Target BP Goals in Children/Adolescents
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Abstract

Ever increasing pandemic of obesity, hypertension (HTN), and other factors that may contribute significantly to the cardiovascular morbidity and mortality in adulthood has shifted the focus from management of HTN to its prevention. Tracking of adult HTN from childhood HTN, increasing recognition of reversible childhood markers of target organ damage and effective interventions, both pharmacological and non-pharmacological, have made it mandatory for the clinicians to control childhood HTN more aggressively although deleterious effects of HTN may not be as commonly seen as in adults. A thorough literature search was conducted to formulate the target blood pressure (BP) goals in children/adolescents, mainly based on the European and American guidelines. Reduction in systolic and diastolic BP to <90th percentile in children and <130/80 mm mercury in adolescents more than or equal to 13 years old is a consensus target BP goals in children. Reduction in BP levels <90th percentile in children and <130/80 in adolescents is a good control to prevent further progression. Prevention of early determinants of HTN, factors that determine BP tracking in childhood to adulthood and of end organ damage shall be the field of further research in this arena.

Key words: Childhood hypertension, goals, targets, treatment

Introduction

Childhood hypertension (HTN), increasingly being detected and being prevalent, has become a significant public health problem not only posing a therapeutic challenge but also being associated with increased fatality and morbidity. Cutoffs for different age groups for the diagnosis, difficulties with accurate measurements in childhood, poor adherence to medication due to dependency, and absence of enough evidences for target organ damage of this disease, which is less prevalent in children when compared to adults, makes monitoring of HTN and of its associated morbidities more complicated in pediatric population. Predisposition to adult HTN and increased cardiovascular events in adults mandate the clinician to treat and monitor the childhood HTN more aggressively.\(^1\)\(^2\)

The Need for the Target BP Goals in Children and Adolescents

In adults, medication management reduces incidence of cerebrovascular accidents by 35–40%, myocardial infarction by 15–25%, and cardiac failure by 64%.\(^3\)\(^4\) Adequate and safe control of HTN in childhood and adolescents will have beneficial effects on these comorbidities as evidenced by the following.

a. HTN has been shown to track (or persist) from childhood to adulthood. The origins of HTN in adulthood extend to childhood ages, and the frequency of increased blood pressure (BP) in adolescence progresses to HTN by 7% yearly.\(^1\)\(^7\)\(^8\) However, the strength of tracking has been shown to vary between studies and depends on baseline age, length of follow-up, and susceptibility alleles. It is evidenced that approximately 10% of adult HTN can be prevented if elevated BP in childhood can be controlled. In view of the global burden of disease attributable to adult HTN, even a small shift in the control of pediatric BP levels (left or right) will have a significant impact on morbidity and financial cost.\(^9\)

b. HTN in childhood and adolescence, no more considered as a benign disease, is known to have significant target organ damage at diagnosis. Although clinically detectable
ischemic heart disease is rare in childhood, it is known that the extent of target organ damage is the main risk factor for future cardiovascular events.\textsuperscript{[10]} Current evidence suggests that preclinical markers of cardiovascular health in adulthood associate with multiple early-life risk factors such as birth size and adiposity, BP, own and parental smoking, blood lipid levels, family history, and socioeconomic factors (among others). Therefore, primary prevention by controlling the early-life risk factors could lead to a lifelong benefit in the growing era of pandemic of obesity and HTN\textsuperscript{[9,11-13]}

c. Cardiovascular disease begins early in life in children with HTN and other comorbidities and has a long manifest stage before clinical end-points such as myocardial infarction and stroke present.\textsuperscript{[9]}

**Current Guidelines for Control and Monitoring of BP in Children and Adolescents**

American academy of Paediatrics published “Clinical Practice Guideline for Screening and Management of High BP in Children and Adolescents” by Flynn et al. in the year 2017.\textsuperscript{[14]} These guidelines provide clear-cut recommendations on diagnosis, evaluation, and management of childhood HTN aiming at practicing clinicians seeing outpatients. Salient features are as follows:

a. To start BP measurement at age 3 years (No change in old recommendation) and annual measurement is recommended unless risk factors (to be measured at every health-care visits if obesity, are taking medications known to increase BP, have renal disease, a history of aortic arch obstruction or coarctation, or diabetes) are present

b. Doctors and other health care workers should make a diagnosis of HTN if a child or adolescent has auscultatory confirmed BP readings ≥95\textsuperscript{th} percentile (or ≥130/80 in adolescents ≥13 years of age) at three different visits

c. Ambulatory BP Monitoring (ABPM) should be performed for confirmation of HTN in children and adolescents with office BP measurements in the elevated BP category for ≥1 year or with Stage 1 HTN over three clinic visits. Routine performance of ABPM should be strongly considered in children and adolescents with high-risk conditions to assess the severity of HTN and determine if abnormal circadian BP patterns are present, which may indicate increased risk for target organ damage. ABPM may be used to assess treatment effectiveness in children and adolescents with HTN, especially when clinic and/or home BP measurements indicate insufficient BP response to treatment

d. Home BP monitoring should not be used to diagnose HTN, masked HTN or white-coat HTN but may be a useful adjunct to office and ambulatory BP measurement after the diagnosis

e. There is no need to evaluate extensively for secondary causes for HTN in children and adolescents ≥6 years of age, if they have a positive family history of HTN, are overweight or obese, and/or do not have history or physical examination findings suggestive of a secondary cause of HTN

f. Echocardiography to be performed to assess for cardiac target organ damage (left ventricular mass, geometry, and function) at the time of consideration of pharmacologic treatment

g. At the time of diagnosis, clinicians should provide advice on the Dietary Approaches to Stop HTN (DASH) diet and recommend moderate to vigorous physical activity at least 3 to 5 days per week (30–60 min per session) to help reduce BP

h. Definition of HTN (Term prehypertension deleted) refer to Table 1

i. New BP table (with age and height percentile) refer to Table 2

j. Patient evaluation and management by BP level refer to Table 3.

**Target BP in Management of HTN in Children and Adolescents**

The remarkable increase in the prevalence of pediatric HTN over the last two decades mirroring the rise in obesity and sleep disorders in children mandates the clinicians to be familiar with the management of HTN in children by pharmacological and non-pharmacological means. However, absence of large, well-structured safety and efficacy trials in children, challenges in understanding of pharmacokinetics and unknown risk of life-long exposure to antihypertensive medications, and pharmacotherapy in childhood HTN challenging.\textsuperscript{[15]}

The following point’s needs to be considered while deciding the target BP goals in children

a. The extent of antihypertensive interventions to will depend largely on the relative risk of BP levels and the pathological changes in target organs. Thus, well conducted longitudinal studies are required in hypertensive pediatric population to determine the advantages and risks of interventions in preventing cardiovascular and other short- and long-term end-organ injury related to the level of BP.

b. The cause and effects of HTN in kidney diseases need to be clearly understood as they are the major target organs in pediatric population.

**Table 1: Definition of hypertension**\textsuperscript{[14]}

| For children aged 1–13 years | For children aged >13 years |
|-------------------------------|----------------------------|
| Normal BP: <90\textsuperscript{th} percentile | Normal BP <120/<80 mmHg |
| Elevated BP: >90\textsuperscript{th} percentile or 120/80 mmHg to <95\textsuperscript{th} percentile (whichever is lower) | Elevated BP: 120/<80–129/40 mmHg |
| Stage 1 HTN: >95\textsuperscript{th} percentile + 12 mmHg, or 130/80–139/89 mmHg (whichever is lower) | Stage 1 HTN: 130/80–139/89 mmHg |
| Stage 2 HTN: >95\textsuperscript{th} percentile + 12 mmHg, or >140/90 mmHg (whichever is lower) | Stage 2 HTN: >140/90 mmHg (whichever is lower) |
c. Management of hypertensive emergencies is another area of concern in pediatric population in view of significant mortality and morbidity associated with it.

d. Absence of a well-tolerated, affordable and cost effective, and antihypertensive intervention in reducing the mortality and morbidity in this vulnerable pediatric population makes it still more difficult to define the targets.

e. More than 50% of hypertensive adults have additional risk factors. The common ones are diabetes mellitus (15–20%), lipid disorders (elevated low-density lipoprotein-cholesterol and triglycerides (30%)), overweight-obesity (40%), hyperuricemia (25%) metabolic syndrome (40%), and unhealthy lifestyle habits (e.g., smoking, high alcohol intake, and sedentary lifestyle). The presence of one or more

Table 2: New BP table (with age and height percentiles)[14]

| Age (years) | Height percentile or measured height |
|-------------|--------------------------------------|
|             | SBP (mmHg)                           |
|             | Height percentile                     |
|             | 5%                                   |
| 1           | 30.4                                 |
|             | 10%                                  |
|             | 31.6                                 |
|             | 25%                                  |
|             | 32.4                                 |
|             | 50%                                  |
|             | 33.4                                 |
|             | 75%                                  |
|             | 34.6                                 |
|             | 90%                                  |
|             | 34.8                                 |
|             | 95%                                  |
|             | 35.4                                 |
|             | 95%+12 mmHg                          |
| 2           | 33.9                                 |
|             | 10%                                  |
|             | 34.3                                 |
|             | 25%                                  |
|             | 35.3                                 |
|             | 50%                                  |
|             | 36.3                                 |
|             | 75%                                  |
|             | 37.3                                 |
|             | 90%                                  |
|             | 38.2                                 |
|             | 95%                                  |
|             | 38.8                                 |
|             | 95%+12 mmHg                          |
| 3           | 36.4                                 |
|             | 10%                                  |
|             | 37.4                                 |
|             | 25%                                  |
|             | 37.9                                 |
|             | 50%                                  |
|             | 39                                 |
|             | 75%                                  |
|             | 40.1                                 |
|             | 90%                                  |
|             | 41.1                                 |
|             | 95%                                  |
|             | 41.7                                 |
|             | 95%+12 mmHg                          |

Table 3: Patient evaluation and management by blood pressure level[14]

| BP category | BP screening schedule | Lifestyle counseling (weight, nutrition) | Check upper and lower extremity BP | ABPM | Diagnostic evaluation | Initiate treatment | Consider sub-specialty referral |
|-------------|-----------------------|------------------------------------------|-----------------------------------|------|-----------------------|-------------------|-------------------------------|
| Normal      | Annual                | X                                        |                                   |      | X                     |                   |                               |
| Elevated BP | Initial measurement   | X                                        |                                   |      | X                     |                   |                               |
|             | Second measurement:   | X                                        |                                   |      | X                     |                   |                               |
|             | Repeat in 6 months    | X                                        |                                   |      | X                     |                   |                               |
|             | Third measurement:    | X                                        |                                   |      | X                     |                   |                               |
|             | Repeat in 6 months    | X                                        |                                   |      | X                     |                   |                               |
| Stage 1 HTN | Initial measurement   | X                                        |                                   |      | X                     |                   |                               |
|             | Second measurement:   | X                                        |                                   |      | X                     |                   |                               |
|             | Repeat in 1–2 weeks   | X                                        |                                   |      | X                     |                   |                               |
|             | Third measurement:    | X                                        |                                   |      | X                     |                   |                               |
|             | Repeat in 3 months    | X                                        |                                   |      | X                     |                   |                               |
| Stage 2 HTN | Initial measurement   | X                                        |                                   |      | X                     |                   |                               |
|             | Second measurement:   | X                                        |                                   |      | X                     |                   |                               |
|             | Repeat/refer to specialty care within 1 week | X                                    |                                   |      | X                     |                   |                               |
additional cardiovascular risk factors proportionally increases the risk of coronary, cerebrovascular, and renal diseases in hypertensive adults.\textsuperscript{[13-15]} Many of these comorbid lifestyle related diseases are also associated with HTN in children and hence, the increased risk.

Hence, the goals for the treatment of HTN in pediatric population, include achieving a level that decreases the risk for target organ damage (which are, to a large extent reversible) and reduces the risk for HTN and related cardiovascular diseases in adulthood.\textsuperscript{[14]}

**The Treatment Goal of Antihypertensive Therapy**

“Clinical Practice Guideline for Screening and Management of High BP in Children and Adolescents” by Flynn et al. in the year 2017 published by American academy of Paediatrics has given the following practical guidelines.\textsuperscript{[14]} We, In India, follow the same guidelines as these guidelines are applicable in Indian children also.

**Target BP Goals in Children and Adolescents, in General**

- Key action statement 19 “Reduction in systolic and diastolic BP to <90th percentile in children and <130/80 mm mercury in adolescents more than or equal to 13 years old (Grade C, moderate recommendation).

These recommendations were based on the predictions and progression of childhood HTN into adult HTN and effects of childhood HTN on cardiovascular health in adults.\textsuperscript{[17-19]}

In a cohort of 4210 participants (mean follow-up, 23 years), Juhola et al. had concluded that individuals with persistently elevated BP from childhood to adulthood had increased risk of carotid atherosclerosis. This risk was reduced if elevated BP during childhood resolved by adulthood.\textsuperscript{[18]} Sladowska et al. found that antihypertensive treatment leads to significant improvement and normalization of the left ventricular geometry. However, patients with concentric hypertrophy are less prone to normalized geometry and may require more intensive treatment\textsuperscript{[10,19]}

- Key Action Statement 22: ABPM may be used to evaluate treatment effectiveness especially when clinic and/or home measurements indicate insufficient response (Grade B, moderate recommendation).

These recommendations were based on the effectiveness of ABPM in achieving the target control of HTN in children.\textsuperscript{[20-22]}

**Target BP Goals in Children/Adolescents, with Kidney Diseases**

- Key Action Statement 23: Children and adolescents with Chronic kidney disease should be evaluated for HTN at each medical visit; children with HTN should be treated to lower 24-h Mean arterial pressure to <50th percentile by ABPM; and regardless of apparent control of BP with office measures, children, and adolescents with chronic kidney disease and a history of HTN should have BPs assessed by ABPM at least yearly to screen for masked HTN (Grade B; strong recommendation).

Intensified BP control confers a substantial benefit with respect to renal function among children with chronic kidney disease.

The recommendations were based on the fact that the treatment of childhood and adolescent HTN with chronic kidney disease might slow the progression of or reverse end organ damage.

In a study of 385 children, 3–18 years of age, with chronic kidney disease, Wuhl et al. described that achievement of BP targets and a decrease in proteinuria were significant independent predictors of delayed progression of renal disease.\textsuperscript{[23,24]}

**Target BP Goals in Children/Adolescents, with Diabetes Mellitus**

- Key action statement 26: Children and adolescents with diabetes should be evaluated for HTN at each medical visit and treated if BP is >95th percentile or >130/80 mmHg in adolescents ≥13 years of age (Grade C, moderate recommendation).

These recommendations were based on the evidences that early detection and treatment of childhood HTN with type 1 and type 2 diabetes mellitus might reduce future cardiovascular and kidney disease. The prevalence of elevated BP in youth with type 1 diabetes mellitus was 5.9% (n = 3691); and in type 2 was 23.7% (n = 410) (P < .0001), hence, the need for intense screening.\textsuperscript{[26-27]}

**Target BP Goals in Children/Adolescents, with Acute Severe HTN**

- Key Action Statement 27: In children and adolescents with acute severe HTN and life-threatening symptoms, BP should be reduced by no more than 25% of the planned reduction over the first 8 h (grade expert opinion D, weak recommendation). The ultimate short-term BP target in such patients should generally be around the 95th percentile.

These recommendations were based on the fact that acute severe HTN may precipitate encephalopathy, acute kidney injury, and congestive heart failure in children and a rapid reduction in the BP my result in further complications.\textsuperscript{[24,26]} Patel et al. in their review observed that a larger rapid reduction in pressure can worsen end-organ function, leading to worsening neurological status, and possibly cause cerebrovascular compromise and should therefore be avoided.\textsuperscript{[26]}

**Target BP Goals in Children/Adolescents, who are in Competitive Sports**

- Key Action Statement 29 – Children and adolescents with HTN should receive treatment to lower BP below Stage 2
thresholds before participating in competitive sports (Grade C, weak recommendation)
- Black et al. in their research article stated that both systolic and diastolic pressures increase during resistance (static or isometric) exercise, and strenuous aerobic or resistance exertion may precipitate myocardial infarction and sudden death in susceptible, untrained people. In a person with normal BP at rest, a rise in systolic BP to >200 mm Hg during an exercise treadmill test may suggest underlying HTN. This person may benefit from further investigation, including 24-h ABPM, to document true sustained HTN. A hypertensive responsive to exercise testing may also indicate an independent risk for cardiovascular events and mortality.[28] Similar observations were also made by McCambridge et al.[30]

These are summarized in Table 4

Conclusions

There are enough evidences to prove the assumptions that BP tracks from childhood to adulthood and that an increased BP in childhood is likely to help predict adult HTN. The end organ damage that may predispose the adverse outcome in children and adolescents begins in the childhood and is reversible to a very large extent, if target BPs could be achieved with an early diagnosis, prompt management (both pharmacologically and non-pharmacologically) and a close follow-up. Future studies should concentrate on early determinants of HTN in children, on identifying the factors that determines BP tracking in infancy, childhood, and adolescence and on early markers of end organ damage.

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