Nutrition and Hypertension

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Lecture Objectives

1. Describe the major components of the DASH diet that contribute to blood pressure reduction
2. Explain general mechanisms by which addition of fruits and vegetables are thought to contribute to blood pressure reduction
3. Describe the effect of high Na^+ diets and Na^+ restriction on blood pressure in older compared to younger individuals with primary hypertension
4. Describe the effect of weight reduction on blood pressure of overweight/obese individuals with hypertension

I. Overview

A. The Seventh Report of the Joint National Commission on Detection, Evaluation, and Treatment of High Blood Pressure (1) says "Adoption of healthy lifestyles by all persons is critical for the prevention of high BP and is an indispensable part of the management of those with hypertension" and promotes the Dietary Approaches to Stop Hypertension (DASH) diet as an important component of this lifestyle modification. We will use this diet, emphasizing its components shown to be effective in reducing blood pressure (BP), as the basis for our discussion of nutrients in the management of hypertension. Our focus will be upon primary (formerly known as "essential") hypertension.

B. The following are the nutritional aspects of hypertension management that we will discuss:

1. Dietary Approaches to Stop Hypertension (DASH) diet
   a. Increased fruits and vegetables, less red meat
      1) more base-inducing rather than acid-inducing proteins
      2) increased intake of electrolytes that are in high amounts in fruits and vegetables that have been shown to reduce blood pressure (e.g., K^+)
   b. Low-fat dairy
   c. Decreased saturated fat
   d. Decreased calories (independent of weight reduction?)
2. Sodium (Na^+) restriction
3. Weight reduction for overweight/obese hypertensives

II. The Dietary Approaches to Stop Hypertension (DASH) diet

Life style modification including changes in our "standard" diet (i.e., the diet that we who live in industrialized societies routinely ingest) is the recommended first line of treatment for hypertensive individuals (1) and the DASH diet, that has become the preferred recommended diet for individuals with pre-hypertension or hypertension, reduces BP (2).

Because Na^+ intake and body weight were maintained at constant levels in the original DASH trial (2), the DASH diet lowers BP independent of these two important factors that contribute to hypertension (discussed below). Nevertheless, the DASH diet has many components that distinguish it from our standard, ad lib diets, and some of these distinguishing features are outlined above. Because the goal of BP control in hypertensive individuals is to “reduce cardiovascular and renal [kidney] mortality” (1), we will discuss recent data showing that dietary interventions can reduce kidney injury and better preserve GFR in subjects whose GFR is reduced by hypertensive nephropathy. Knowing some of the individual aspects of the DASH diet that contribute to reducing BP not only helps in the design of dietary treatment strategies but might also help provide insight as to the mechanisms that lead to sustained hypertension in some subjects. We will address some of these aspects below.

A. Increased fruits and vegetables, less red meat

1. More base-inducing rather than acid-inducing proteins

a. Epidemiological studies show that strict vegetarians have a lower incidence of hypertension than those who are not (3) and that the BP of vegetarians is less likely to increase with aging as is typically the case in most individuals eating the standard diets of industrialized societies (4). Such studies suggest that reduced dietary intake of particular components of our standard diet was not the responsible factor for this BP difference but that lower BP in vegetarians was due instead a larger intake of potentially beneficial nutrients from the increased intake of vegetables (and fruits) (5). In support of this contention, addition of fruits and vegetables to the Mediterranean diet, one that is similar in make up to the DASH diet and is higher in vegetables than our standard diets, was associated with a lower risk for development of hypertension (6). The typical standard diets of industrialized societies are acid-inducing, due in part to the comparatively high ingestion of red meat and other animal protein (7). Reduction of red meat consumption and substitution with vegetable protein reduced BP in pre-hypertensive, post menopausal women (8). Consequently, the comparatively high acid content of our standard diets might contribute to hypertension and the substitution of base-inducing foods like fruits and vegetables might help reduce BP in hypertensive individuals.

b. African Americans in an urban setting who are at comparatively higher risk for hypertension and its complications (1) have lower intake of fruits and vegetables and the amount of intake is directly related to income (9). These studies support that interventions that increase dietary intake of fruits and vegetables will help in BP reduction for this vulnerable population.

c. Although there are likely many constituents of fruits and vegetables that contribute to the observed beneficial effects of these dietary constituents on blood pressure (increased content of BP-lowering electrolytes; see below), at least one characteristic that might contribute to this benefit is that metabolism of their constituent proteins yields net base production as opposed to animal protein that yields net acid (7). This untoward aspect of our standard diets might contribute to progression of hypertensive nephropathy despite achievement of recommended BP control with regimens that include angiotensin converting enzyme inhibition (10). In support of the important role of dietary acid to the progression of hypertensive nephropathy, oral Na^+ Citrate ameliorated kidney injury and better preserved eGFR in subjects with hypertensive nephropathy and severely reduced GFR (baseline = 33 ml/min) (11). Similarly, oral $NaHCO_3$ ameliorated kidney injury and slowed eGFR rate decline in subjects with hypertensive nephropathy and moderately reduced GFR (baseline = 75 ml/min) (12). Furthermore, oral $NaHCO_3$ slowed the decline rate of creatinine clearance and improved some aspects of nutritional status in subjects with severely reduced GFR of various etiologies (13).

2. Increased intake of electrolytes shown to reduce blood pressure (e.g., K^+)

   a. Fruits and vegetables have many other constituents that might reduce BP in hypertensive individuals, including a comparatively high K^+ content. Population studies show an inverse relationship between K^+ intake and BP and prevalence of hypertension (14). In addition, K^+ depletion increases BP in previously normotensive individuals (15), and exacerbates hypertension in those with primary hypertension (16). Consequently, intake of fruits and vegetables might reduce BP and/or reduce the risk for developing hypertension through increasing K^+ intake. Dietary K^+ intake without Cl^- as the accompanying cation, like that in fruits and vegetables, have greater anti-hypertensive effect (17).

   b. Fruits and vegetables also contain reasonable amounts of calcium and magnesium that might contribute to BP reduction (18, 19). To date, however, the data do not support a major role in BP reduction in comparison to the other factors discussed (18, 19).

B. Low-fat dairy

Some observational studies show a benefit of dairy consumption on BP (20) but a prospective study of subjects ingesting the Mediterranean diet showed that the benefit to reduce the risk of incident hypertension was limited to low-fat, not high fat, dairy consumption (21).

C. Decreased saturated fat

In a head-to-head comparison of DASH diets, the one with higher saturated fat reduced BP in hypertensive subjects less (22), supporting an adverse effect of high dietary fat in BP reduction in the treatment of hypertension.

D. Decreased caloric intake

Reduced caloric intake is understandably associated with reduced body weight so it has been problematic to separate this feature of the DASH diet that distinguishes it from our standard diets with respect to BP reduction. In controlled trials of subjects with hypertension and the metabolic syndrome who ate a Mediterranean diet, reduced carbohydrate lowered BP more than reduced fat although subjects ingesting the reduced carbohydrate diet lost more weight (23).

III. Sodium (Na^+) restriction

A. Dietary Na^+ and the incidence of hypertension

Primary hypertension and the age-related increase in BP is nearly absent in populations ingesting < 50 mmol/day of Na^+ and are most characteristic in populations ingesting > 100 mmol/day of Na^+ (24). In addition, Na^+ more effectively causes hypertension when accompanied by Cl^- as opposed to non-Cl^- anions (25).

B. Effect of Na^+ restriction in the setting of the DASH diet

Three levels of Na^+ restriction in subjects eating the DASH diet led to an incremental BP reduction, the greatest being with the least Na^+ intake (26). In this study, BP was higher in older subjects and the BP-lowering effects of Na^+ restriction were greatest with increasing age (27). By contrast, BP was not different among older and younger subjects ingesting the lowest Na^+ diet (27), supporting the earlier statement that the rise in BP with age requires comparatively high dietary Na^+ intake.

C. Effect of Na^+ restriction on BP reduction among subjects not ingesting the DASH diet

Dietary Na^+ restriction also reduces BP in hypertensive subjects not ingesting the DASH diet (28, 29) and appears to prevent hypertension in overweight/obese individuals (30) eating standard diets.

D. Effect of Na^+ restriction on BP reduction among hypertensive individuals of different ethnic groups.

Na^+ restriction appears to reduce BP among most if not all ethnic groups, doing some among whites (29), blacks (28, 29), and Asians (29).

E. Effect of Na^+ restriction on BP reduction among hypertensive individuals of different ethnic groups.

Na^+ restriction helps control “resistant” hypertension (31), supporting that high dietary Na^+ intake contributes to hypertension that is not optimally responsive to pharmacologic therapy.

F. Efforts to sustain long-term Na^+ restriction

Although Na^+ restriction effectively reduces BP in hypertensive individuals and makes “resistant” hypertension more susceptible to pharmacologic intervention, sustaining Na^+ restriction has proven difficult (32). These and other data across population groups support public health approaches to reducing Na^+ intake in conjunction with individual patient recommendations and counseling.

IV. Weight reduction for overweight/obese hypertensives

A. Effect of overweight/obesity on BP of populations

Epidemiological studies show that age-adjusted prevalence of hypertension increases progressively with higher body mass index in both men and women (33) and the link is stronger for systolic than for diastolic BP (34).

B. Effect of weight loss on the incidence of hypertension

Even modest weight loss among overweight subjects reduces their incidence of hypertension (35) and this reduced incidence is sustained when weight loss is maintained (36).

C. Effect of weight loss on BP of individual overweight hypertensive individuals

A 5% weight reduction in overweight hypertensive individuals with stage 1 hypertension reduces systolic BP by a mean of 4.2 mmHg while also reducing fasting plasma insulin, leptin, and aldostereone (37). Normalization of weight reduced systolic BP even further, by 5.0 mmHg, and some of these subjects with normalized weight achieved normal blood pressure without pharmacologic therapy (36)

D. Efforts to sustain weight reduction

Although weight reduction effectively reduces BP in overweight/obesity individuals with hypertension, in general it has been difficult to sustain the weight loss over the long term and therefore its beneficial effects on BP reduction (38). Consequently, there is need for more research as to how to sustain weight loss in subjects who have been initially successful in achieving it so as to maintain the blood pressure reduction and other benefits of this intervention

V. Sustaining adherence to DASH diet

As indicated, the DASH diet as a whole and many of its components implemented alone effectively reduces BP and maintains this BP reduction with maintenance of the diet. Although attempts at public policy approaches are now being made, these solutions will require time and the sustained effort and cooperation of health care professionals and government leaders to begin implementing and testing potential solutions. In the meantime, neighborhood approaches to implementing the DASH diet might prove successful (39), possibly in conjunction with individual patient recommendations.

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