Learning Objectives

- Define diagnosis and types of hypertension with pharmacologic management.
- Describe when and how to use ambulatory blood pressure monitoring (ABPM) in pediatric patients.
- Recognize the role APRNs have in starting and implementing an ABPM program.

Classification of HTN

- Normal BP—average SBP and DBP less than the 90th percentile for sex, age, and height
- Prehypertension—average SBP or DBP levels that are greater than or equal to the 90th percentile, but less than the 95th percentile.
  - Adolescents with BP levels greater than or equal to 120/80 mmHg should be considered pre-hypertensive.
- Hypertension—average SBP and/or DBP that is greater than or equal to the 95th percentile for sex, age, and height on 3 or more occasions.
- White-coat hypertension—A patient with BP levels above the 95th percentile in a physician's office or clinic, who is normotensive outside a clinical setting (ambulatory BP monitoring is usually required to make this diagnosis).

Prevalence of HTN

- In the US childhood HTN and preHTN appears to be increasing
  - In part explained by increasing prevalence of obesity
- National Health and Nutrition Examination Survey (NHANES) data
  - Prevalence of prehypertension and hypertension significantly ↑ from NHANES III (88-94) to NHANES 96-08
  - In the continuous NHANES data there were independent associations with BMI, waist circumference, and salt intake
  - Risk of HTN doubles for every unit increase in BMI z-score (NHANES)
- Association between BMI and high BP seen even in early childhood

ETIOLOGY

- Hypertension in children can be categorized as essential/primary hypertension or secondary hypertension
Other Epidemiologic Risk factors

- Gender
  - M>F
- Family history (important in 1st HTN)
  - Up to 70-80% with primary HTN have a FHx
- Prenatal/neonatal factors
  - LBW and prematurity associated with risk of HTN in adolescence/adulthood

ESSENTIAL HYPERTENSION

- Multifactorial problem
- Increases with age
- Genetic Predisposition
- Racial Predisposition
- Prevalence varies with sodium intake
- Associated Risk Factors: Obesity, Smoking

SECONDARY HYPERTENSION

- Renal Parenchymal Disease (70-80%)
- Renovascular Disease (5-10%)
- Cardiac disease-Coarctation (2-5%)
- Endocrine Disorders (1%)

Use of ABPM in pediatrics

- Emerging data suggests that ABPM may be superior to clinic BP in predicting cardiovascular morbidity and mortality in adults. Therefore, ABPM is being increasingly used in the evaluation for HTN and risk of end-organ damage in children

Flynn et al, 2014

Ambulatory BP Monitoring

- Patient wears lightweight BP monitor that takes BP at regular intervals for 24 hr
- Readings are recorded by monitor and later downloaded to a personal computer
- Equipment available for use in children
- Validity confirmed in children

Ambulatory BP Monitors

- Portable blood pressure monitor is worn by the patient and records blood pressure over a 24 hour period
- Helpful in evaluating the patient with white-coat hypertension and those for whom more information on BP patterns are needed
- Multiple BP measurements taken at 20 minute intervals during the day and 30 minute intervals during sleep in a 24 hr period outside of clinical setting
Importance of utilizing ABPM in pediatrics

- Wuhl, et al (2004) completed a study which concluded that 1 in 5 children diagnosed with HTN by ABPM would have been missed with self measurement BP or clinic BP alone.
- ABPM is considered the gold standard for evaluation of both WCH and masked HTN
- ABPM eliminates white coat effect, problems with improper technique, and allows assessment of nocturnal BP

White Coat HTN (WCH)

- Definition: BP levels above the 95th percentile in a physician’s office or clinic in a patient who is normotensive outside a clinical setting.
- Transient stress response: “Physician pressor effect”
- Very common in children – although prevalence varies depending on what criteria used
- Less likely with increasing clinic BP

Masked Hypertension

- Defined as normal BP in the office but elevated BP outside of the office
- Only recently described in children
- Unlike WCH, masked HTN is associated with increased CV risk
- Associated with hypertensive target organ damage in children
- More prevalent in children with CKD

Nocturnal HTN

- Nocturnal hypertension has significant prognostic implications in certain patient populations, including children with CKD and DM
- May be found in patients with sleep disordered breathing
- More common after solid organ transplantation
Case study 1

- **TB** is a 15-year-old female with a history of diabetes mellitus diagnosed in February 2009. She was referred to Nephrology for high blood pressure readings, mostly 130s-140s systolic.
- **Vitals:** BP 128/82 | Pulse 100 | Ht 1.609 m (5' 3.35") | Wt 117.9 kg (259 lb 14.8 oz) | BMI 45.54 kg/m²
- **Blood pressure percentiles are 96% systolic and 96% diastolic based on the August 2017 AAP Clinical Practice Guideline. Blood pressure percentile targets: 90: 123/77, 95: 127/81, 95+12 mmHg: 139/93.** This reading is in the Stage 1 hypertension range (BP >= 130/80).

**Case study 1**

- **ROS:** negative
- **PMH:** Diabetes mellitus, Obesity, Precocious puberty
- **PSH:** none
- **Family History:** positive for heart disease in maternal grandmother. Negative for kidney disease, dialysis/kidney transplant, HTN, kidney stones, autoimmune disease, hearing loss

**Medication:** Insulin Lispro (HUMALOG KWIKPEN) 200 UNIT/ML, Insulin Degludec (TRESIBA FLEXTOUCH) 200 UNIT/ML, Aspirin‐Acetaminophen‐Caffeine (EXCEDRIN PO) PRN, ondansetron (ZOFRAN ODT) 4 mg tablet PRN

**Allergies:** Amoxicillin

**Physical Exam:**

- **GENERAL APPEARANCE:** alert, well appearing, in no acute distress, obese
- **SKIN:** no rashes, no petechiae
- **HEAD:** atraumatic, normocephalic
- **EYES:** lids and lashes normal, conjunctivae and sclera clear, pupils equal, round, reactive to light LOM full and intact
- **EARS:** no discharge, no cerumen, tympanic membranes normal
- **NOSE:** no discharge, no masses, normal
- **NECK:** supple without significant adenopathy
- **CHEST/BREAST:** symmetrical and normal in appearance, no masses or lesions noted
- **HEART:** normal S1 and S2, regular rate and rhythm, no murmurs, rub or gallops detected
- **VASCULAR:** warm and well perfused with normal pulses in the distal extremities
- **LUNGS:** clear to auscultation without rales or wheezes
- **ABDOMEN:** soft, nontender, nondistended, no hepatosplenomegaly, no masses, no bruit heard.
- **GENITOURINARY:** deferred
- **EDema:** no periorbital or peripheral edema noted
- **NEURO:** no sensory or motor deficits noted, alert

**Urinalysis:** + for moderate blood (pt on menstrual period), 40 ketones, 500 glucose, otherwise normal

**Labwork:** cbc: normal, cmp: normal electrolytes, bicarb and sCr 0.5 mg/dL

**Imaging studies:** Abdominal ultrasound:
- Kidneys: Normal in echogenicity, size, and corticomedullary differentiation. The right kidney measures 11.2 cm in length. The left kidney measures 12.0 cm in length. There is no focal abnormality or hydronephrosis in either kidney. Liver: Moderate hepatomegaly. No focal lesion is seen within the liver. Otherwise normal

**ABPM completed**
Case study #1 question

• What is the diagnosis?
  A. Masked Hypertension  
  B. Normal study
  C. Nocturnal hypertension
  D. White Coat Hypertension

Case study #1 treatment

• ABPM revealed nocturnal hypertension. Given patients history of obesity & snoring along with results of ABPM she was referred to pulmonology for sleep study, which confirmed sleep apnea. Now that her sleep apnea is being treated with CPAP, her hypertension improved.

Case Study #2

• DW is a previously healthy 14 year old male who presents today for evaluation of high blood pressure readings at his PCP’s office. Mom reports that his readings are usually 160-150s/80s when first coming into a clinic visit, and these usually come down to 140s systolic when he is leaving clinic visits. In addition, he recently had a urinalysis done that showed proteinuria, which triggered his referral to nephrology.

• Vital: BP 162/92 | Pulse 111 | Temp 37.2 °C (99 °F) | Ht 1.774 m (5’9.84”) | Wt 78.3 kg (172 lb 9.9 oz) | BMI 24.88 kg/m²

• Blood pressure percentiles are >99 % systolic and >99 % diastolic based on the August 2017 AAP Clinical Practice Guideline. Blood pressure percentile targets: 90: 129/80, 95: 134/84, 95 + 12 mmHg: 146/96. This reading is in the Stage 2 hypertension range (BP >= 140/90).

• ROS: negative
• PMH: none
• PSH: none
• Family History: mother and father have hypertension

Case study #2

• Medications: none
• Allergies: Cephalosporin and Penicillin
• Physical Exam:
  • General Appearance: alert, well appearing, in no acute distress
  • Head: atraumatic, normocephalic
  • Eyes: lid and lashes normal, conjunctivae and sclera clear, pupils equal, round, reactive to light, EOM full and intact
  • Ears: no ear pits/tags, no nasal congestion, lips normal with moist mucous membranes
  • Neck: no asymmetry, no masses, supple without significant adenopathy
  • Chest/Breast: symmetrical and normal in appearance, no masses or lesions noted
  • Lungs: no increased work of breathing, clear to auscultation without rales or wheezes
  • Heart: normal S1 and S2, regular rate and rhythm, no murmurs, rub or gallops detected
  • Vascular: warm and well perfused with normal pulses in the distal extremities
  • Abdomen: soft, nontender, nondistended, no hepatosplenomegaly, no palpable masses, no abdominal bruit
  • GU: normal
  • Neuro: no gross focal deficits noted, alert
Case study #2

- Urinalysis: normal, no protein noted on urine dip in nephrology
- Labwork: cbc: normal, cmp: normal electrolytes, bicarb and sCr 1 mg/dL, normal TSH
- Imaging studies: Renal ultrasound: 2 cysts are seen in the right kidney, otherwise unremarkable bilateral kidneys and bladder

Case study #2 question

- What is the diagnosis?
  A. Masked Hypertension
  B. Normal study
  C. Nocturnal hypertension
  D. White Coat Hypertension

Case study #2 treatment

- DW asked to follow up in one year with nephrology or PCP as white coat hypertension can lead to true hypertension in the future

Case study #3

- WD is a 13 year old male who was noted to have high blood post MVA in August 2017. He was initially referred to cardiology and was cleared in October 2018 after having a normal echocardiogram. Mom reports blood pressures are elevated at home
  - BP 114/58 | Pulse 96 | Temp 37.2 °C (99 °F) | Ht 1.684 m (5' 6.3") | Wt 47.1 kg (103 lb 13.4 oz) | BMI 16.61 kg/m²
  - Blood pressure percentiles are 60 % systolic and 30 % diastolic based on the August 2017 AAP Clinical Practice Guideline. Blood pressure percentile targets: 90: 126/77, 95: 131/81, 95 + 12 mmHg: 143/93.

Case study #3

- ROS: negative
- PMH: ADHD, anxiety
- PSH: none
- Family History: maternal grandmother has a history of hypertension
Case study #3

- Medications: amphetamine-dextroamphetamine (ADDERALL) 30 mg tablet daily, fluoxetine (PROZAC) 10 mg capsule daily, clonidine 0.3 mg tablet nightly at bedtime, fluticasone propionate (FLONASE) 50 mcg/act nasal spray PRN
- Allergies: none
- Physical Exam:
  - General Appearance: alert, well appearing, no acute distress
  - Skin: no rashes, no petechiae
  - Head: atraumatic, normocephalic
  - Eyes: lids and lashes normal, conjunctivae and sclera clear, pupils equal, round, reactive to light, EOM full and intact
  - ENT: no ear pitting, no nasal congestion, lips normal with moist mucous membranes
  - Neck: no asymmetry, no masses, supple without significant adenopathy
  - Chest/Breast: symmetrical and normal in appearance, no masses or lesions noted
  - Lungs: no increased work of breathing, clear to auscultation without rales or wheezes
  - Heart: normal S1 and S2, regular rate and rhythm, no murmurs, rub or gallops detected
  - Vascular: warm and well perfused with normal pulses in the distal extremities
  - Abdomen: soft, nontender, nondistended, no hepatosplenomegaly, no palpable masses, no abdominal bruit
  - Genitourinary: deferred
  - Edema: no periorbital or peripheral edema noted
- Urinalysis: normal
- Labwork: cmp: normal electrolytes, bicarb and sCr 0.73 mg/dL, normal TSH & T4
- Imaging studies: Renal ultrasound: normal study
- ABPM completed

Case study #3 question

- What is the diagnosis?
  A. Masked Hypertension
  B. Normal study
  C. Nocturnal hypertension
  D. White Coat Hypertension

Case study #3 treatment

- WD was started on Losartan 25 mg daily for treatment of masked hypertension

CONCEPTS OF PHARMACOLOGIC MANAGEMENT

- Indications for antihypertensive drug therapy in children include secondary hypertension and inadequate response to lifestyle modifications
- Goal for antihypertensive treatment in children is reduction of BP to <95
- Drug therapy should be initiated with a single drug
Angiotensin-Receptor Blockers (ARBS)

- **Action**: As an angiotensin II receptor antagonist, blocks the vasoconstrictor and aldosterone-secreting effects of angiotensin II
- **Benefits**: Renal & cardiac protective effect; few side effects; less likely to cause cough and angioedema than ACE-I; single daily dose
- **Risks**: anemia; decrease appetite; increase serum creatinine; hyperkalemia
- **Contraindicated in pregnancy (Black Box Warning)**
- **Agents include**: Losartan

Diuretics

- **Action**: Decrease plasma volume; decrease peripheral resistance
- **Benefits**: Inexpensive; counteracts high sodium intake; additive effect with ACE-I
- **Risks**: Hypokalemia; hyperuricemia; hyperlipidemia
- **Agents include**: Thiazide Diuretics (HCTZ); Furosemide (Lasix)

Calcium Channel Blockers

- **Action**: Vasodilatation secondary to inhibition of calcium influx
- **Benefits**: Can be used once daily
- **Risks**: Headaches; lower limb edema; cardiac problems
- **Agents**: Nifedipine; Amlodipine (Norvasc)

Adrenergic Blockers/Antagonists

- **Action**: Decrease peripheral resistance usually via a central effect
- **Benefits**: Second line drugs that are additive to all other agents; cardio protective; inexpensive
- **Risk**: hyperlipidemia; insulin resistance; worsen asthma; decrease exercise tolerance; depression
- **Agents include**: Propranolol; Atenolol; Labetalol

Angiotensin Converting Enzyme Inhibitors (ACE-I)

- **Action**: Inhibit the production of angiotensin II (vasoconstriction, aldosterone release)
- **Benefits**: Renal & cardiac protective effect; few side effects; single daily dose
- **Risks**: Cough; anemia; decrease appetite; increase serum creatinine; hyperkalemia
- **Contraindicated in pregnancy (Black Box Warning)**
- **Agents include**: Lisinopril, Enalapril

Angiotensin Converting Enzyme Inhibitors (ACE-I)

- Hicks et al (2018) completed a study of 992,061 patients newly treated with antihypertensive drugs between January 1, 1995 and December 31, 2015. The patients were followed until December 31, 2016.
- The study concluded the use of ACEIs was associated with an increased risk of lung cancer. The association was particularly elevated among people using ACEIs for more than five years.
- The study noted that additional studies, with long term follow-up, are needed to investigate the effects of these drugs on incidence of lung cancer.

Hicks et al, 2018
**Limitations of ACE-I study**

- Lacked information on other potential confounders such as socioeconomic status, diet, exposure to radon or asbestos, and family history of lung cancer
- Despite adjusting for smoking status, lacked detailed information on duration and intensity of smoking, which have been shown to be associated with lung cancer incidence
- Persistent cough is a common and well known side effect of ACEIs, raising the possibility that the observed association could be due to detection bias as patients taking ACEIs may be more likely to undergo diagnostic evaluations, such as CT of the chest, leading to an increased detection of preclinical lung cancers

  Hicks et al, 2018

---

**Role of the nurse practitioner in implementing an ambulatory blood pressure monitoring program**

- Order and learn how to use equipment
- Implement schedule and tracking system
- Create documents (diary, contract, instructions)
- Initialize monitors for each patient
- Teach patient and families proper technique for placement and documentation of events for 24 hours
- Implement templates in electronic medical record to interpret studies using most recent schema and bill appropriately
- Meet with electronic medical record team to find best way to store studies in patient charts so other providers have access
- Review results with patient and family at follow-up visit

---

**Barriers to implementing an ABPM program**

- Expense of equipment
- Patients keeping equipment for longer than expected
- Equipment maintenance (batteries, BP cuffs, belts)
- Revising documents appropriately

---

**Use of ABPM at our facility**

---

**References**