Pediatric Hypertension

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If you ask what is the single most important key to longevity, I would have to say it is avoiding worry, stress and tension. And if you didn't ask me, I'd still have to say it.

― George Burns

Learning Objectives:
1. Define “hypertension” in the pediatric patient and distinguish between elevated blood pressure, stage 1 hypertension, and stage 2 hypertension
2. Recognize which children and adolescents need regular blood pressure monitoring
3. Demonstrate proper technique for blood pressure measurement
4. Initiate an evaluation for secondary causes, comorbidities, and end-organ damage in the pediatric hypertensive patient
5. Design an effective management strategy for treatment of children and adolescents with hypertension

Primary Reference:

Included Resource:
1. Screening for Blood Pressure in Pediatric Primary Care. http://pcpc.yale.edu

Author’s note: The 2017 AAP Clinical Practice Guideline provides a comprehensive discussion of blood pressure cutoffs, terminology, and treatments. Clinicians will find it to be a useful reference during patient care: http://pediatrics.aappublications.org/content/140/3/e20171904

CASE ONE:

Hy P. Tennyson, a 15-year-old boy, comes into clinic for his school physical. He has no concerns, but his blood pressure is noted to be 138/88.

1. How do you define hypertension in kids?

There is a growing incidence of blood pressure elevation in children, in particular with the increased prevalence of obesity. Blood pressure measurement and treatment guidelines in children were defined in the 2017 AAP Clinical Practice Guideline and 2018 AAP Technical Report published in Pediatrics. The guideline classifies blood pressure as normal, elevated blood pressure, stage 1 hypertension, and stage 2 hypertension.

Normotension in children is defined as a blood pressure less than the 90th percentile for age, height, and sex for children under 13 years of age. For children 13 years of age and older, normal blood pressure is defined as less than 120/80. Blood pressure charts are available in the Practice Guideline on pages 9-14.

Elevated blood pressure is defined as a blood pressure, on repeated measurements, between the 90th and 95th percentiles (or any value above 120/80, even if less than the 90th percentile) for children under age 13. If older than 13, as long as diastolic is under 80, a systolic value of 120-129 is termed elevated blood pressure.

Hypertension is systolic blood pressure and/or diastolic blood pressure greater than the 95th percentile for age, height, and sex, measured on three separate occasions for children under age 13, and equal or greater than 130/80 for children 13 years and older. Stage 1 hypertension is greater than the 95th
percentile and less than 12 mmHg above the 95th percentile (or between 130-139/80-89 in children 13 years of age and older). Stage 2 hypertension is blood pressure greater than 12 mmHg above the 95th percentile for children under age 13, and greater than or equal to 140/90 for children 13 years of age and older. Hypertension cannot be diagnosed unless it is found on 3 separate occasions, though the work-up and treatment of symptomatic or severe (stage 2) hypertension should not be delayed for additional measurements on separate days.

A rough “rule of thumb” for blood pressure norms for children greater than 1 year of age is: normal SBP < (100 + 3*age in years), and normal DBP < (70 + 1.5*age in years), up to 120/80. This is a quick way to evaluate whether a child’s blood pressure is within normal limits, and reasonably accurate for a child of normal height. This method provides only an approximation, however, and any concerning blood pressure should be checked against the tables.

Criticisms of these definitions are prevalent, as they are epidemiologically based, and prospective research has yet to correlate them with end-organ damage or any outcome data in children. Long-term prospective studies are under development.

2. Should we be screening for hypertension in children?

The 2013 US Preventive Services Task Force (USPSTF) recommendations regarding screening for primary hypertension concluded that evidence is insufficient to assess the risk-benefit for routine blood pressure screening in asymptomatic children and adolescents. In a subsequent press release, the American Society of Pediatric Nephrology (ASPN) expressed concern that the above conclusion may discourage primary care physicians from screening. Indeed, even before the USPSTF guidelines were published, a study by Shapiro illustrated that blood pressure screening was done at only 67% of preventative visits. The ASPN urges primary care providers to interpret the USPSTF statement as not a recommendation to discontinue routine blood pressure screening in children, but rather a call that more evidence is needed to fully understand the treatment goals and long-term effects of blood pressure elevation. The 2017 Clinical Practice Guideline therefore recommends that blood pressure be screened yearly, beginning at the age of 3, and earlier in children with certain risks or exposures. Additionally, the guideline specifies that children 3 years of age and older with comorbidities including obesity, renal disease, history of coarctation of the aorta, diabetes, or taking medications known to increase blood pressure, should have their blood pressure checked at every healthcare encounter (rather than just at annual health maintenance).

Notably, because normal blood pressure in children varies based on age, height, and sex, providers may have difficulty identifying blood pressure measurements as abnormal at the point of care. Hansen and colleagues demonstrated the under-recognition of pediatric hypertension. In a large cohort of children and adolescents, only 26% of patients meeting criteria for hypertension or prehypertension (based on blood pressure measurements documented in the medical record) were actually identified as having an abnormal blood pressure. These findings were confirmed by Brady, et al., who additionally found that delayed recognition was more common in children who were not obese, lacked family history of cardiovascular disease, or had blood pressures that were not obviously elevated (less than 120/80). Being seen by a “less experienced” provider was also a predictor of under-recognition. More recently, in 2016, Nambam, et al. demonstrated under-recognition of blood pressure elevation in a population of 9362 children with type 1 diabetes. Elevated blood pressure measurements were recorded in the medical record in consecutive visits in 4% of these children, however hypertension was diagnosed in only 1% of these patients. Likewise in 2016, Kaelber, et al. found that only 23.2% of children with 3 or more visits with blood pressure elevation were diagnosed with hypertension, and only 5.6% of these patients were prescribed anti-hypertensive medications.

This under-recognition of blood pressure elevation has led to a key action statement within the AAP guideline, “organizations with EHRs used in an office setting should consider including flags for abnormal BP values both when the values are being entered and when they are being viewed.”

3. How do you measure blood pressure? Demonstrate on a colleague, talking through all of the necessary details of proper measurement.
Proper technique for measurement of blood pressure is essential, but can be tricky in children. Blood pressure should be taken with a correctly-sized cuff; the cuff should span at least 40-50% the length of the humerus, from acromion to olecranon, and the bladder should encircle 80-100% of the arm circumference (although many pediatric nephrologists recommend always using a cuff with a bladder that completely encircles the arm). Too large a cuff will not falsely lower blood pressure to the same extent that too small a cuff will falsely elevate it. Therefore, if uncertain about the appropriateness between two cuffs, the Clinical Practice Guideline suggests choosing the larger of the two. Automated blood pressure cuffs can be used for screening, but if there is any concern for elevation, the blood pressure should be confirmed through manual auscultation. In infants, Doppler may be used or systolic blood pressure may be palpated, if necessary.

In an ideal world, the blood pressure would be taken in a patient who had not had any stimulant drinks or food, who has been sitting quietly for five minutes with back supported and feet on the floor, with the right arm supported at heart level.

The systolic blood pressure is indicated by the first Korotkoff phase (K1), the onset of “tapping.” The diastolic blood pressure is indicated by the fifth Korotkoff phase (K5), which is disappearance of sounds entirely as flow through the brachial artery becomes turbulence-free once again. If pulsatile sounds do not disappear entirely by 0 mmHg, the onset of muffling [the fourth Korotkoff phase (K4)] should be used as the diastolic blood pressure.

4. What, if any, further evaluation does Hy require at this visit?

Start by rechecking the blood pressure manually, double-checking cuff size, and using proper technique. A diagnosis of hypertension requires an elevated blood pressure on three separate occasions. Ambulatory blood pressure monitoring (ABPM), usually arranged by pediatric hypertension specialists, can be used as a method of confirming hypertension prior to further work-up. The patient wears a portable blood pressure cuff for 24 hours, and blood pressure measurements are taken every 15-30 minutes in the patient’s regular environment. However, ABPM is not always easily available or tolerated by young children, so an alternative can be having the blood pressure taken by the school nurse twice weekly for 1-2 months. Prior to requesting school blood pressure monitoring, be sure to determine the correct cuff size and let the nurse know, so that the measurements are accurate. Interestingly, a study by Lo and colleagues found that the incidence of blood pressure elevation in their community based pediatric practice was actually lower than that reported in school-based studies. Therefore, ABPM, despite its limitations, is emerging as the most definitive method to assess blood pressure as it eliminates white coat effect, observer bias, and measurement error, and additionally, allows assessment of nocturnal measurements. Furthermore, the Clinical Practice Guideline suggests that school-based measurements (and likewise, home-based measurements if a home cuff were available for use) can be used as adjunct monitoring for patients with known blood pressure elevation, but that these should not be used to make or confirm a diagnosis of hypertension.

A detailed past medical, social, and family history is essential to check for the presence of secondary causes, comorbidities, and complications of hypertension. Birth history should focus on prematurity, low birth weight, maternal hypertension, or NICU procedures or complications. A dietary history should evaluate for high amounts of salt, total fat, unsaturated fat, or caffeine; providers should be comfortable assessing not just for salt added at the table or kitchen but for salt in processed food and restaurant/fast food. Psychosocial history should assess for sources of stress and anxiety in the child’s life, including bullying at school, and at ages over 12 should also assess for smoking, alcohol, or other substance use. Additional history can be aimed at eliciting information on prior urinary tract infections and symptoms of OSA, on other medications or drugs (consider athletic supplements, over-the-counter medications, prescribed stimulants, contraceptives, NSAIDs, “energy” drinks, and alternative medicines/supplements), and on familial cardiovascular, renal, or endocrine disease.

Physical exam should include height, weight, and BMI. Vital signs may reveal tachycardia or increased pulse pressure. Physical exam should also include auscultation for diastolic abdominal bruits, observation for stigmata of genetic diseases or other secondary causes, and a search for evidence of end-organ damage (including funduscopic examination) and comorbidities. Blood pressure in both arms and one leg should be done to rule out aortic coarctation. Leg blood pressure is normally 10-20 mmHg more than the arm blood pressure.
higher than arm, and can be measured by palpation, auscultation, or Doppler. Be sure to use a large enough cuff, as described above. For more specific signs on exam, the moderator can refer learners to table 14 on page 26 of the Clinical Practice Guideline.

CASE continued:

| Hy’s height is 50th percentile, his BMI is 31 (116% of the 95th percentile), and his mom has had high blood pressure for years. Otherwise his history and exam are completely unremarkable. His blood pressure is persistently in the range of 130s/80s over several office visits and in the ambulatory setting. |

5. What is your leading diagnosis for the cause of Hy’s hypertension? What are some less likely causes? What further work-up will you pursue at this point?

Hypertension in a medical setting that is normalized when in a routine setting, known as white coat hypertension, is common, and can be confirmed with ABPM, as noted above.

Essential hypertension, or primary hypertension, is becoming increasingly common among children and adolescents, especially in constellation with metabolic syndrome and insulin resistance. A review by Flynn highlights that children with obesity have a high incidence of blood pressure elevation, making hypertension one of the more common health conditions in children and adolescents. Essential hypertension is usually Stage 1. Children may be overweight or have a family history of hypertension or cardiovascular disease. The practice guideline addresses this, stating that children over 6 years of age who have a positive family history of hypertension or are overweight or obese, as long as they have no positive history or physical examination findings, can have a focused evaluation and do not require an extensive evaluation for secondary causes of hypertension.

Hypertension secondary to an underlying pathologic process is more common in children under 6 years. Secondary causes should be especially considered when the blood pressure is higher (i.e., stage 2 hypertension), and when history or physical exam suggest an underlying cause. Secondary causes of hypertension include renal disease (e.g., reflux nephropathy or renal dysplasia, glomerulonephritis, structural renal disease such as polycystic kidney disease, or renovascular disease such as renal artery stenosis), cardiovascular disease (patent ductus arteriosus, anemia, or aortic coartation), endocrine disease (e.g., hypo/hyperthyroidism, congenital adrenal hyperplasia, Cushing’s syndrome, or pheochromocytoma), environmental exposures, medications or drugs (including steroids, stimulants, oral contraceptives, cocaine, caffeine, and over-the-counter medications such as pseudoephedrine, NSAIDs, and athletic “nutritional” supplements), or sleep apnea/sleep-disordered breathing.

Table 11 on page 20 of the Clinical Practice Guideline provides a summary of steps to consider according to level of blood pressure.

Once hypertension is confirmed, the Clinical Practice Guideline recommends obtaining basic screening labs in all patients. These include electrolytes, BUN, Cr, and urinalysis with microscopy. In addition, the guideline recommends a lipid panel (fasting or non-fasting) to screen for dyslipidemia as a co-morbidity. A renal ultrasound (with Doppler if available) is also recommended on all patients under age 6, or with an abnormal urinalysis, abnormal renal function, and/or stage 2 hypertension to screen for renal scarring, asymmetry, or congenital disease, as well as renovascular disease. The guideline recommends getting an echocardiogram (not an electrocardiogram) at the time of initiating pharmacotherapy to look for evidence of end-organ damage that will impact treatment and monitoring goals. If the history and physical are concerning for overweight/obesity, appropriate screening for insulin resistance and liver disease can be added.

If there is a strong concern for a secondary cause of hypertension, additional testing might include drug screen, sleep study, plasma renin and aldosterone concentrations, more advanced renovascular imaging, CBC, thyroid function testing, plasma metanephrines (testing for pheochromocytoma), and plasma and urine steroid levels to assess adrenal hormone pathways. Specific testing will vary based on age, severity, and the history and physical examination.

6. How will you treat Hy?
Even normotensive kids should have a healthy diet, sleep, and regular physical activity. Children with elevated blood pressure and with Stage 1 hypertension (like Hy) should get counseling towards fostering a healthy lifestyle: physical activity and dietary education, including a visit to a nutritionist. The DASH diet (Dietary Approaches to Stop Hypertension), frequently used for adults (though with lack of firm evidence of efficacy in children), consists of increased fruits, vegetables, fiber, and low-fat dairy, while decreasing salt. Sodium restriction in children has proven to provide small benefits in blood pressure reduction. Likewise, for overweight individuals, calorie reduction through decreased portion sizes and elimination of sugary drinks (e.g., soda, juice) may be helpful. A decrease in BMI by 10% can lead to 8-12 mmHg decrease in blood pressure. It is worth emphasizing that exercise and weight loss independently lower blood pressure. Patients should avoid decongestants, caffeine, energy drinks, cocaine, steroids, and licorice root (which can have a mineralocorticoid effect, not present in “licorice” candies that do not contain true licorice) and receive smoking cessation counseling. Risk benefit discussions should be pursued in the case of stimulants and oral contraceptives, as well as other classes of prescribed medications that can elevate blood pressure.

Children with hypertension may participate in sports when the blood pressure has lowered to a safe range (i.e., below stage 2 hypertension), provided there is no evidence of end-organ damage. High-static sports are of highest concern.

CASE continued:

| 18 months later, Hy’s blood pressure remains elevated in the 130s/80s range. |

7. What would you do now?

Currently, pharmacologic treatment is recommended for kids with secondary hypertension, stage 2 hypertension, symptomatic hypertension, end-organ damage, diabetes or other cardiovascular or renal comorbidity, and/or persistent stage 1 hypertension despite the above lifestyle modifications.

Anti-hypertensives have not been compared directly to each other in pediatric patients, so choices should be made based on the patient’s underlying conditions and side effect profiles. Moderators can direct learners to the 2009 paper by Lande and Flynn for additional reading on a pharmacologic approach to the management of children and adolescents with hypertension. In essential hypertension, diuretics (primarily thiazides) are cheap, effective, and well-studied. Angiotensin converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARBs), and calcium-channel blockers would also be considered first line agents in pediatric essential hypertension. Thiazide diuretics are often effective in patients with primary renal disease, though ACE inhibitors and ARBs may be even more useful, if tolerated, as they can reduce proteinuria and progression of many chronic kidney diseases. Likewise, ACE inhibitors and ARBs are useful in renin-mediated hypertension, including reflux nephropathy/renal dysplasia, glomerulonephritis, as well as for patients with proteinuria/microalbuminuria and/or diabetes (though they are contraindicated in pregnancy, so use them cautiously in adolescent females). Renovascular disease may also result in renin-mediated hypertension, but ACE inhibitors and ARBs should be used with caution in these patients, because blocking renin’s downstream effects could result in renal ischemia. Additionally, ACE inhibitors, ARBs, and diuretics require periodic monitoring of serum potassium and creatinine, a week or two after starting or adjusting the medication and then several times in the first two years. Calcium channel blockers are also used as a first line agent in children, and may be a good choice for kids with migraine headaches. Of note, beta-blockers are relatively contraindicated in asthma and diabetes and heart rate reduction can be a dose-limiting side effect, especially in athletes. They are no longer considered first line agents, but may be considered as a second line choice or for certain pediatric populations.

CASE continued:

When you broach the idea of antihypertensive medication, Hy’s parents chime in “but he feels fine! Can we wait?”
8. Can they wait? What are the short- and long-term effects of hypertension?

Hypertension has both long- and short-term effects. Severe hypertension can cause encephalopathy, stroke, and end-organ failure in the short term, but this is not likely to happen to Hy. The long-term effects of hypertension include end-organ damage, including left ventricular hypertrophy (LVH), renal disease (hypertensive nephropathy), and retinal vascular abnormalities. Atherosclerosis has been found to start in childhood, and teens with hypertension have been found to have LVH, glomerular hyperfiltration (which can lead to glomerulosclerosis), and retinopathy.

Kids who have hypertension are more than twice as likely to have hypertension as adults, and half of adults with hypertension have a documented elevated blood pressure as kids. Hypertension in adulthood is associated with myocardial infarction (MI), stroke, renal failure, congestive heart failure, and increased mortality. Lewington and colleagues state that for adults, risk for cardiovascular death due to stroke, MI, or other vascular causes doubles with every 20/10 increase in blood pressure over 110/75.

There is limited long-term data regarding the effect of treatment of childhood and adolescent hypertension, and the effects of antihypertensive medications on developing children are not well understood. Therefore, the decision of exactly how and when to treat hypertension in children is complex and requires a balancing of the potential long-term consequences of untreated hypertension vs. the adverse consequences of likely long-term pharmacological therapy. Clinical judgment and the preferences of the family are important aspects of the decision to treat high blood pressure. Ultimately, the decision to delay pharmacotherapy must be individualized.

CASE TWO:

Hy’s little brother, Perry is a 6-month-old, born at 32 weeks gestation, coming in for a health maintenance visit. He is found to have a blood pressure of 110/80.

9. Should his blood pressure have been checked? What do you make of the value?

Neonatal hypertension was not specifically addressed in the Clinical Practice Guideline, but the article by Dionne (2012) is an excellent review with charts defining 95% confidence intervals according to birth weight, post-conceptual age, and gestational age for the first 12 months of life. The Clinical Practice Guideline recommends routine blood pressure screening in children less than 3 years of age in special circumstances such as prematurity, congenital heart disease, renal or urologic disease, family history of renal disease, or exposure to a medication, intervention, or systemic illness known to increase blood pressure or with adverse renal side effects.

Renal parenchymal disease (congenital anomalies, history of acute kidney injury), renovascular disease (such as history of umbilical artery catheterization), and coarctation of the aorta are some of the most important causes of hypertension in the newborn period. Neonates and infants with a history of bronchopulmonary dysplasia have a higher incidence of high blood pressure as well. Neonatal medications such as exogenous steroids, caffeine, and ophthalmic drops may elevate blood pressure too. Artifact is also common, due to incorrect blood pressure cuff size and nonstandard measurement circumstances (e.g., crying baby, lower extremity measurement). There are many less common causes of neonatal hypertension, including congenital adrenal hyperplasia; or increased intracranial pressure. The work-up is similar to that of older children, and generally includes renal function testing, urinalysis, and ultrasound with Doppler of the genitourinary tract. Other studies may be obtained if indicated by the history and physical and initial screens.

Additional References:

Resources:

Acknowledgment:
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