
- ACEi or ARB induced AKI
- Flash pulmonary edema (bilateral >> unilateral RAS)

Changes in CrCl after Correction of RAS



Radermacher et al. N Engl J Med 2001;344:410.

Renal Function in Azotemic* Patients Following Renal Revascularization

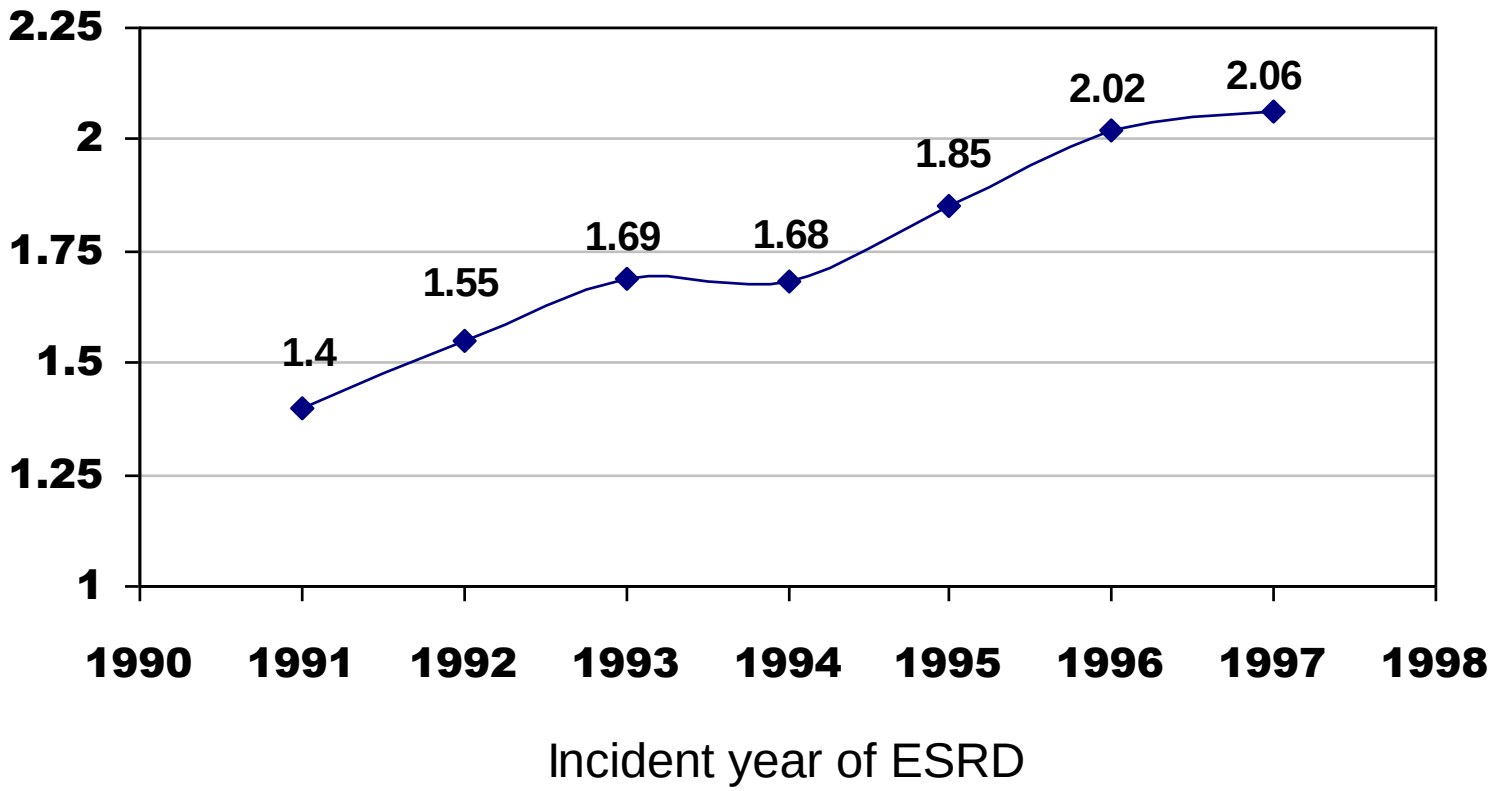
	IMPROVED SCr ¯ >1 mg/dL	NO CHANGE D SCr <1 mg/dL	WORSE SCr >1 mg/dL
Surgery (n = 304)	27.7 %	52.6 %	19.7 %
PTRA (n = 44)	27.3 %	52.2 %	20.5 %

Serum creatinine $\geq$ 2.0 mg/dL. Mean follow up 27 months

SCr = serum creatinine

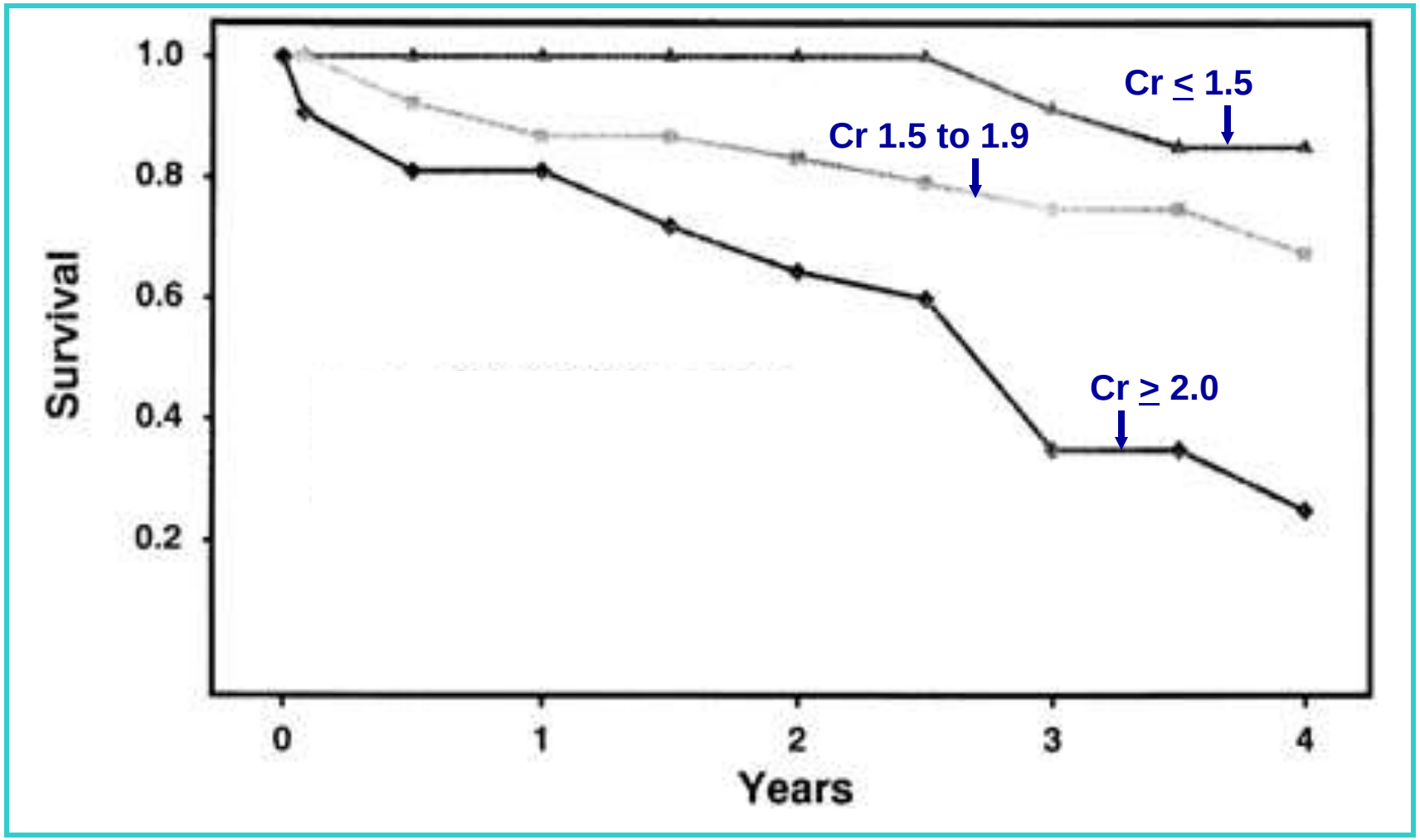
Hallett, Bonelli, McKusick, Textor.
J Vas Surg 1995:21:750 and
Mayo Clin Proc 1995:70:1041

Absolute Percentage of Incident ESRD Patients with RVD as Primary Cause



Fatica RA et al. Am J Kidney Dis 2001;37:1184.

Actuarial Patient Survival Following Renal Artery Stenting Stratified by Baseline Serum Creatinine



Dorros G. Circulation 1998;98:642

Management of Ischemic Nephropathy

- Stenoses of ≤60% are NOT hemodynamically significant
- Progression of stenosis <60% is common, but total occlusion rare (3-yr follow-up)
- Progression of stenoses ≥60% is common, but progression to total occlusion occurs in only 7% of cases (3-yr follow-up)
- Progression may not be accompanied by deterioration of renal function or BP control
- Renal artery stenting will improve BP control (particularly systolic BP) in most cases, but the long-term impact on renal function unclear

Management of Ischemic Nephropathy

- Unilateral RVD – angioplasty and medical therapy are similar in control
- Bilateral RVD – usually will require more medication if managed medically; ischemic nephropathy may prompt angioplasty/surgery
- Screening renal angiography DURING coronary angiography widespread but controversial.
- % incident ESRD pts with ARAS as cause of ESRD is increasing, but contribution to total ESRD population is relatively small.
- NO "standard" antihypertensive regimen
- There is no standard of care

Current Clinical Trials

- **STAR** – The Benefit of STent Placement and Blood Pressure and Lipid-Lowering for the Prevention of Progression of Renal Dysfunction Caused by Atherosclerotic Ostial Stenosis of the Renal Artery (STAR)
- **ASTRAL** – Angioplasty and Stent for Renal Artery Lesions
- **CORAL** – Coronary Outcomes on Renal Atherosclerotic Lesions
- **NITER** – Nephropathy Ischemic Therapy
- **RAVE** – Renal Atherosclerotic Revascularization Evaluation

STAR

- *Aim:* RCT to compare the effects of renal artery stent placement together with medication vs. medication alone on renal function in patients with atherosclerotic renal artery stenosis (ARAS)
- *Primary endpoint:* progressive renal function loss (= reduction in estimated Cr Cl by >20%) after 2 yrs follow-up, with an extended follow-up of 5 yrs
- *Inclusion criteria:* >18 years, ostial ARAS ≥50% on CTA, MRA or intra-arterial angiography, estimated Cr Cl <80 ml/min/1.73 m^2 according to the Cockcroft and Gault formula, on two occasions within one month
- *n* = 140, NIH sponsored, Utrecht, Netherlands

Bax L, et al, for the STAR study group. Ann Intern Med 2009;150:840

STAR

- 10 European medical centers
- 140 patients with CrCl < 80 ml/min and ARAS of ≥ 50%
- *Conclusion:* Stent placement with medical treatment had no clear effect on progression of impaired renal function but led to a small number of significant procedure-related complications. Study findings favor a conservative approach to patients with ARAS, focusing on CV risk factor management and avoiding stenting

Bax L, et al, for the STAR study group. Ann Intern Med 2009;150:840.

ASTRAL

- *Aim:* randomized trial comparing renal function in atherosclerotic renal artery disease (ARVD) patients randomized to either revascularization or medical management alone
- *Inclusion criteria:*
  - at least one ARAS lesion suitable for balloon angioplasty and/or stent, confirmed by intra-arterial angiography, MR angiography or CT
  - not previously undergone a revascularization procedure for ARVD
- *Primary endpoint:* Rate of progression of renal dysfunction (using serum creatinine analyzed by reciprocal creatinine plots over time)
- *Goal n* =750 -- 1,000, recruited over 5 years, UK

Wheatley K et al. *N Engl J Med* 2009; 361:1953

ASTRAL Trial

- 2000-2007, 806 patients recruited from 58 centers
- No differences were seen between revascularization and medical arms in:
  - renal events (46 vs. 47, HR 0.98, CI 0.66 -1.48, $p = 0.9$)
  - CV events (95 vs. 107, HR 0.90, CI 0.66-1.15, $p = 0.03$)
  - mortality (79 vs. 81, HR 0.92, CI 0.68-1.26, $p = 0.6$)
- Overall 5-yr mortality was 43%.
- CONCLUSION: Initial results of ASTRAL, the largest randomized ARVD trial, show no worthwhile benefit to revascularization for any outcome measure when compared with optimal medical therapy alone in clinically representative patients.

Wheatley K et al. *N Engl J Med* 2009; 361:1953

ASTRAL

"In a post hoc subgroup analysis, …no significant difference in the primary outcome [was found] between 163 patients with severe anatomical disease (103 patients with bilateral renal-artery stenosis of more than 70% and 60 patients with renal-artery stenosis of more than 70% in a single functioning kidney) and patients without such severe anatomical disease (p = 0.23)"

ASTRAL Investigators. N Engl J Med 2009;361:1953

CORAL

Cardiovascular Outcomes In Renal Atherosclerotic Lesions

National Heart, Lung, and Blood Institute

CORAL

- *Aim:* multicenter, randomized, unblinded, two-arm trial to test whether medical therapy with stent placement of hemodynamically significant ARAS in patients with refractory systolic HTN reduces the incidence of adverse CV and renal events compared **with optimal medical therapy alone. Enrollment spring 2005; expected to be completed in 2007 – Study completion by 2011**
- *Inclusion criteria:* history of refractory stage II hypertension defined as a SBP greater than 155 mmHg while taking two or more antihypertensive medications
- *Primary endpoint:* event-free survival from CV and renal adverse events, defined as a composite of CV or renal death, stroke, MI, hospitalization for CHF, progressive renal insufficiency, and need for permanent renal replacement therapy.
- *n =* ~1000 — 100 sites, mainly North America

• Selection of Patients for Treatment of ARAS

- Is renal artery disease causing hypertension?
- Severity of hypertension
- Specific type of renal artery disease and threat to renal function
- General medical condition of patient
- Relative efficacy and risk of medical antihypertensive therapy, PTRA/stent, and surgical revascularization

Anatomic Presence of ARAS is ***NOT*** a Mandate for Intervention

Primary Hyperaldosteronism

- Found to be increasingly common in patients with severe or resistant HTN
- May account for 5% of all hypertensives
- Reported in different series to be present in up to 38% of patients with resistant HTN

Primary Hyperaldosteronism

- Autonomous secretion of aldosterone from the adrenal cortex
- Elevated aldosterone levels result in suppression of renin levels
- Increased aldosterone results in sodium retention, HTN, loss of potassium in the urine, hypokalemia, metabolic alkalosis

Primary Hyperaldosteronism

- Conn's Syndrome - Unilateral adrenal adenoma
- Bilateral Adrenal Hyperplasia
- Important to distinguish between these 2 causes as the treatment of the conditions differs

Diagnose Hyperaldosteronism

- Make a biochemical diagnosis before imaging
- Ratio of aldosterone: renin > 30:1
- Plasma aldosterone level > 15
- 24 hr urine aldosterone elevated

- Low or normal K levels
- Metabolic alkalosis

- If biochemical evidence, need imaging study to assess adenoma vs bilateral hyperplasia (CT abdomen)

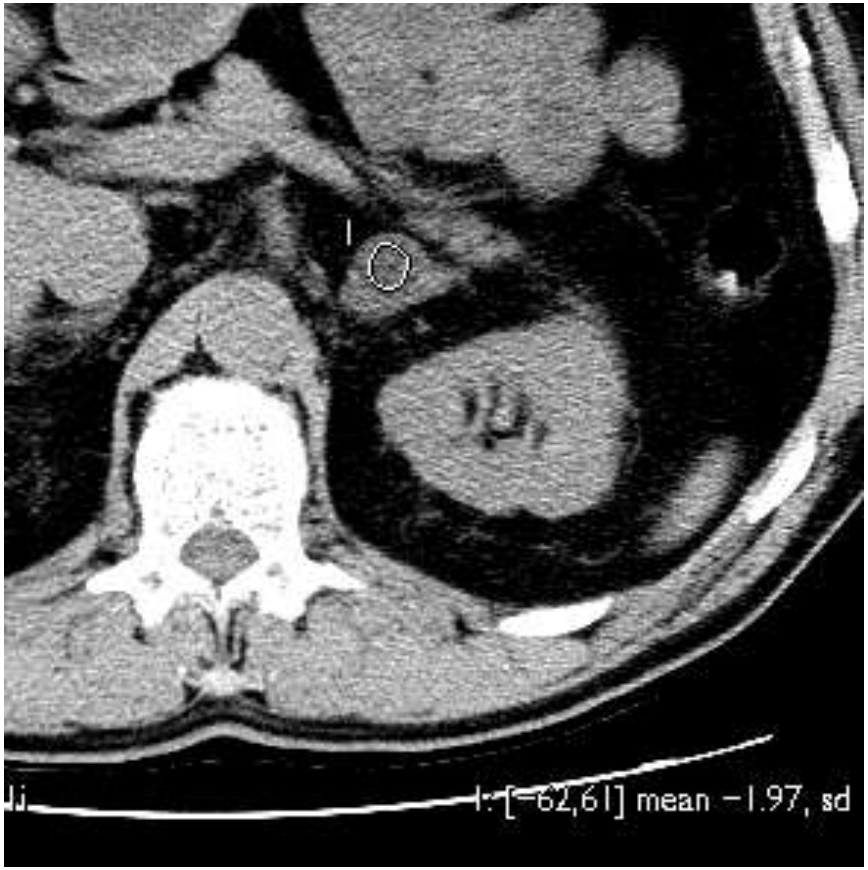
Conn's Syndrome

- Unilateral adrenal adenoma
  - Specific appearance on CT scan due to increased fat content (<10 Hounsfield units)

- Treat surgically in most patients
  - Laparoscopic adrenalectomy
  - Adrenal Vein Sampling prior to surgery to confirm lateralization

- Can treat medically in mild cases, elderly or poor surgical candidates

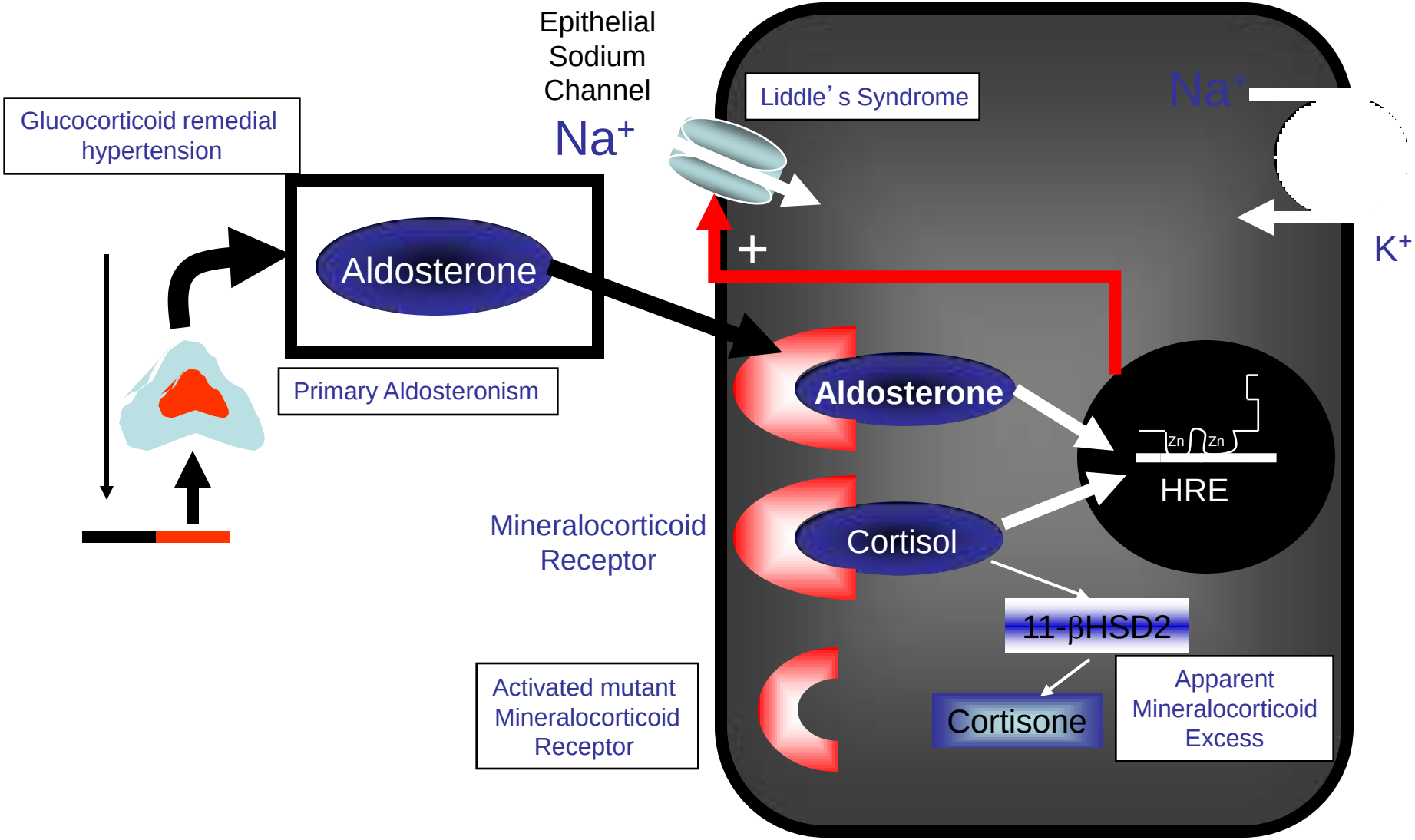
Adrenal Adenoma



Bilateral Adrenal Hyperplasia

- CT abdomen: Bilateral Thickening or nodularity of Adrenal limbs
- Always treat **medically**
- **No role for surgery**
- Use aldosterone inhibiting drug: Aldactone, Eplerenone, Amiloride

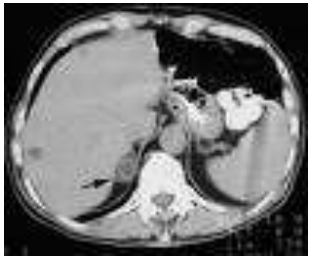
Primary Aldosteronism



Primary Hyperaldosteronism

- Spironolactone - need to use high doses usually in the range of 50-100mg twice daily
- Is NOT tolerated by male patients
- Eplerenone - less potent but definitely less gynecomastia and less hyperkalemia
- Amiloride - well tolerated, occasionally GI side effects can use up to 10 mg twice daily, problem amiloride only comes in 5 mg tablets

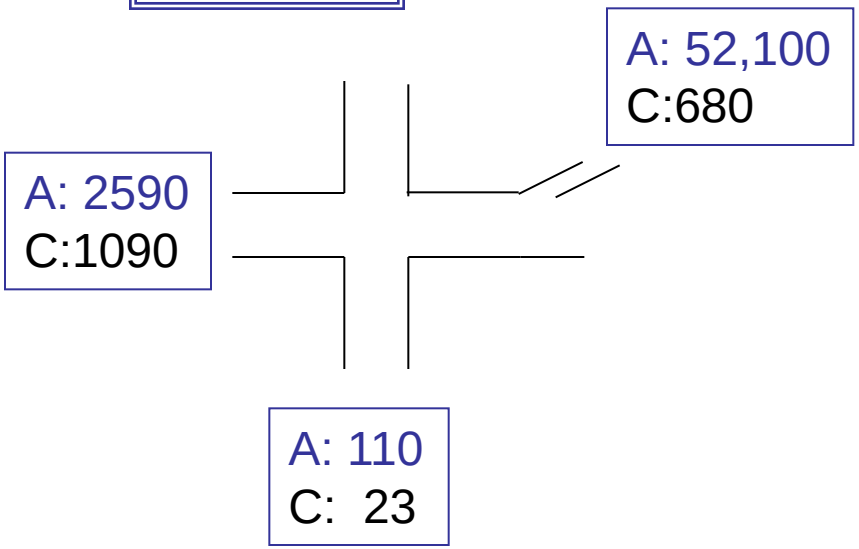
IMAGING



SAMPLING

Lateralization index (LI) =
ipsilateral A/C ratio [ng/dL/mcg/dL]
over contralateral A/C ratio: 76/2.5=31

MAPPING



Selectivity index (SI) = ratio of cortisol level in each adrenal vein compared with IVC.
Right 1090/23 = 47
Left 680/23=30

AVS Results

	Aldo	Cortisol	Ratio
R adrenal	2590	1090	**2.5**
L adrenal	**52 100**	**680**	**76**
IVC	110	23	4.7

Primary Hyperaldosteronism

- More common than previously thought
- Worthwhile screening patients particularly with severe or resistant hypertension
- Potential cure of HTN

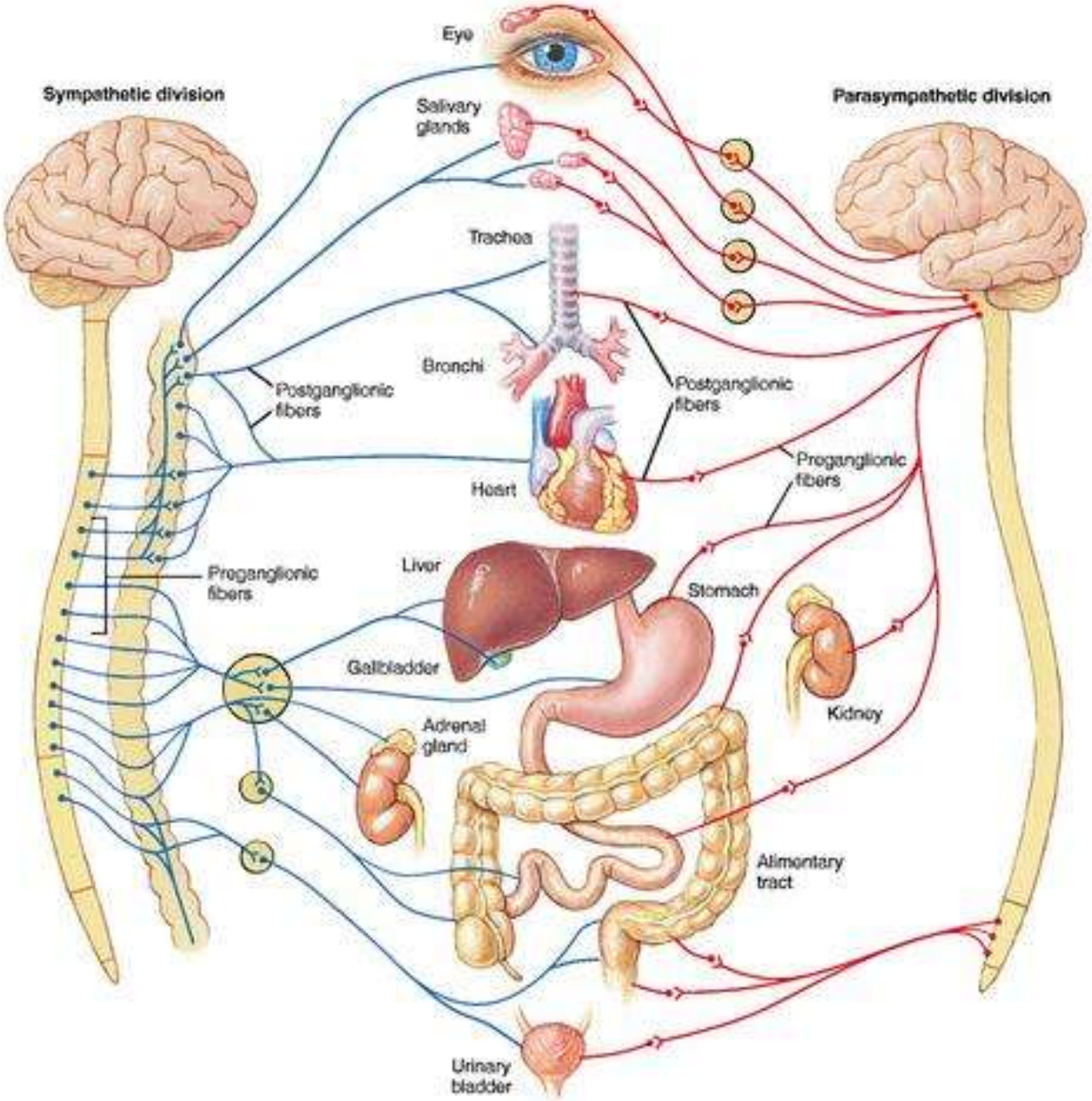
Pheochromocytoma

- Rare cause of hypertension
- Approximately 800 new cases diagnosed annually in the United States
- Penn: 30-40 new cases per year and 70-100 patients in follow up per year

Autonomic nervous system

- Innervates vascular and visceral smooth muscle, exocrine and endocrine glands, and parenchymal glands throughout the organs

- Two divisions
  - Sympathetic chain, includes the adrenal medulla
  - Parasympathetic ganglia


Eye
Sympathetic division
Parasympathetic division
Salivary glands
Trachea
Bronchi
Postganglionic fibers
Postganglionic fibers
Preganglionic fibers
Heart
Preganglionic fibers
Liver
Stomach
Gallbladder
Kidney
Adrenal gland
Alimentary tract
Urinary bladder

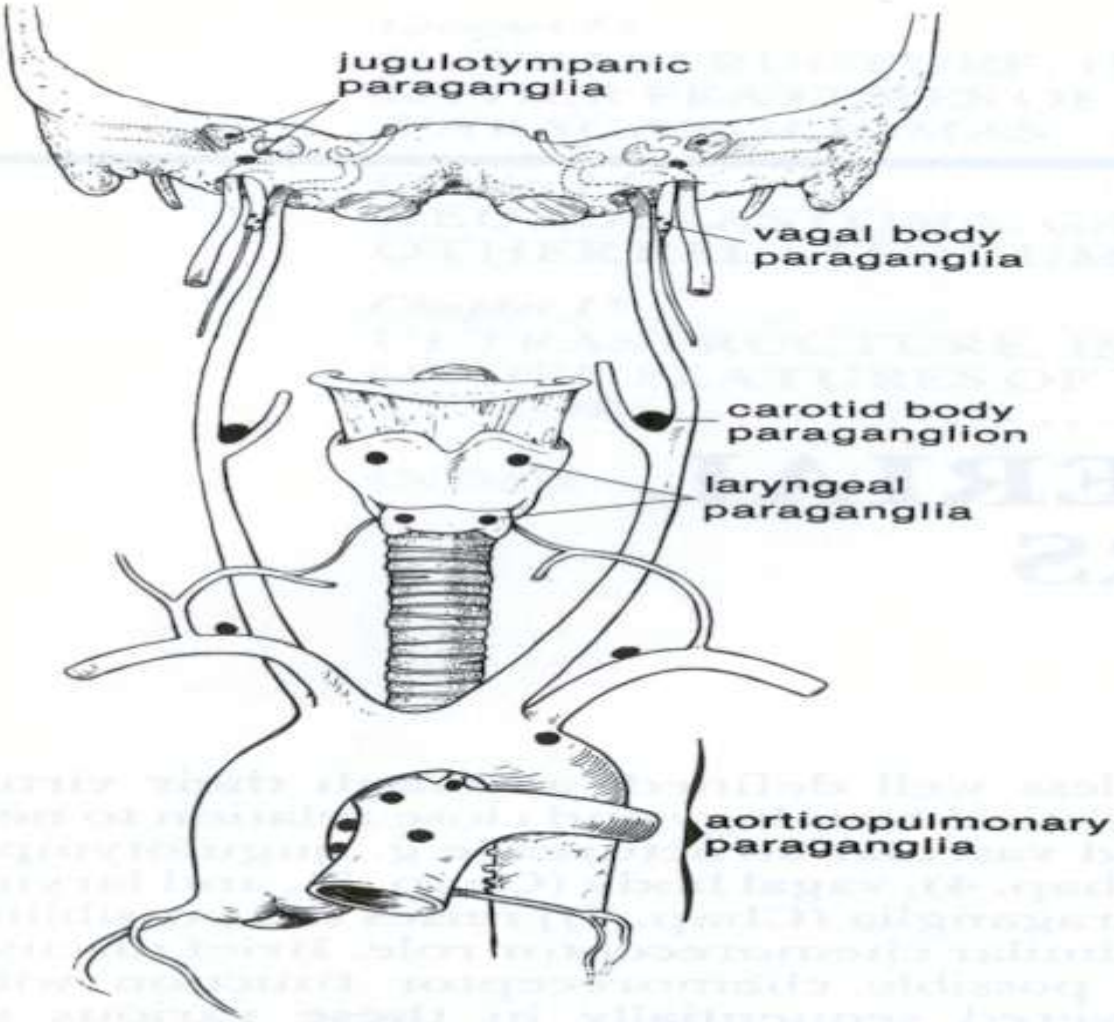
Tumors of the Autonomic Nervous System

- **Adrenal medulla**
  - **Pheochromocytoma**

- **Sympathetic chain**
  - Sympathetic paraganglioma – usually located retroperitoneal, but can be found in abdomen or thorax, usually secrete catecholamines
    - Usually termed **extra adrenal pheochromocytoma**

- **Parasympathetic ganglia**
  - Parasympathetic paraganglioma usually in the head and neck region, generally biochemically silent
    - **Glomus tumors, chemodectomas, carotid body tumors**

Sites of Paraganglionomas



Pheochromocytoma

- Chromaffin cells are derived from the neural crest which function as post-synaptic nerve cells
- Unregulated growth of chromaffin cells results in the development of pheochromocytomas which can occur in the adrenal gland or in an extra-adrenal location
- Norepinephrine (NE) is converted to epinephrine (E) in the adrenal medulla
- Pheo - Increased catecholamine secretion
- NE is predominantly excreted and causes intense stimulation of alpha receptors

Pheochromocytoma

- Alpha receptors are stimulated resulting in hypertension, tachycardia, palpitations and headaches
- Not all patients have these classic symptoms
- BP can be labile
- Rare cause of hypertension

Pheochromocytoma

- Previously “10%” tumor

- 90% of lesions are found in the adrenal gland
- 10% extra-adrenal (paraganglionomas)
- 10% bilateral
- (10%) 20-30% malignant
- 30-40 % genetic in origin

Metabolic Pathway

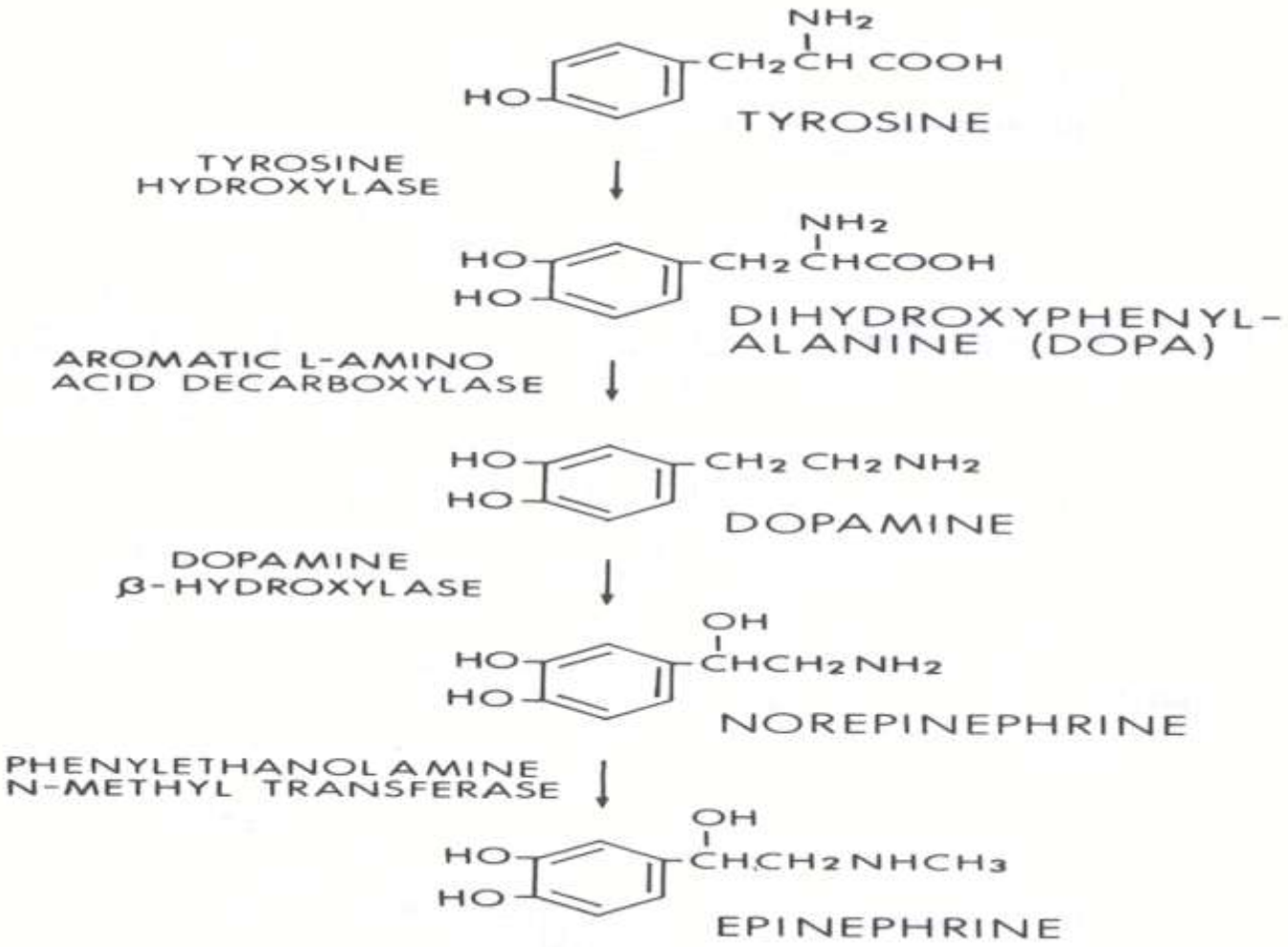
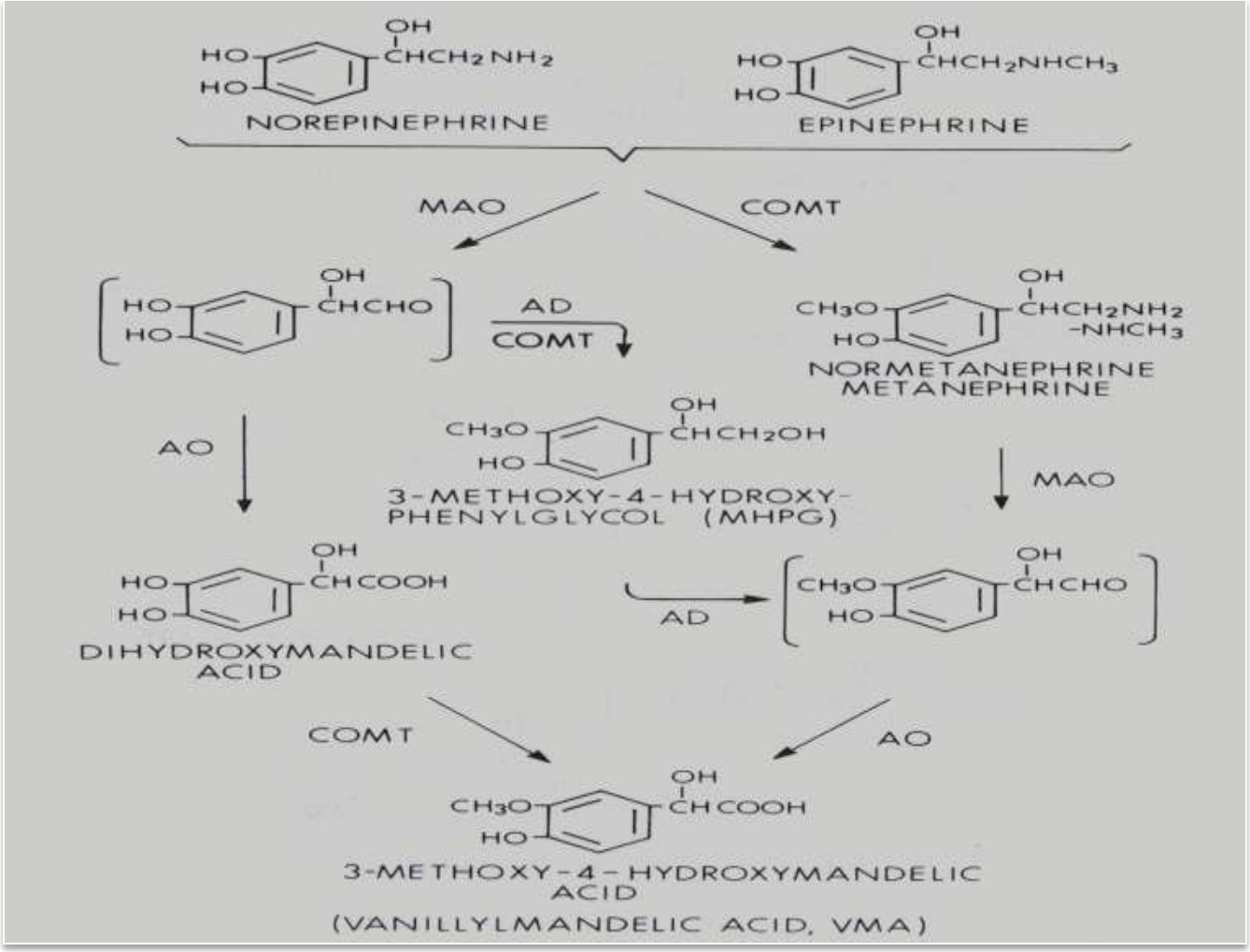


FIG. 1. Catecholamine biosynthesis.

Metabolic Pathway



Diagnosis of Pheochromocytoma

- Plasma metanephrines **(BEST SCREENING TEST)**
- 24 hour urine for catecholamines, metanephrines, VMA
- Values are usually 3-4 x greater than normal
- If borderline values and strong clinical suspicion, can pursue further testing

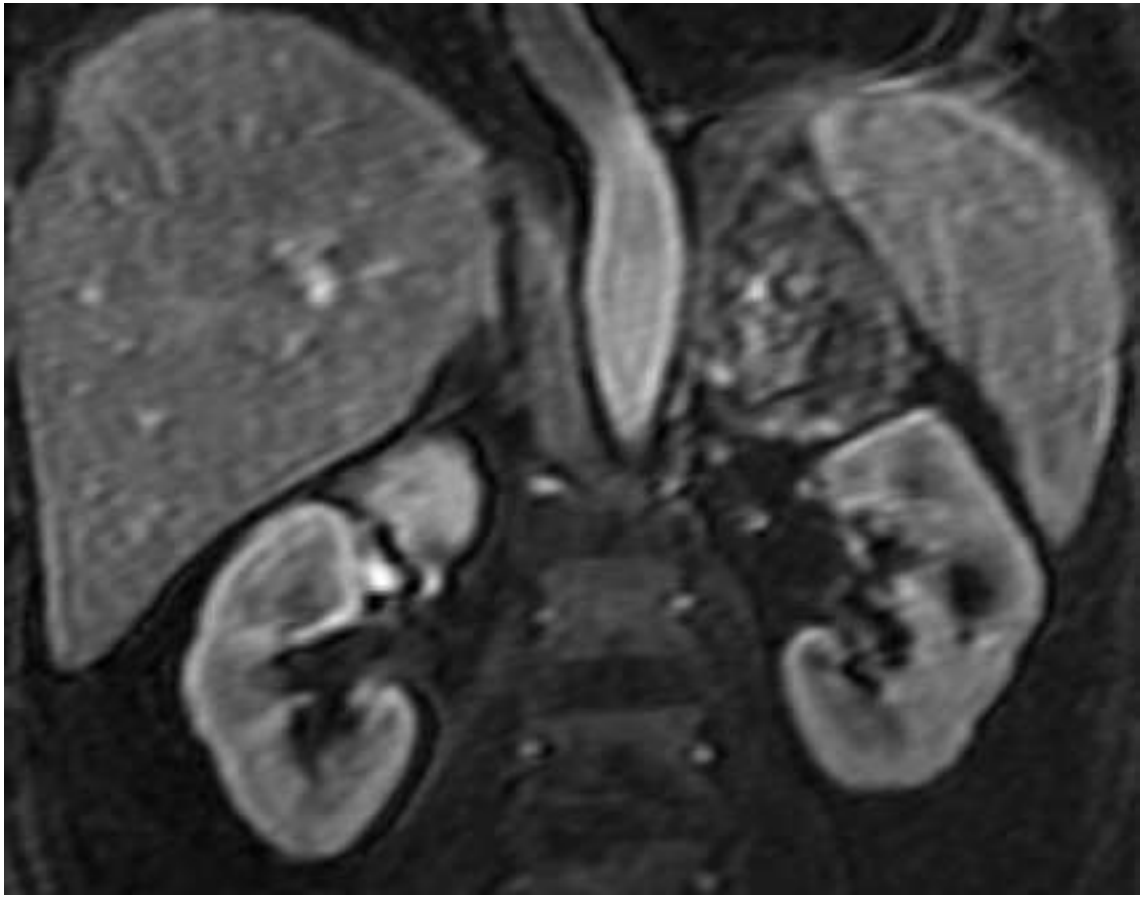
Screening for pheo in dialysis patients

- Cannot measure 24 hr urines
- Plasma catecholamines have been shown to consistently elevated in HD patients but never more than 3-fold (Mayo)
- Plasma catecholamine levels are inversely elevated with decreasing renal function
- Study from NIH showed **plasma free metanephrines** are relatively independent of renal function and more suitable for diagnosis of pheochromocytoma among patients with renal failure or in dialysis patients

Biochemical Testing

	Hereditary	Spontaneous
	sensitivity/specificity	sensitivity/specificity
Plasma Met	97/96	99/82
Plasma Cat	69/89	92/72
Urine Met	96/82	97/45
Urine Cat	79/96	91/75
Total Urine Met	60/97	88/89
VMA	46/99	77/86

MRI upper abdomen



Genetic syndromes with Pheo/PGL

Syndrome	Gene	Chr	Major component	Other manifestations
PGL 1*	***SDHD***	11q23	PHEO or PGL	--------
PGL 2*	Unknown	11q13	PGL	--------
PGL 3	***SDHC***	1q21-23	PGL	--------
PGL 4	***SDHB***	1p36	PGL	Renal clear cell cancer
Carney triad	Unknown		PHEO	Gastric leiomyosarcoma Pulmonary chondroma Adrenal adenoma
Familial PGL and gastric stromal sarcoma	Unknown		PGL	Gastric stromal sarcoma
VHL	*VHL*	3p25-26	PHEO	Hemangioblastomas (brain, spine, retina) Renal clear cell cancer Pheochromocytoma
MEN 2	*RET*	10q11.2	PHEO	Medullary thyroid carcinoma Parathyroid hyperplasia
NF 1	*GNDF*	17q11	PHEO	Neurofibromas, café-au-lait spots Lisch nodules Plexiform neurofibromas Malignant peripheral nerve sheath tumors

Carotid body tumors

- In 1987 reported that people living in the Andes had an increased incidence of carotid body tumors (1987)
- High altitude causes chronic hypoxia
- Report from 1970s showing that patients in the Andes with carotid body tumors had increased succinate levels
- In 2000 linkage studies from families in the Netherlands in with apparent pheo/PGL syndromes showed mutations in the SDH complex

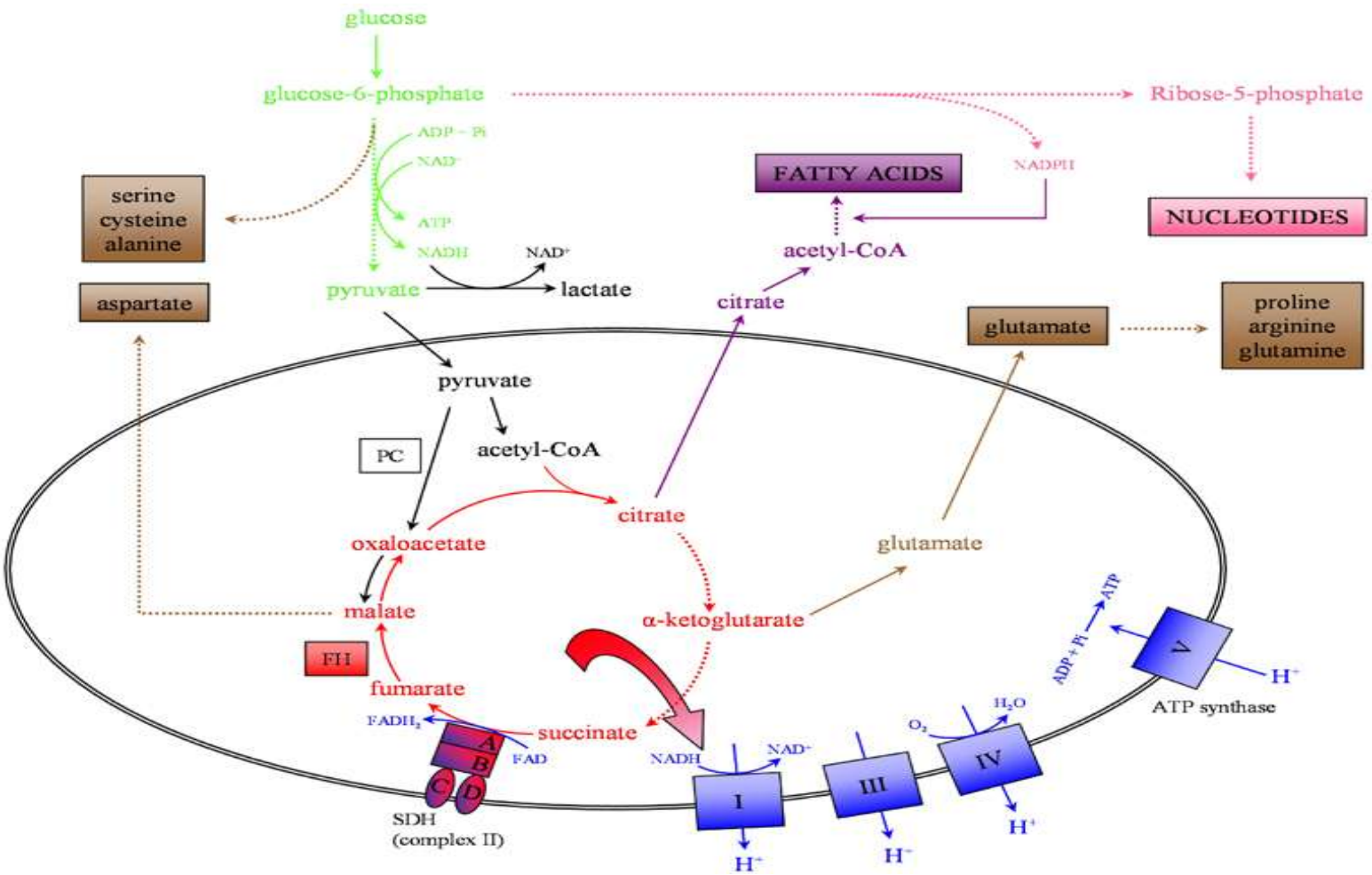
Familial pheo/PGL

- Succinate dehydrogenase (SDH) catalyzes the conversion of succinate to fumarate in the Krebs cycle

- Succinate dehydrogenase (SDH) or mitochondrial complex II is comprised by four subunits (A–D) in the inner mitochondrial membrane

- SDH subunits are encoded by autosomal genes

SDH complex


glucose
glucose-6-phosphate
Ribose-5-phosphate
ADP + Pi
NAD+
ATP
NADH
NAD+
pyruvate
lactate
serine
cysteine
alanine
aspartate
FATTY ACIDS
NADPH
NUCLEOTIDES
acetyl-CoA
citrate
glutamate
proline
arginine
glutamine
pyruvate
PC
acetyl-CoA
citrate
oxaloacetate
glutamate
malate
α-ketoglutarate
FH
fumarate
FADH2
succinate
FAD
A
B
C
D
SDH
(complex II)
NADH
NAD+
I
H+
III
H+
O2
H2O
IV
H+
ADP + Pi
ATP
V
H+
ATP synthase

- Germline heterozygous mutations in SDHD were found to cause familial and apparently sporadic pheochromocytoma/PGL (2000)
- Subsequently, germline heterozygous mutations in SDHB and SDHC were also found in heritable pheo and PGL
- Recent mutations identified in SDHA
- SDHB mutations have been associated with malignancy, decreased survival and renal cell carcinoma

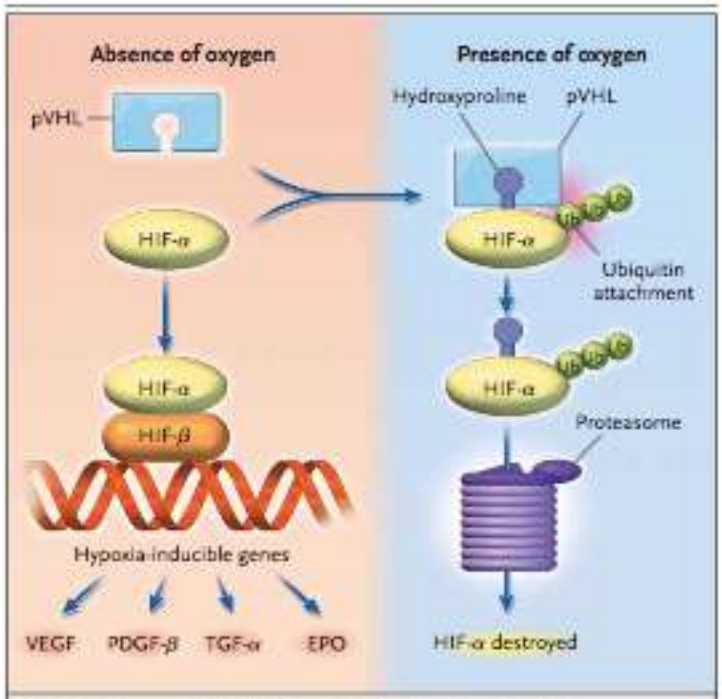
What is the Difference SDHB/C/D PGL

Familial PGL Syndrome	**PGL1**	**PGL3**	**PGL4**
SDH subunit	**SDHD**	**SDHC**	**SDHB**
Mutation in gene locus	11q23	1q21	1p35-36.1
	Baysal 2000	Niemann 2000	Astuti 2001

What is the Difference SDHB/C/D PGL

	SDHD	SDHC	SDHB
Chest/abdomen/pelvis	++	+	**+++**
Adrenal	++	+	**+**
Extra-adrenal	+	+	**+++**
multifocal	+	_	**++**
malignant	rare	_	**+++**
Head/Neck	+++	+++	**++**
multifocal	+++	_	**+**
malignant	Rare	Rare	**Rare**

Using von-Hippel Lindau as a model to connect HIF and VEGF



Control of Hypoxia-Inducible Factor (HIF) by the Gene Product of the von Hippel–Lindau Gene (pVHL).

HIF is a heterodimer consisting of an α subunit and a β subunit. In the presence of oxygen, HIF-α is hydroxylated on one of two proline residues. The pVHL binds to hydroxylated HIF-α and directs the attachment of a polyubiquitin chain, which targets HIF-α for destruction by a multiprotein complex called the proteasome. Under hypoxic conditions, or in the absence of pVHL, HIF-α accumulates and activates the transcription of hypoxia-inducible genes. VEGF denotes vascular endothelial growth factor, PDGF-β platelet-derived growth factor β, TGF-α transforming growth factor α, and EPO erythropoietin.

Genetic Testing

Consider genetic testing in sporadic pheochromocytoma if age at diagnosis < 50 for mutations in

VHL, *RET*, *SDHD*, *SDHB*

using the patient's findings and table below as a guide

Syndrome	Gene	Average age of diagnosis	Adrenal disease	Multifocal adrenal disease	Extra-adrenal disease	Predominant biochemical profile	Mutation frequency
MEN 2	*RET*	35-40	++	++	-	Metanephrine	low
VHL	*VHL*	20-30	++	++	+	Normetanephrine	high
SDHB	*SDHB*	20-30	+	-	++	Unknown	low
SDHD	*SDHD*	20-30	+	+	++	Unknown	medium

Pheo/PGL

- The diagnosis and management of both adrenal and extra-adrenal pheos remain a diagnostic challenge
- Plasma metanephrines best screening test
- Levels greater than 4X normal definite pheo
- Refer all patients for genetic testing
- SDHB/SDHD mutations increasingly common
- Future challenges remain in treatment for metastatic disease and predicting who will have a poor outcome

Who to work up for secondary HTN

- All young patients (<30yrs)
- New onset hypertension in older patients >70 years
- Sudden worsening of previously well controlled hypertension
- Strong suspicion for secondary HTN
- Negative family history for HTN
- Unusually severe HTN

Who to work up for Secondary HTN

- Unprovoked hypokalemia
- Triad of symptoms: headache, sweating and palpitations
- Epigastric bruit (RAS)
- Different BP measurements in the arms and legs or radiofemoral pulse delay
- Drug resistant hypertension

Initial Evaluation for Secondary HTN

- Plasma Renin
- Serum aldosterone
- Plasma metanephrines
- CT angiogram / MRA
- Sleep study

Conclusion

- Secondary Hypertension accounts for 10% of hypertension
- Need to decide which patients are worthwhile to evaluate for secondary hypertension
- If diagnosis is confirmed, may be potentially curative form of HTN especially in a young patient