

## Pediatric Hypertension: A Primer for the Busy Primary Care Provider

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### Abstract

Hypertension affects up to 5% of all children in the United States. The prevalence of “essential” hypertension in particular is rising in tandem with the childhood obesity epidemic. The primary care provider acts as the first-line of contact for many of these children and has an important role in early detection and referral to subspecialty care when needed. Despite published recommendations from the American Academy of Pediatrics on blood pressure screening at well child visits, adherence to these recommendations remains suboptimal. Elevated blood pressure readings, especially in non-obese children, may be overlooked. This may be due to a variety of factors including unfamiliarity of the primary care provider with pediatric blood pressure norms, time constraints in a busy practice, or the assumption that the elevated reading is an isolated clinically insignificant finding that could be dealt with at a later visit. This is particularly worrisome for children with secondary hypertension, which tends to be more severe and almost always requires anti-hypertensive therapy to prevent end organ damage. In this mini-review we present a case of a late diagnosis of secondary hypertension that had gone unnoticed for years. We then review relevant literature and suggest a clinical approach to the hypertensive child in a concise format useful for the busy primary care provider. A consistent clinical approach and firm understanding of the basic principles of pediatric hypertension diagnosis and management can prevent untoward outcomes related to a missed diagnosis.

**Keywords:** Hypertension; Pediatrics; Essential hypertension; Secondary hypertension; Antihypertensives; Clinical approach

### Introduction

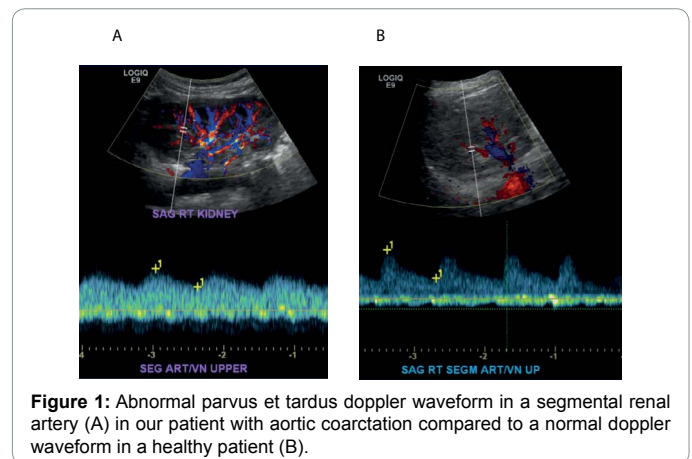
Hypertension afflicts approximately 2 to 5% of children in the United States [1]. Over the past decade, this prevalence has been steadily increasing due in part to increasing rates of “essential” hypertension fueled by a growing prevalence of obesity [2]. Despite this trend of pediatric “essential” hypertension, primary care providers need to remain vigilant to identify secondary etiologies of hypertension, which still account for up to 85% of cases in pre-teen children and otherwise lean adolescents [3]. This is well illustrated by the following case.

### Case Presentation

A 12 year old previously healthy boy was referred to the nephrology clinic for evaluation of elevated blood pressure (BP) noted during a recent ED visit for an unrelated sports injury. His BP in the ED was 140/90 mmHg but he was complaining of arm pain at the time. In clinic he appeared well and comfortable. Multiple manual auscultated BP readings ranged from 155-164/85-92 mmHg on his right upper extremity with an appropriately sized cuff. His body mass index (BMI) was 15.4 Kg/m<sup>2</sup>. His neck was supple with no goiter. Chest was clear and he had regular heart sounds with a 2/6 ejection systolic murmur at the left sternal border. His abdomen was soft with no bruits. Distal lower extremity pulses were weak and he had a radio-femoral delay. Based on these findings he was admitted to the hospital for further evaluation.

### Review

The above presentation is particularly concerning for coarctation of the aorta. Subsequent 4 extremity BP measurements confirmed lower BPs in both legs compared to his arms. A renal ultrasound demonstrated normal kidneys and the doppler study showed an abdominal aorta and bilateral renal artery parvus et tardus pattern which is seen in proximal aortic arch narrowing (Figure 1). An echocardiogram confirmed the diagnosis of thoracic aortic coarctation. This late diagnosis of a potentially life threatening cardiac condition also highlights the importance of BP screening at well child visits for early detection of hypertension. The American Academy of Pediatrics (AAP) recommends annual BP measurements for all children 3 years



**Figure 1:** Abnormal parvus et tardus doppler waveform in a segmental renal artery (A) in our patient with aortic coarctation compared to a normal doppler waveform in a healthy patient (B).

of age or older [4]. Younger children should have their BP measured if they have a co-morbid condition predisposing to hypertension such as known renal disease, history of prematurity, congenital heart disease, or intake of medications known to increase BP [4]. The issue of screening has been a contentious discussion in the medical community as of late. The US Preventive Services Task Force (USPSTF) recently published recommendations that do not endorse routine BP measurements in children citing a systematic review that found no direct evidence that screening for hypertension in children and adolescents reduces adverse cardiovascular outcomes in adults [5,6]. The USPSTF report came under extreme scrutiny and criticism by the American Society of Pediatric Nephrology for essentially evaluating an endpoint that has not been

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studied. Any study attempting to directly answer the USPSTF question would necessarily have to follow both screened and unscreened children for many decades to determine the direct impact of early hypertension detection [7,8]. It is concerning that the potential outcome of the USPSTF recommendation is sending a message to general practitioners that BP measurement in children is not valuable. This can lead to missed or late diagnosis of secondary hypertension such as described in the case above. This is especially concerning when screening rates in children prior to the updated USPSTF recommendations remain low at only 35% of ambulatory pediatric visits and 67% of preventive visits according to a recent study by Shapiro et al. [9].

A screening test, however, is only useful if it's accurate and reliable. Primary care providers should be made aware of the pitfalls associated with screening Dinamap BP readings obtained on children as they check in to clinic [10-12]. Ideally, children should be resting in a seated position for at least 15 minutes with both feet firmly on the ground. Measurements should not be taken immediately after eating or exercise. A manual auscultated BP reading using an appropriately sized cuff corresponding to the child's mid-arm circumference remains the gold standard upon which the pediatric blood pressure tables are based [13]. An elevated reading > 90<sup>th</sup> percentile for the child's age, gender and height, or greater than 120/80 mmHg, should be repeated and an average of 3 readings recorded. This final BP reading is then used to determine the stage of hypertension based on age, gender, and height specific percentiles, which will dictate the next course of action (Table 1) [13]. Several electronic mobile applications now allow direct BP entry to calculate child specific percentiles without resorting to complex tables [14]. In a busy practice, educating nursing staff responsible for patient intake, and employing a simplified approach for BP evaluation may improve the recognition of pediatric hypertension [15]. For example, a nurse may start by having the child rest in the seated position while the caregiver is answering intake questions. The child's mid right upper arm circumference is then measured to facilitate accurate cuff size selection. An automated Dinamap reading is then obtained. This reading may be automatically compared to appropriate reference ranges if the practice utilizes an electronic health records (EHR) system with such capabilities. If an EHR is not available, comparison to a simplified BP reference table that eliminates the need of a height percentile requirement can be an easy way to "flag" potentially elevated BP readings [16]. The busy primary care provider is made aware of this abnormal screen so they can then selectively obtain an auscultated manual reading for confirmation. Establishing an alliance with the child's school nurse might be a useful strategy to closely monitor those children with incidental findings of elevated BP in the office. This allows outpatient repeated BP measurements for confirmation of hypertension. The child can then be specifically brought back to the office for a dedicated hypertension evaluation visit.

A thorough medical history and physical examination in a hypertensive child is aimed at eliciting signs and symptoms suggestive of secondary etiology, and to identify possible end organ damage. A summary of selected relevant findings is presented in Table 2. This should facilitate a focused diagnostic work-up. In general, younger children and lean adolescents are by far more likely to have a secondary etiology and therefore warrant a more aggressive approach [3,13]. Obese adolescents should have basic studies to rule out significant renal disease, with subsequent focus on co-morbidities related to obesity [13,17]. A suggested diagnostic approach endorsed by the author is summarized in Table 3.

The treatment approach will depend on the hypertension stage

Stage	Definition	What to do?
Normal BP	Both systolic BP (SBP) and diastolic BP (DBP) < 90 <sup>th</sup> percentile for age, height and gender or < 120/80 mmHg, whichever is lower	Continue annual screening or sooner if clinically indicated
Pre-hypertension	SBP or DBP between 90 <sup>th</sup> -95 <sup>th</sup> percentile for age, height and gender or BP > 120/80 mmHg but less than 95 <sup>th</sup> percentile	Counsel regarding life style modification (Diet, exercise, weight loss) and recheck BP in 6 months
Stage I Hypertension	SBP or DBP between the 95 <sup>th</sup> percentile and the 99 <sup>th</sup> percentile + 5 mmHg	If asymptomatic: confirm on 2 additional occasions 1-2 weeks apart. If persistent proceed with evaluation within 1 month and counsel regarding life style modification. If symptomatic: Counsel regarding life style modification and discuss with specialist for immediate treatment and evaluation possibly in outpatient setting.
Stage II Hypertension	SBP or DBP greater than the 99 <sup>th</sup> percentile + 5 mmHg	If asymptomatic: Counsel regarding life style modification and proceed with evaluation and treatment within 1 week. If symptomatic: Refer to Emergency department or inpatient admission for immediate treatment and evaluation.

**Table 1:** Definition of hypertension stages in children and recommended course of action (adapted from [13]).

Symptom	Possible etiology
Headache, blurry vision, seizures	High intracranial pressure
Chest pain, palpitations	Aortic coarctation, pheochromocytoma, Thyrotoxicosis, anxiety
Shortness of breath	Congenital heart disease (e.g. coarctation)
Nausea, sweating, flushing	Pheochromocytoma, Thyrotoxicosis
Dysuria, hematuria, frequency, urgency, foamy urine	Renal parenchymal disease
Rash, joint pain or swelling, weight loss, unexplained fever	Rheumatologic disease, systemic vasculitis
<b>Sign</b>	<b>Possible etiology</b>
Growth parameters: obesity	Essential hypertension
Growth parameters: failure to thrive	Renal parenchymal disease
Dysmorphic features	Williams syndrome, Turner syndrome
Abnormal UE: LE BP gradient	Coarctation of the aorta
Tachycardia	Thyrotoxicosis, anxiety, pheochromocytoma
Bradycardia	Intracranial hypertension
Thyromegaly	Thyrotoxicosis
Heart murmur, poor perfusion	Coarctation of the aorta
Abdominal bruit	Renovascular disease
Abdominal mass, nephromegaly	Wilms' tumor, neuroblastoma, pheochromocytoma, polycystic kidney disease
Acanthosis nigricans, café-au-lait spots, adenoma sebaceum	Essential hypertension, Neurofibromatosis, Tuberous sclerosis
Joint swelling, joint tenderness	SLE
Edema	Renal parenchymal disease

**Table 2:** Possible hypertension etiologies based on presenting signs and symptoms in the hypertensive child.

as summarized in Table 1 [13]. All practitioners need to consistently encourage their patients to adopt healthier life style habits with regards to diet and exercise. The Dietary Approaches to Stop Hypertension (DASH) diet is a safe and well-studied dietary approach proven to lower blood pressure in adults with stage I hypertension [18]. This

Suggested diagnostic work-up for children and adolescents with hypertension		
	First-line for most patients	Additional studies to be considered
Pre-teens and lean adolescents	CBC, Urinalysis, Basic metabolic profile, Thyroid function test, Plasma renin activity, serum aldosterone level, Renal ultrasound with doppler, echocardiogram (for etiology and evidence of LVH)	Urine toxicology screen Plasma metanephrines DMSA renal nuclear scan 24-hr ambulatory BP monitor Renal angiography
Overweight adolescents	CBC, Urinalysis, basic metabolic profile, Thyroid function test, Lipid profile, uric acid, Glycated Hemoglobin, Renal ultrasound with doppler, echocardiogram (for evidence of LVH)	Urine toxicology screen 24-hr ambulatory BP monitor Polysomnography

**Table 3:** Suggested diagnostic work-up for children and adolescents with hypertension based on age and body habitus.

diet focuses on increasing daily intake of fresh fruit, vegetables, and low fat dairy products along with reducing saturated and total fat. A multidisciplinary team with a dietician can assess the hypertensive child's typical daily diet and tailor it to conform to the DASH diet principles. On the other hand, treatment with anti-hypertensives is necessary in almost all cases of secondary hypertension (unless the primary etiology can be reversed), and a fair percentage of "essential" hypertension when patients are symptomatic, have end organ damage, or fail conservative therapy [13]. Even though younger children with more severe secondary hypertension are likely to be referred and managed by pediatric nephrology specialists, the overwhelming majority of adolescents with primary hypertension are prescribed anti-hypertensives by primary care providers [19]. Hence, knowledge of representative agents from the different anti-hypertensive classes is valuable. When faced with a severely hypertensive child, this knowledge will allow the primary care provider to initiate safe and effective anti-hypertensive therapy. For example, calcium channel blockers have an excellent safety profile and are available in both short acting (e.g. isradipine) and long acting formulations (e.g. amlodipine) making them an ideal first line agent before a full diagnostic work-up is completed [20,21]. Angiotensin converting enzyme (ACE) – inhibitors (e.g. enalapril and ramipril), and angiotensin II receptor blockers (e.g. losartan) are an excellent choice for most pediatric patients due to their renoprotective effect in children with chronic kidney disease [22-24]. However, they should not be used in suspected renovascular disease until it is confirmed that it is not bilateral due to risk of precipitating acute renal failure [25]. They should also be used with caution in sexually active adolescent females due to their teratogenicity [26]. B-blockers (e.g. atenolol) are ideal for children who also suffer from migraine headaches or thyrotoxicosis, but they should be avoided in children with asthma due to risk of bronchoconstriction, and used with caution in children with diabetes [1]. Diuretics can be used as first line agents or as add-on therapy along with other medications. The use of a combination pill may reduce pill burden and improve adherence [27]. Clonidine is a centrally acting agent available as a transdermal formulation. It is generally reserved as an add-on agent for children who cannot take oral medications or those with severe hypertension on multiple agents due to its sedative side effects [28]. Other less commonly used agents include hydralazine, minoxidil, direct renin inhibitors, alpha-blockers, and aldosterone antagonists [13].

## Conclusion

Finally, one cannot stress enough the value of a multi-disciplinary approach to hypertension evaluation and treatment involving the primary care provider, the pediatric nephrologist, the dietician, the school nurse, and other specialties as deemed appropriate. As with any other chronic health condition, satisfactory outcomes can only be expected if we effectively engage the family, provide close follow-up and encourage adherence.

### Self-Assessment Questions

#### Question 1

The American Academy of Pediatrics recommends annual blood pressure measurements in children starting at age:

- Birth
- 1 year old
- 2 year old
- 3 year old
- 4 year old

#### Question 2

A child is considered hypertensive when repeated blood pressure measurements are found to exceed which percentile for age, height and gender?

- 50<sup>th</sup> percentile
- 75<sup>th</sup> percentile
- 90<sup>th</sup> percentile
- 95<sup>th</sup> percentile
- BP percentiles are not used to diagnose hypertension in children

#### Question 3

An abnormal blood pressure gradient between the upper and lower extremities in a child with hypertension is most concerning for:

- Hyperthyroidism
- Aortic coarctation
- Renal artery stenosis
- Essential hypertension
- Chronic kidney disease

#### Question 4

A 15 year old African American boy presents to hypertension clinic for evaluation of elevated blood pressure detected on routine check-ups at his PCP. He denies chest pain, headache or blurry vision. Physical exam is notable for acanthosis nigricans and a BMI at the 90<sup>th</sup> percentile. His height is at the 50<sup>th</sup> percentile. BP is 146/84 mmHg.

Of the following the best course of action to pursue at this time is:

- Basic metabolic profile (BMP) and urinalysis (UA). No therapy.
- BMP, UA and start a diuretic.
- BMP, UA, Renal US with Doppler, plasma renin and aldosterone, and start an ACE-inhibitor.
- BMP, UA, Lipid panel, Renal US with Doppler, Echocardiogram. Recommend a low salt diet and increased physical activity.
- BMP, UA, Plasma renin and aldosterone, Plasma metanephrines, Renal US with Doppler. Recommend a low salt diet and increased physical activity.

#### Question 5

The following anti-hypertensive class should be avoided, if possible, in children with bronchial asthma:

- ACE-inhibitors

- b) Diuretics
- c) B-blockers
- d) Calcium channel blockers
- e) Centrally acting agents (e.g. Clonidine)

Answer Key: 1: d; 2: d 3; b 4: d; 5: c

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