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Prevention and Control of Hypertension

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ABSTRACT

Hypertension, the leading risk factor for cardiovascular disease, originates from combined genetic, environmental, and social determinants. Environmental factors include overweight/obesity, unhealthy diet, excessive dietary sodium, inadequate dietary potassium, insufficient physical activity, and consumption of alcohol. Prevention and control of hypertension can be achieved through targeted and/or population-based strategies. For control of hypertension, the targeted strategy involves interventions to increase awareness, treatment, and control in individuals. Corresponding population-based strategies involve interventions designed to achieve a small reduction in blood pressure (BP) in the entire population. Having a usual source of care, optimizing adherence, and minimizing therapeutic inertia are associated with higher rates of BP control. The Chronic Care Model, a collaborative partnership among the patient, provider, and health system, incorporates a multilevel approach for control of hypertension. Optimizing the prevention, recognition, and care of hypertension requires a paradigm shift to team-based care and the use of strategies known to control BP.
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High blood pressure (BP) is the leading risk factor for cardiovascular disease (CVD), and hypertension ranks first as a cause of disability-adjusted life-years worldwide (1,2). Suboptimal BP control is the most common attributable risk factor for CVD and cerebrovascular disease, including hemorrhagic (58%) and ischemic (50%) stroke, ischemic heart disease (55%), and other forms of CVD (58%), including heart failure and peripheral arterial disease (1,2). In addition, hypertension is a leading cause of chronic kidney disease, kidney disease progression, and end-stage kidney disease, as well as dementia due to cerebral small vessel disease (3–6).

Large-scale epidemiological studies have provided definitive evidence that high BP, at all ages and in both sexes, maintains a continuous graded association with the risk of fatal and nonfatal stroke, ischemic heart disease, heart failure, and noncardiac vascular disease, without heterogeneity due to ethnicity, down to a BP nadir of 115/75 mm Hg (7–9). Each 20-mm Hg increment of systolic blood pressure (SBP) or 10-mm Hg increment of diastolic blood pressure (DBP) is associated with a doubling of the risk of a fatal cardiovascular event (7).

The prevalence of hypertension globally is high and continues to increase (1,10). Defined at the SBP/DBP cutoff of ≥140/90 mm Hg, the worldwide prevalence of hypertension is 31%, translating to approximately 1.4 billion adults (1,10). The prevalence of hypertension in the adult U.S. population is similar to the worldwide prevalence at 31.9% (72.2 million

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people) using the ≥140/90 mm Hg BP cutoff; the U.S. prevalence is projected to increase to 45.6% (103.3 million people) using the 2017 American College of Cardiology (ACC)/American Heart Association (AHA) hypertension clinical practice guideline definition of BP ≥130/80 mm Hg (10–12).

In this review, we first describe the current state of knowledge regarding pathophysiological determinants of high BP. We then describe strategies for, and barriers to, prevention and control of hypertension, and suggest multilevel and population health actions to improve BP control.

PATHOPHYSIOLOGICAL DETERMINANTS OF HIGH BP

Hypertension can be divided into primary and secondary forms. Primary (essential) hypertension accounts for the vast majority (≥90%) of cases, and poor diet and insufficient physical activity seem to be important and potentially reversible environmental causes. A specific, sometimes remediable cause of hypertension can be identified in approximately 10% of adults with hypertension, termed secondary hypertension (**Table 1**) (11). If the cause can be accurately diagnosed and treated, patients with secondary hypertension can achieve normalization of BP or marked improvement in BP control, with concomitant reduction in CVD risk (11). The majority of patients with secondary hypertension have primary aldosteronism or renal parenchymal or renal vascular disease, whereas the remainder may have more unusual endocrine disorders or drug- or alcohol-induced hypertension.

Figure 1 depicts the major pathophysiological determinants of BP in primary hypertension. Primary hypertension originates from a combination of genetic and environmental factors. The heritability of BP is 30% to 50% (13–18), reflecting the degree of phenotypic resemblance among family kin, and depends both upon shared genetic background contributing to BP as well as environmental factors and their interactions with the genome.

GENETIC AND EPIGENETIC PREDISPOSITION. Hypertension is a complex polygenic disorder in which many genes and/or combinations of genes influence BP (19,20). Although several monogenic forms of hypertension, such as glucocorticoid-remediable aldosteronism, Liddle's and Gordon's syndromes, and others, have been identified in which single-gene mutations completely explain the pathophysiology of the hypertension, these disorders are rare (21). Common genetic variants influencing BP have been identified at over 300 independent genetic loci. However, these genetic variants typically have effects on the order of only 1.0 mm Hg SBP and 0.5 mm Hg DBP per BP-raising allele. Individually, these genetic variants each explain <0.1% of BP phenotype and collectively ≤3.5% of total BP variance (20,22,23).

Because primary hypertension is a highly heritable condition, but genetic variants only explain a miniscule fraction of phenotypic variation and disease risk, the term *missing heritability* has been introduced. Missing heritability is the difference between estimated and observed phenotypic variance (24). Recent studies have suggested that missing heritability in hypertension may be due, in part, to pathological events during embryonic, fetal, and early postnatal life (e.g., nutritional deprivation of the fetus during pregnancy leading to low birth weight) having persistent effects on CVD homeostasis and thereby increasing CVD risk, including hypertension, with advancing age. These fetal programming events may be mediated by epigenetic mechanisms (i.e., alterations in gene expression in the absence of changes in DNA sequence, including post-translational histone modification, DNA methylation, and noncoding microRNAs) (25). During early life, epigenetic mechanisms seem to be strongly influenced by the environment, and environmentally induced epigenetic modification is heritable through multiple generations (26).

ENVIRONMENTAL (LIFESTYLE) FACTORS. Although the genetic predisposition to hypertension is nonmodifiable and conveys lifelong CVD risk, the risk for hypertension is modifiable and largely preventable due to a strong influence by key environmental/lifestyle factors. The most important of these factors, which often are gradually introduced in childhood and early adult life, are weight gain leading to overweight/obesity, unhealthy diet, excessive dietary sodium and inadequate potassium intake, insufficient physical activity, and consumption of alcohol (11). The greatest impact can be achieved by targeting lifestyle areas of highest deficiency and combining more than 1 of these lifestyle modifications, as the individual BP reductions are often additive. Nevertheless, only a minority of adults change their lifestyle after a diagnosis of hypertension (27), and sustainability is difficult, posing a substantial challenge for successful implementation of lifestyle modification (28). The evidence underlying each of the environmental/lifestyle factors that promote elevation of BP and hypertension will be briefly reviewed.

ABBREVIATIONS AND ACRONYMS

ABPM = ambulatory blood pressure monitoring
BMI = body mass index
BP = blood pressure
CCM = Chronic Care Model
CVD = cardiovascular disease
DBP = diastolic blood pressure
SBP = systolic blood pressure