Talwalkar JS, Fenick AM. Evaluation of a Case-Based Primary Care Pediatric Conference Curriculum. *J Grad Med Educ*. 2011;3(2):224-231.

Week 41

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 prehypertension, 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:

1. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. Pediatrics. 2004;114(2): 555-76.
   (Focus on pages 555-562 and the tables in preparation for conference.)
   http://pediatrics.aappublications.org/cgi/reprint/114/2/S2/555

CASE ONE:

Uri Nei Chen, a 15-year-old boy, comes into clinic for his school physical. He has no complaints, but his blood pressure is noted to be 140/90.

1. How do you define hypertension in kids?

Blood pressure measurement in children was redefined in the 2004 recommendations from the American Academy of Pediatrics (AAP) Working Group. They used a system similar to that of the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7), a widely recognized guideline in adult medicine, published in 2003. The JNC-7 classified blood pressure as normal, prehypertensive, stage 1 hypertension, and stage 2 hypertension.

Normotension in children is now defined as a blood pressure less than the 90th percentile for age, height, and sex. Blood pressure charts are available in the national working group's Statement on pages 558-559.

Prehypertension is blood pressure, on repeated measurements, between the 90th and 95th percentiles (or any value above 120/80, even if less than the 90th percentile, as in the JNC-7 recommendations for adults).

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. Stage 1 hypertension is greater than the 95th percentile and less than 5 mmHg above the 99th percentile. Stage 2 hypertension is blood pressure greater than 5 mmHg above the 99th percentile. Hypertension cannot be diagnosed unless it is found repeatedly on 3 separate occasions, though the work-up and treatment of

symptomatic or severe hypertension should not be delayed for additional measurements on separate days.

There have been criticisms of these data points, as they are somewhat arbitrary and it is not clear that they correlate with end-organ damage or any outcome data in children. In addition, 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 recent study. 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.

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.

2. How do you measure blood pressure? Demonstrate on a colleague, talking through all of the necessary details of proper measurement.

The proper measurement of blood pressure is essential in children, beginning yearly at the age of 3 years. Blood pressure must 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. Automated blood pressure cuffs can be used for screening, but if there is any concern for hypertension, the blood pressure should be manually auscultated. 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 at 0 mmHg, the onset of muffling [the fourth Korotkoff phase (K4)] should be used as the diastolic blood pressure.

3. What, if any, further evaluation does Uri require at this visit?

Start by rechecking the blood pressure manually, double-checking cuff size, and using proper technique. A diagnosis of hypertension requires high 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 20-30 minutes in a non-clinical setting. However, ABPM is not always easily available or tolerated by young children, so an alternative would 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.

A careful history is essential to check for the presence of secondary causes, comorbidities, and complications of hypertension. A detailed past medical, social, and family history can reveal urinary tract infections (UTI), snoring, medications or drugs (consider athletic supplements, over-the-counter medications, as well as "energy" drinks), and 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 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 higher than arm, and can be measured by palpation, auscultation, or Doppler. Be sure to use a large enough cuff, as described above.

Don't forget that falsely elevated blood pressure secondary to improper cuff size is common and easily remedied!

CASE continued:

Uri's height is 50th percentile, his BMI is 31, 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 140/90 over several office visits and in the ambulatory setting.

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

Essential hypertension, or primary hypertension, is becoming increasingly common among children and adolescents, especially in constellation with metabolic syndrome and insulin resistance. Essential hypertension is usually mild (Stage 1). Children may be overweight or have a family history of hypertension or cardiovascular disease. Hypertension in a medical setting that is normalized when in a routine setting, known as white coat hypertension, is also common, and can be diagnosed with ambulatory blood pressure monitoring.

Hypertension secondary to an underlying pathologic process is more common in younger children than adults or adolescents (see tables 7 & 8 in the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents). Secondary causes for hypertension are also more common when the blood pressure is higher. Secondary hypertension should be considered in young children, children with Stage 2 hypertension, and any child whose history and 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 renal artery stenosis), cardiovascular disease (patent ductus arteriosus, anemia, or aortic coarctation), endocrine disease (e.g. hypo/hyperthyroidism, congenital adrenal hyperplasia, Cushing's syndrome, or pheochromocytoma), medications or drugs (including steroids, cocaine, and over-the-counter medications such as pseudoephedrine and athletic "nutritional" supplements), or sleep apnea/sleep-disordered breathing.

Once hypertension is confirmed, the Pediatric Hypertension Working Group recommends obtaining basic screening labs in all patients. These include electrolytes, BUN, Cr, and urinalysis with microscopy. In addition, they recommend a CBC and urine culture on all patients, though some experts add those only if clinical history or exam suggests potential chronic or systemic disease or UTI, respectively. A renal ultrasound with Doppler is also recommended on all patients with confirmed hypertension to detect renal scarring, asymmetry, or congenital disease, as well as renovascular disease. The Working Group recommends getting an electrocardiogram, echocardiogram and retinal exam on all hypertensive patients to look for evidence of end-organ damage. If the history and physical are concerning for obesity, insulin resistance, and/or possible metabolic syndrome, obtain fasting lipids, glucose, and insulin. Also consider drug screen, sleep study, plasma renin and aldosterone concentrations, more advanced renovascular imaging, thyroid function testing, and plasma/urine steroid or catecholamine (e.g. metanephrines, if assessing for pheochromocytoma) levels based on age, severity, and your history and exam.

5. How will you treat Uri?

Even normotensive kids should have a healthy diet, sleep, and physical activity.

Children with prehypertension and with Stage 1 hypertension (like Uri) 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. Smoking cessation counseling and avoidance of oral contraceptives, decongestants, cocaine, steroids, and licorice (which can have a mineralocorticoid effect) are recommended.

6. 18 months later, Uri's blood pressure remains elevated in the 130-140/90 range. 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.

Antihypertensives 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. In essential hypertension, diuretics (primarily thiazides) are cheap, effective, and well-studied. Angiotensin converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARBs), calcium-channel blockers and beta-blockers would also be considered first line agents in essential hypertension. Thiazide diuretics are often effective in patients with primary renal disease. 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 and beta-blockers are also used, and may be a good choice for kids with migraine headaches. Of note, beta-blockers are relatively contraindicated in asthma and diabetes. Also, heart rate reduction can be a dose-limiting side effect, especially in athletes.

7. Uri and his parents want to know why you are so concerned about his blood pressure. He feels fine. What do you tell them?

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 Uri. 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 >2 times more 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 no 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.

CASE TWO:

Uri's little brother, Mickey Churay Chen, is a 2-month-old, born at 32 weeks gestation, coming in for a well child visit. He is found to have a blood pressure of 110/80.

8. What do you think?

Neonatal hypertension was not addressed in the Working Group article on hypertension, but infant blood pressure charts can be found in reference guides such as The Harriet Lane Handbook. The article by Flynn (2000) 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 AAP working group 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, 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. 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 medications such as exogenous steroids, caffeine, and ophthalmic drops; catecholamines released from neuroblastoma or pheochromocytoma; congenital adrenal hyperplasia; or increased intracranial pressure. The work-up generally includes renal function testing, urinalysis, and ultrasound of the genitourinary tract. Other studies may be obtained if indicated by the history and physical.

Additional References:

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Resources:

1. Online pediatric blood pressure norms chart. http://www.pediatrichypertension.org/calcs.asp
2. Handout for patients from International Pediatric Hypertension Association. http://www.pediatrichypertension.org/faq.asp

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