

# ***HYPERTENSIVE*** **JEOPARDY!**

**Banner's Favorite Quiz Show®**



# Consequences: PGY-1

Which of the following are consequences of hypertension?

- A. Retinal hemorrhages
- B. Lacunar infarcts
- C. Renal artery stenosis
- D. Peripheral arterial disease
- E. All of the above

# Consequences

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# Consequences of Hypertension

## Brain:

- Cerebral aneurisms
- Retinal hemorrhage
- Atherosclerosis
  - lacunar infarcts
  - vascular dementia

# Consequences of Hypertension

## Cardiovascular:

- Myocardial hypertrophy
  - Diastolic heart failure
- Atherosclerosis
  - Thrombotic and embolic events
    - MI
    - Renal artery stenosis
    - CVA
    - Peripheral arterial disease

# Consequences of Hypertension

## Renal:

- Arteriolosclerosis
- Atherosclerosis
- Fibrinoid necrosis – thrombotic microangiopathy

## Causes – PGY 2

How frequently can secondary causes of hypertension be found in patients?

- A. 10% of the time
- B. 30%
- C. 50%
- D. 90%

# Causes

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B. 30%

C. 50%

D. 90%



# Major Causes of Hypertension

• Essential	90%
• Renal disease	3%
• Renovascular disease	2%
• Birth control pills	2%
• Primary aldosteronism	2%
• Coarctation of the aorta	0.2%
• Pheochromocytoma	0.1%
• All others	0.5%

# Classification PGY - 3

A 57 year old woman comes to the office for evaluation. Her CV risk is  $<10\%$ . She has no medical problems. Her BP is 132/70. Classify and recommend treatment for her hypertension.

- A. Elevated blood pressure – lifestyle modification
- B. Stage 1 hypertension - lifestyle modification
- C. Stage 1 hypertension – lifestyle modification and drugs
- D. Stage 2 hypertension – lifestyle modification and drugs

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# Classification of Hypertension

## ACC/AHA

Elevated BP: 120-129/80

Stage 1: 130-139/80-89

Stage 2: >140/90

# Treatment of Hypertension

ACC/AHA: if 10 year CV risk <10%

Elevated BP: 120-129/80 (lifestyle modification)

Stage 1: 130-139/80-89 (lifestyle modification)

Stage 2: >140/90 (lifestyle modification + drug)

If BP 20/10 above BP target, 2 first line drugs

# Classification PGY - 1

A 57 year old woman comes to the office for evaluation. She has Her CV risk is  $>10\%$ . She has hyperlipidemia, hypertension, and is a smoker. Her BP is 134/73. Classify and recommend treatment for her hypertension.

- A. Elevated blood pressure – lifestyle modification
- B. Stage 1 hypertension - lifestyle modification
- C. Stage 1 hypertension – lifestyle modification and drugs
- D. Stage 2 hypertension – lifestyle modification and drugs

# Classification PGY - 1

A 57 year old woman comes to the office for evaluation. She has Her CV risk is  $>10\%$ . She has hyperlipidemia, hypertension, and is a smoker. Her BP is 134/73. Classify and recommend treatment for her hypertension.

- A. Elevated blood pressure – lifestyle modification
- B. Stage 1 hypertension - lifestyle modification
- C. Stage 1 hypertension – lifestyle modification and drugs
- D. Stage 2 hypertension – lifestyle modification and drugs

# Treatment of Hypertension

ACC/AHA goals in special populations:

CV disease or 10 year CV risk >10%: 130/80

Heart failure: <130/80

Intracerebral hemorrhage: 130/80

DM: 130/80

CKD: 130/80



# Treatment – PGY 2

45 year old African American woman with a history of HTN and diabetes comes to the office for evaluation.

PE is normal. VS: 142/78 80

BMI 32

SH: non-smoker

Medication: metformin

Labs: creatinine 0.8, potassium 4.0, urine microalbumin 28mg/g

In addition to lifestyle changes, which of the following management strategies are best?

- A. Only lifestyle changes
- B. Add lisinopril
- C. Add chlorthalidone
- D. Add carvedilol

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# Pharmacologic Therapy

## General population

- Thiazide
- CCB
- ACE-I/ARB

## Black population

- Thiazide
- CCB

# Pharmacologic Therapy - special populations

## CKD 4 or greater

- Consider loop rather than thiazide

## Patients already on ACE-I or ARB

- Use caution with potassium – sparing diuretics that work (spironolactone, eplerenone, amiloride)

## Proteinuria

- ACE-I/ARB
- Non-dihydropyridine CCB (diltiazem)

## Pregnancy

- Avoid ACE-I/ARB

# Treatment – PGY 3

50 year old woman with a history of HTN and strong family history of DM asks for ways to reduce her risk of developing diabetes.

PE is normal. VS: 124/78 76

BMI 22

Medications: lisinopril and amlodipine

Labs: A1c 5.8%, UMA 50mg/g creat

Which of the following changes can reduce her risk of developing diabetes?

- A. Weight loss
- B. Low fat diet
- C. Move the lisinopril to bedtime
- D. Add chlorthalidone

# Treatment

50 year old woman with a history of HTN and strong family history of DM asks for ways to reduce her risk of developing diabetes.

PE is normal. VS: 124/78 76

BMI 22

Medications: lisinopril and amlodipine

Labs: A1c 5.8%, UMA 50mg/g creat

Which of the following changes can reduce her risk of developing diabetes?

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- D. Add chlorthalidone

# Treatment

2012 pts with HTN randomized to take BP meds in morning or at night.

- Improved overnight BP
- Lower incidence of DM2 (0.43 hazard ratio)
- (possible RAAS activation at night results in hepatic glucose release and decreased insulin sensitivity)

# Treatment – PGY 1

48yo man with HTN, CKD, hyperlipidemia comes for routine office visit.

Meds: metoprolol, hctz, atorvastatin

PE: 142/84 66 BMI 29.  
Exam otherwise normal

Which is the most appropriate management?

- A. Target SBP <120
- B. Target SBP <130
- C. Target SBP <140
- D. No change in management.



# Treatment – PGY 1

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Meds: metoprolol, hctz, atorvastatin

PE: 142/84 66 BMI 29.  
Exam otherwise normal

Which is the most appropriate management?

- A. Target SBP <120
- B. Target SBP <130
- C. Target SBP <140
- D. No change in management.

## Treatment – PGY 2

65yo woman with HTN but no other cardiovascular risk factors comes for routine office visit.

Home BP average 156/62

Meds: none

PE: 158/70 70 BMI 28.

Exam otherwise normal

Which is the most appropriate management?

- A. Target SBP <130
- B. Target SBP <140
- C. Target SBP <150
- D. No change in management.

# Treatment – PGY 2

65yo woman with HTN but no other cardiovascular risk factors comes for routine office visit.

Home BP average 156/62

Meds: none

PE: 158/70 70 BMI 28.

Exam otherwise normal

Which is the most appropriate management?

A. Target SBP <130

B. Target SBP <140

C. Target SBP <150

D. No change in management.

# Treatment – PGY3

68yo man with HTN, CAD, hyperlipidemia comes for routine office visit.

He quit smoking 4 years ago, exercises and follows a low salt diet. Home BP average 135/76

Meds: metoprolol, hctz, atorvastatin, clopidogrel

PE: 142/84 66 BMI 29. Exam otherwise normal

Which is the most appropriate management according to the SPRINT trial?

- A. Target SBP <120
- B. Target SBP <120 if he demonstrates SBP >170 on stress echo
- C. Order 24hr ambulatory BP monitoring
- D. No change in therapy

# Treatment – PGY 3

68yo man with HTN, CAD, hyperlipidemia comes for routine office visit.

He quit smoking 4 years ago, exercises and follows a low salt diet. Home BP average 135/76

Meds: metoprolol, hctz, atorvastatin, clopidogrel

PE: 142/84 66 BMI 29. Exam otherwise normal

Which is the most appropriate management according to the SPRINT trial?

- A. Target SBP <120
- B. Target SBP <120 if he demonstrates SBP >170 on stress echo
- C. Order 24hr ambulatory BP monitoring
- D. No change in therapy

# Treatment

Patients with HTN but without DM randomized to SBP <140 vs <120mm Hg

- Lower incidence of MI, ACS, CVA, heart failure, death from cardiovascular causes in <120 mmHg group

# Treatment – PGY 1

35yo woman with a history of HTN and diabetes complains that she wants to reduce her pill burden.

Medications: lisinopril 20mg qd, amlodipine 5mg qd, metformin 500mg bid, vitamin D3 2000 iu qd.

BP 130/80 in the office

Home BP average 128/78

How do you advise her to maintain optimal BP control?

- A. Continue current management.
- B. Stop amlodipine and increase lisinopril to 40mg qd
- C. Stop lisinopril and increase amlodipine to 10mg qd.
- D. Stop amlodipine and monitor

# Treatment – PGY 1

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- C. Stop lisinopril and increase amlodipine to 10mg qd.
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A combination of 2 agents at moderate doses often works better than 1 medication at max dose



# Evaluation – PGY 2

35yo man with no medical history is noted to have a BP of 146/90 in the office. A friend took his BP at work recently and it was 155/92.

FH: HTN, DM2, father with MI at age 55

SH: no tobacco, 2 drinks/week  
PE normal. BP 146/90 HR 76  
BMI 24.

Which is the most appropriate methods to confirm HTN in this patient

- A. Home BP readings
- B. 24hr ambulatory BP monitoring
- C. Repeat in-office BP measurements over 5 days
- D. Plasma aldosterone-renin ratio

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# Treatment PGY 3

55yo woman with hyperlipidemia, hypothyroidism and longstanding difficult to control HTN here for evaluation of HTN. Home BP average 155/82.

Medications: telmisartan-hctz, nifedipine, atorvastatin, levothyroxine

SH: 1ppd tobacco, social EtOH

PE: 164/82, HR 76, BMI 34. Exam normal

Labs: Creatinine 0.8, K 3.8, TSH 2.5

According to the PATHWAY-2 trial, which is the most appropriate add on therapy?

- A. Lisinopril
- B. Doxazosin
- C. Spironolactone
- D. Bisoprolol

# Treatment – PGY 3

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# Treatment – PATHWAY 2 trial

Patients randomized to 12 weeks of spironolactone, bisoprolol, doxazosin or placebo.

Spironolactone superior to:

- Placebo (-8.7mmHg)

- Doxazosin and bisoprolol (-4.26mmHg)

- Bisoprolol (-4.48mmHg)

# Evaluation – PGY 1

65yo man with uncontrolled hypertension. Clinic BPs always above 140/90, and home BP readings 150s-170s/90s.

ROS: negative

Medications: lisinopril 40mg qd, nifedipine 60mg qd, and atenolol 100mg qd

PE: BP 165/95, HR 62

S4 gallop, no edema

Labs: creatinine 1.5, potassium 4.0, urinalysis normal

Which is the next best step in management?

- A. Check aldosterone:renin ratio
- B. Check renal artery dopplers
- C. Add chlorthalidone
- D. Add clonidine

Resistant HTN: Addition of a diuretic is needed before diagnosing a patient with resistant hypertension

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# Secondary HTN: Who Should Be Worked Up?

- Young patients (childhood or adolescence), especially without family history
- Resistant HTN
- Abrupt worsening of HTN
- Clinical features of disorder causing hypertension



# Clinical Patterns of Secondary HTN

- Renovascular HTN
  - Early <30 or late > 50 onset
  - Acceleration of treated HTN
  - Worsening renal function during HTN treatment
  - Flash pulmonary edema
  - Progressive renal failure
- Hyperaldosteronism
  - Hypokalemia, metabolic alkalosis (muscle weakness, cramps)
- Pheochromocytoma
  - Headache, sweating, tachycardia, anxiety, chest/abd pain, nausea/vomiting

# Secondary HTN: Classification

- Renal disease
- Renovascular HTN
  - Fibromuscular disease
  - Atherosclerotic disease
- Endocrine causes
  - Adrenal cortex
    - Primary aldosteronism
    - Pseudoaldosteronism
    - Cushing's syndrome
  - Adrenal medulla
    - Pheochromocytoma
  - Pituitary
    - Cushing's disease
    - Acromegaly
  - Thyroid (hypo/hyper)
  - Renin secreting tumors

# HTN from Renal Disease: epidemiology

- Most common cause of secondary HTN
- Hypertension eventually occurs in 85-90% of CKD patients

# HTN from Renal Disease: mechanism

- 80% - volume expansion is primarily responsible for HTN
- $\cong$  20% - increased renin release is important

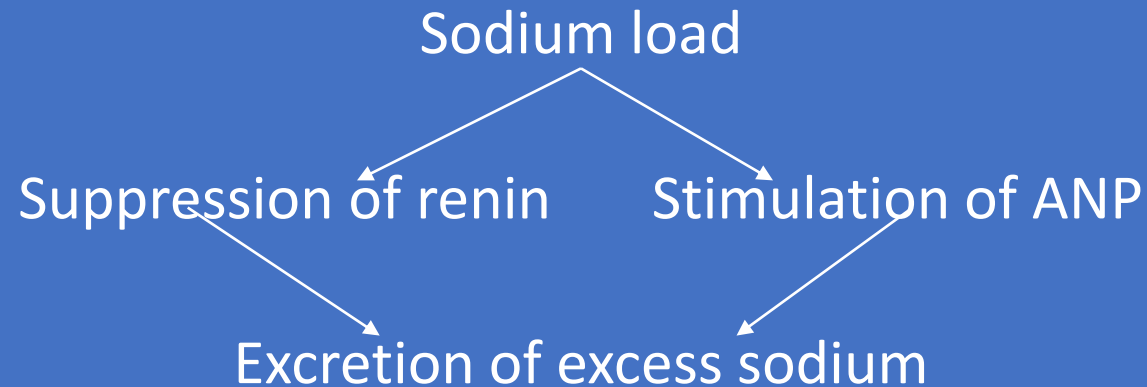
# HTN from Renal Disease: mechanism of renin-mediated HTN

- Primary vascular disease from vasculitis, hypertensive nephrosclerosis, or atherosclerotic renal artery stenosis
- Disordered renal architecture causing focal ischemia leading to increased renin release

(extrinsic and intrinsic renin stimulation)

# HTN from Renal Disease: Why does volume expansion occur?

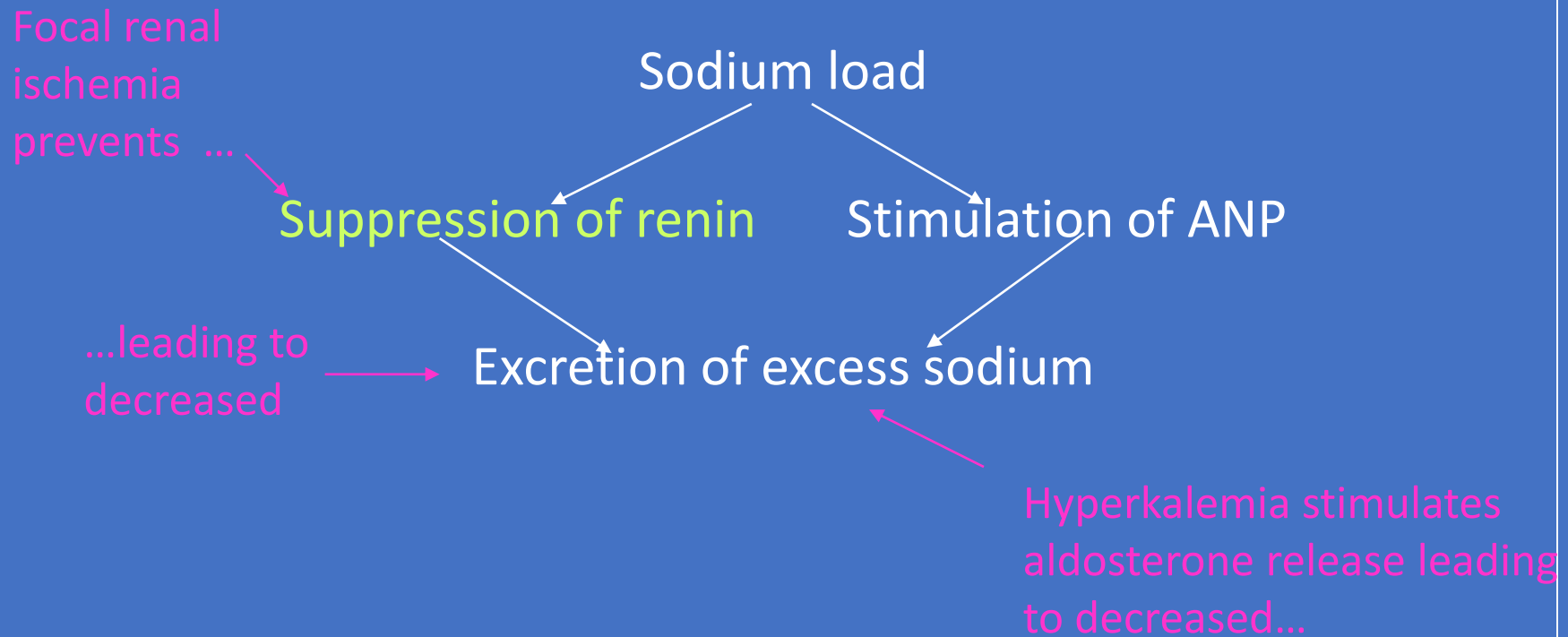
## Role of Pressure Natriuresis:



(this is important to maintain homeostasis; otherwise, we would become progressively volume overloaded)

# HTN from Renal Disease: Why does volume expansion occur?

## Role of Pressure Natriuresis in renal disease:



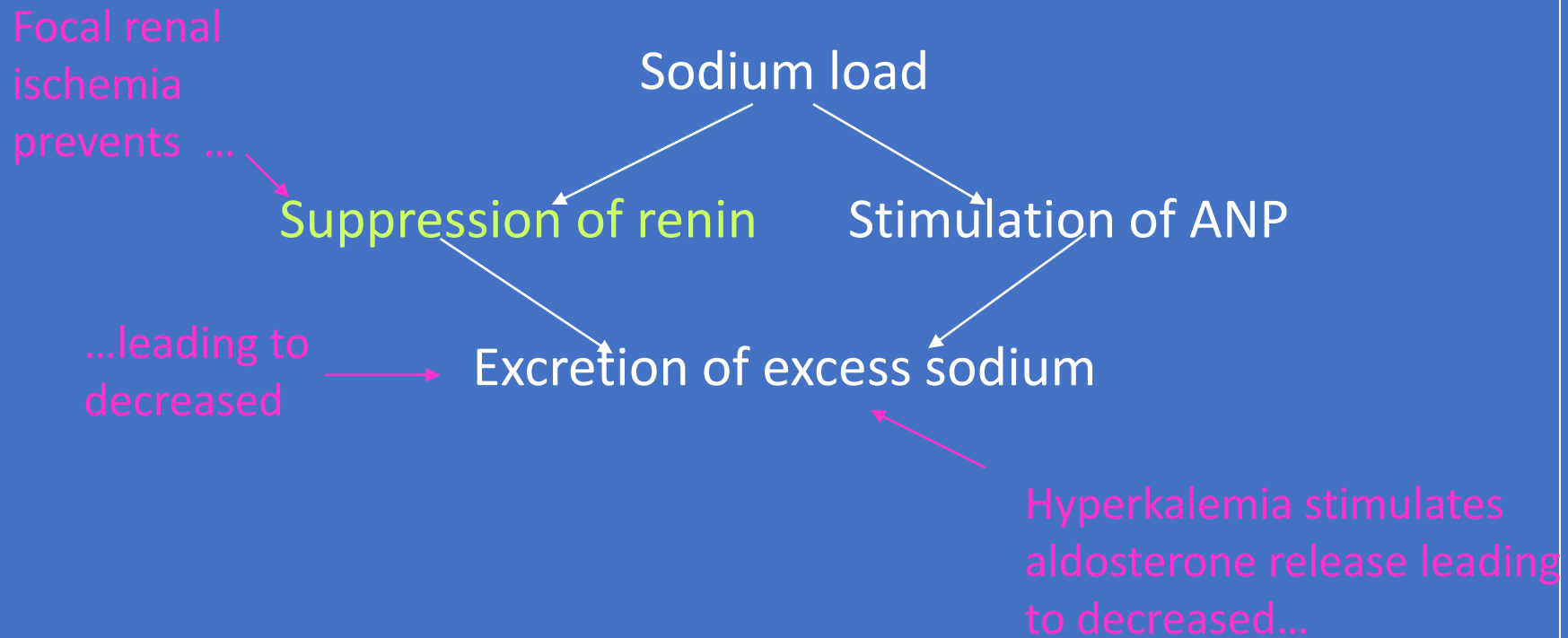
# Renal Disease: HTN is necessary for maintenance of homeostasis

- Decreased number of nephrons requires that each nephron secrete more sodium
- HTN leads to increased renal perfusion pressure which increases sodium excretion
- Thus, HTN is the “price paid” for preventing sodium accumulation



# HTN from Renal Disease: RAAS blockade and diuretics are needed to control BP

## Role of Pressure Natriuresis in renal disease:



# Hyperaldosteronism: Clinical Features

- Consider if unprovoked hypokalemia and metabolic alkalosis or resistant hypertension are present  
(though most patients lack hypokalemia)
- Solitary adenoma or bilateral adrenal hyperplasia

# Hyperaldosteronism:diagnosis

- Increased aldosterone-renin ratio (ARR): PAC/PRA of  $> 30$

AND

- PAC  $> 20\text{ng/dl}$

(can try to suppress aldosterone with volume expansion – i.e. 2L NS over 4hrs, or NaCl tabs 10g/day x 3 days)

- Sensitivity and specificity of 90% for diagnosis of aldosterone-producing adenoma
- Confirm with 24hr urine aldosterone  $> 12\text{mcg/day}$

# Hyperaldosteronism: workup/treatment

- CT scan with thin cuts through adrenal glands
- If unilateral adenoma in patient < 40 yrs old with hyperaldosteronism – surgical removal of adenoma indicated.
- If > 40 yrs old, more likely to have bilateral adrenal hyperplasia, → adrenal vein sampling to document unilateral secretion prior to surgery.
- 60-70% cure rate with laproscopic removal of adrenal gland

# Hyperaldosteronism: workup/treatment

- If CT negative – could consider adrenal vein sampling (many adenomas < 1cm)
- If unilateral secretion, consider surgery
- If bilateral adrenal hyperplasia, aldosterone blockade (spironolactone)
- Calcium channel blockers can help with blood pressure, but still need to replete K

# Pheochromocytoma: clinical features

- Chromaffin cell tumors of the adrenal medulla or extra-adrenal paraganglia
- Cause symptoms of excess adrenaline production
  - HTN
  - Autonomic disturbances (sweating, palpitations, HA)
  - Heightened anxiety
- Only occur in 0.5% of evaluated patients
- HTN can be sustained or paroxysmal
- Those with predominately epinephrine-secreting tumors may have low BP

# Pheochromocytoma: diagnosis

- Plasma free metanephrines has higher sensitivity and specificity than plasma or urinary catecholamines, urine metanephrines, and vanilylmandelic acid.
- In most cases, plasma free metanephrines elevated 2-4 fold.
- If levels only minimally elevated, repeat measurements of plasma metanephrines and check plasma catecholamines.

# Pheochromocytoma: diagnosis

- CT scan sensitive and specific for adrenal pheochromocytoma
- MRI superior for extra-adrenal pheochromocytomas
- Metaiodobenzylguanidine scanning has high specificity, can be used to confirm positive CT/MRI findings.



# Pheochromocytoma: treatment

- Surgical excision curative in 90% of cases.
- Preoperative blockade of catecholamine synthesis needed.
  - Phenoxybenzamine (alpha-adrenoreceptor blocker)
  - Subsequent addition of beta-blocker to oppose reflex tachycardia (avoid beta blockade alone – unopposed alpha activity)

# Renovascular Hypertension: clinical features

Clinical features	Essential HTN (%)	Renovascular HTN (%)
Duration < 1 year	12	24
Age of onset > 50	9	15
Family Hx of HTN	71	46
Grade 3-4 retinopathy	7	15
Abdominal bruit	9	46
BUN >20mg/L	8	16
Potassium <3.4	8	16
Urinary casts	9	20
Proteinuria	32	46

# Renovascular Hypertension: mechanism

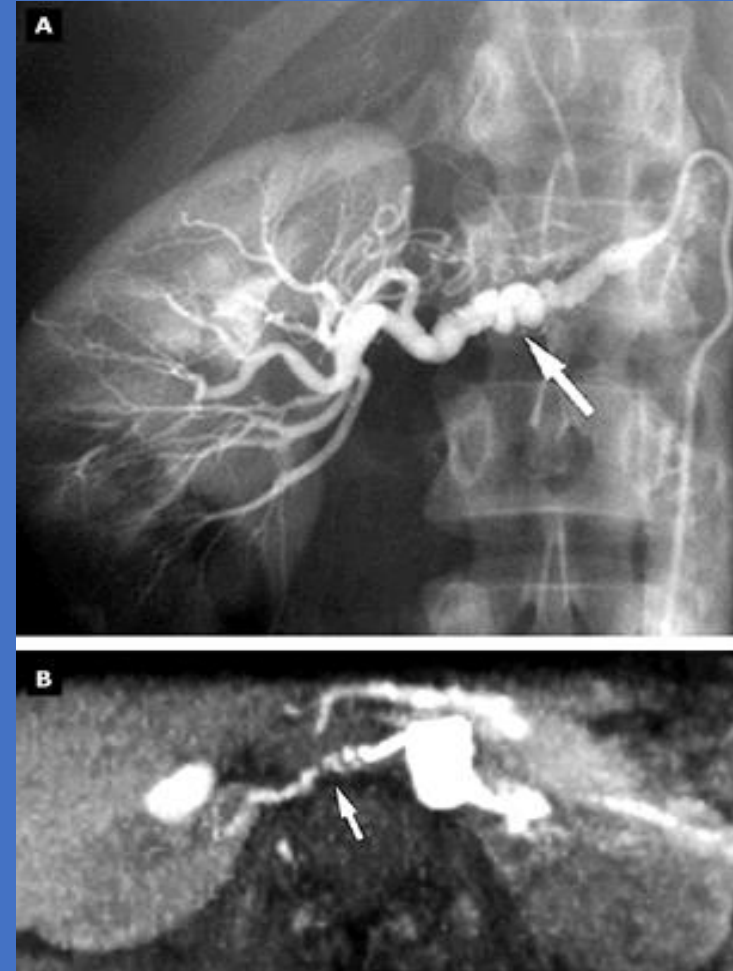
- Occurs in the setting of hemodynamically significant (at least 72-80%) unilateral or bilateral renal artery stenosis via:
  - Stimulation of renin-angiotensin system
  - Sodium retention leading to excess plasma volume

# Renovascular Hypertension: diagnosis

- Gold standard: angiography
- MRA less invasive but risk of nephrogenic systemic fibrosis if GFR <30 (and controversial (GFR 30-60))
- Risks associated with renal artery revascularization (bleeding, vessel dissection, branch occlusion, atheroembolic renal failure, MI, CVA, contrast nephropathy) make establishing diagnosis important.

# Renovascular Hypertension: Fibromuscular dysplasia - diagnosis

- Young women <50
- Affects carotid arteries (30%) and renal arteries (60%)
- Pathogenesis unclear ?hormonal
- HTN, TIA, Stroke



# Renovascular Hypertension: Fibromuscular dysplasia - treatment

- Young patients with fibromuscular dysplasia with HTN should be revascularized.
- Angioplasty successful, stent not needed.
- Surgery if angioplasty unsuccessful
- Need future monitoring with renal artery dopplers to monitor for recurrence/progression.

# Renovascular Hypertension: Atherosclerotic RAS - treatment

- Less clear whether or not revascularization will be helpful
- Coexistent essential HTN confounds diagnosis
- Angioplasty improves BP control in only 30%-50% of patients
- Renal function improves in 25%-29%, but deteriorates in 19-25%(arterioemboli).
- Antihypertensive therapy effectively controls BP in many patients with renovascular hypertension

# Features of Improvement in BP and Renal function after Revascularization

- Sudden acceleration of HTN or renal failure
- Size discrepancy
- Renal resistive index  $<0.8$  on ultrasound  
(RI = peak syst velocity – end diastolic velocity/peak syst velocity)
- Decrease in GFR on radionuclide scanning
- Increase in creatinine after ACE inhibitor
- Lateralization of renin secretion on renal vein renin sampling
- Increased gradient across stenosis at time of angiogram



# Secondary Hypertension – PGY 2

A 65-year-old woman is evaluated for resistant hypertension. Despite use of antihypertensive therapy for over 20 years, her blood pressure usually is approximately 160/90 mm Hg. For several years she has been taking amlodipine, 10 mg/d, and metoprolol, 100 mg/d. However, her regimen recently was changed to lisinopril, 20 mg/d, and sustained-release verapamil, 180 mg/d.

On physical examination, pulse rate is 68/min and blood pressure is 178/100 mm Hg. On cardiac examination, the point of maximal impulse is prominent and displaced laterally. The lungs are clear to auscultation. The remainder of the examination is normal.

# Secondary Hypertension – PGY 2

## Laboratory Studies

BUN 18 mg/dL

Creatinine 0.9 mg/dL

Sodium 147 meq/L

Potassium 3.3 meq/L

Chloride 100 meq/L

Bicarbonate 28 meq/L

An echocardiogram reveals increased left ventricular mass.

**Which of the following is the most appropriate next step in this patient's management?**

**A** Magnetic resonance angiography

**B** Hydrochlorothiazide, 25 mg/d

**C** Aldosterone–renin ratio

**D** CT scanning

# Secondary Hypertension – PGY 2

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**C** Aldosterone–renin ratio

**D** CT scanning

# Secondary Hypertension – PGY 3

A 68-year-old woman with a longstanding history of poorly controlled hypertension is evaluated for primary aldosteronism.

On physical examination, blood pressure is 176/105 mm Hg. Cardiac examination reveals an S3 gallop. The lungs are clear to auscultation.

Plasma renin activity is 0.06 ng/mL (0.06 µg/L) per hour and 24-hour urine aldosterone excretion is 18 µg.

An adrenal CT scan reveals a 1.5-cm solitary nodule in the left adrenal gland. The right adrenal gland appears normal but may be slightly enlarged.

Which of the following is the most appropriate next step in this patient's management?

A Laparoscopic left adrenalectomy

B Adrenal vein sampling for aldosterone and cortisol

C Renal arteriography

D Dexamethasone suppression test

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B Adrenal vein sampling for aldosterone and cortisol

C Renal arteriography

D Dexamethasone suppression test

# Secondary HTN – PGY 1

A 79-year-old man is evaluated for poorly controlled hypertension. He has had hypertension for 30 years, but his condition has become more difficult to control during the past 2 years. Over the last 6 months, his blood pressure measurements have ranged from 150/70 mm Hg to 170/90 mm Hg. Medications are atenolol, 50 mg/d; enalapril, 20 mg twice daily; and hydrochlorothiazide, 25 mg/d.

On physical examination, pulse rate is 66/min and blood pressure is 168/80 mm Hg; these results were the same on two previous office visits. Cardiac examination reveals a faint midline abdominal bruit and a left femoral bruit.

Creatinine level is 1.1 mg/dL, which has not changed for 2 years.

Low-density lipoprotein cholesterol level is 160 mg/dL.

# Secondary HTN – PGY 1

Which of the following is the most appropriate management at this time?

A Renal angiography

B Amlodipine

C Plasma renin activity measurement

D Renal vein renin sampling

E Magnetic resonance angiography of the renal arteries

# Secondary HTN – PGY 1

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B Amlodipine

C Plasma renin activity measurement

D Renal vein renin sampling

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# Secondary HTN – PGY 2

- A 64-year-old man with a history of coronary artery disease, peripheral vascular disease, chronic cigarette smoking, chronic kidney disease, and uncontrolled hypertension comes for a follow-up office visit. He was recently hospitalized for acute pulmonary edema. His estimated glomerular filtration rate is 45 mL/min.

Renal ultrasound performed during his hospitalization revealed a left kidney of 8.5 cm and a right kidney of 11 cm and increased echogenicity of the kidneys. He states that he has been compliant with his diet restrictions.

Medications are aspirin, 81 mg/d; simvastatin, 40 mg/d; carvedilol, 25 mg twice daily; furosemide, 40 mg twice daily; digoxin, 0.125 mg once daily; losartan, 100 mg/d; amlodipine, 5 mg/d; and clonidine, 0.2 mg twice daily.

# Secondary HTN – PGY 2

On physical examination, pulse rate is 62/min and blood pressure is 186/72 mm Hg. Cardiac examination reveals an S4 gallop. An abdominal bruit is heard. There is 1+ bilateral lower-extremity edema.

Which of the following is the most appropriate next step in managing this patient's hypertension?

- A Increase amlodipine to 10 mg/d
- B Perform magnetic resonance angiography of the abdomen (non-gadolinium protocol)
- C Discontinue carvedilol
- D Add lisinopril

# Secondary HTN – PGY 2

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# Hypertensive Emergencies and Urgency – PGY 3

56yo man presents to the emergency with dyspnea. He has not see a doctor in 20 years and is unaware of any medical history.

A. 10%

B. 20%

C. 30%

D. 50%

PE VS 220/113 87 O2 sat 85%

Bibasilar rales

CXR with pulmonary edema

What is the initial goal BP decrease for him?

# Hypertensive Emergencies and Urgency – PGY 3

56yo man presents to the emergency with dyspnea. He has not see a doctor in 20 years and is unaware of any medical history.

A. 10%

B. 20%

C. 30%

D. 50%

PE VS 220/113 87 O2 sat 85%

Bibasilar rales

CXR with pulmonary edema

What is the initial goal BP decrease for him?

# Hypertensive Emergency and Urgency

## Emergency:

- BP >180/120
- Associated with end-organ damage
  - Encephalopathy
  - Focal neurologic deficits
  - MI
  - CHF
  - AKI

## Urgency

- BP >180/120
- Not associated with end organ damage
- More gradual lowering ok

# Hypertensive Emergency

## General Treatment Goals:

- Decrease by 15-20% or DBP 100-110
- Nicardipine, labetalol, nitroprusside

## Hemorrhagic CVA

- BP 160/90 or MAP 110

## Ischemic CVA

- BP 185/110

## MI, Acute heart failure

- MAP 60-100

## Aortic dissection

- SBP 100-120