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A Review of Nutritional Factors in Hypertension Management

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ABSTRACT

Worldwide hypertension is a major health problem posing a great risk to Neuro-Renal-Cardiovascular axis. Increased blood pressure put a lot of impact on patient's quality of life and survival due to enhanced morbidity and mortality. Normalizing blood pressure is known to improve overall health outcomes, which can be achieved through Pharmacological and Non-pharmacological measures. In Non-pharmacological measures changing Life-style is of paramount importance. In life-style alteration dietary modification plays an important role. Many dietary components such as proteins/fats/carbohydrates, minerals like sodium, potassium, calcium, magnesium and vitamins have been studied substantially in the past decades. While some of these nutrients have clear evidence for their recommendation, some remain controversial. Hence, dietary modification remains the main focus in non-pharmaceutical measures. Of the 27 dietary factors widely studied, 17 have been proposed to have protective effects against hypertension, six were proposed to be risk factors for hypertension and rest were neutral. Excessive sodium intake is an important risk factor for hypertension, whereas a diet rich in fruit, vegetables, and low-fat dairy products play a beneficial role.

INTRODUCTION

As per JNC-7 guidelines. adults aged 18 years and older, hypertension is defined as a systolic blood pressure (SBP) equal or more than 140 mmHg and/or diastolic blood pressure (DBP) equal or more than 90 mmHg based on the mean of 2 or more sated blood pressure readings on each of 2 or more visits[1]. JNC-8 recommends the target BP in >60 yr old as 160/90mm whereas in <60 yrs of age as 140/90 mm of HG.[2] As per World Health Organization (WHO), hypertension affects approximately 24.8% of the global population with the range from 19.7% to 35.5% in different regions. It is one of the most common diseases that lead to outdoor visit or hospitalizations and a major risk factor for stroke, congestive heart failure (CHF), myocardial infarction (MI), peripheral vascular disease, and overall mortality. As many of hypertensives remain undiagnosed, and of those who are diagnosed about two-thirds are sub optimally controlled.Now it is conclusively proved that early diagnosis and treatment of hypertension reduces the complications significantly.[4] Therapeutic options include diet and lifestyle changes (including weight loss, smoking cessation, and increased physical activity), antihypertensive drugs, and surgery in special situations. Many studies have conclusively proved that some dietary factors like sodium, potassium, calcium, dietary fibres, fat intake affect blood pressure levels. Modification of these esp.in pre-hypertensive stage (SBP 120-139 & DBP 80-89 mmHg) help in preventing complications.[3]

Let us review the role of each individual dietary factors.

SODIUM

Guyton's physiologic concept that the role of the kidney in handling sodium is key to the long-term regulation of blood pressure is now generally accepted.[5] However, the exact role that dietary sodium plays in this relationship remains controversial. The relationship between renal handling of sodium and blood pressure is apparently influenced by a complex combination of factors including nutritional, environmental, genetic, neuro-hormonal, and metabolic factors. Various studies have proved that hypertension is predominantly observed in persons with average sodium chloride intake >100 mmol/day and very rare in populations consuming <50 mmol/day.[4]

As a review of physiology, sodium homeostasis is maintained by glomerular filtration and tubular reabsorption. About 3/4th of sodium reabsorption is mediated by neuro-humoral hormone in the proximal (angiotensin II and norepinephrine) and collecting tubules (aldosterone, atrial natriuretic peptide), whereas 1/3rd occurs in the loop of Henle and distal tubules.

However, the link between salt and hypertension is still an on going debate. Heterogenous blood pressure response, both in hypertensive & normotensive individuals, to salt intake has led to the concept of salt sensitivity vs salt resistance.

Salt sensitivity is a measure of how your blood pressure responds to salt intake. People are either salt-sensitive or salt-resistant. Those who are sensitive to salt are more likely to have high blood pressure than those who are resistant to salt. Salt sensitivity is defined as decrease in mean arterial pressure ≥10 mmHg and salt resistance as decrease in ≤ 5 mmHg after giving 2 Litres of normal saline intravenous with 3 doses of oral 40 mg furosemide. Salt sensitivity has a higher prevalence in certain populations older age, black, insulin resistance, micro-albuminuria, chronic kidney disease (CKD), and low renin level. Salt sensitivity has been proved to be an independent prognostic factor for increased risk of left ventricular hypertrophy, cardiovascular events, and cumulative mortality, regardless of blood pressure. The

physiological mechanism of salt sensitivity hypertension is by affecting renal tubular Na^+K^+ ATPase activity, decreasing dopamine receptor function in renal proximal tubule, or altering endothelium receptor activity[4,5].

Dietary sodium restriction is strongly advocated as a lifestyle change for prevention and treatment of hypertension and consequently cardiovascular morbidity and mortality. Evidence from several clinical studies like INTERSALT[5],DASH-Sodium Trial[6] shows that a reduction in sodium intake leads to moderate to large reduction in blood pressure in normotensive and hypertensive participants, blunting of age related increase in BP and decreased risk of cardiovascular events as well. Galletti et al. found that in salt sensitive patients, there was a strong correlation between 24-hr urinary sodium excretion and blood pressure changes[7].

On the contrary, some studies have shown the harmful effects of lower salt intake on important clinical outcomes like in diabetics including MI, stroke, ESRD patients. There is increased cardiovascular mortality and higher CHF readmissions due to increased levels of sympathetic hormones, fasting plasma glucose, insulin, brain natriuretic peptide and cholesterol. In addition, there is enhanced development of end stage renal disease (ESRD). Hence, restriction of salt intake is recommended with caution to the climate conditions (high temperate zones), diabetic status, ESRD (End stage Renal Disease), strokes[7] etc.

Currently, based on available evidence, the WHO strongly recommends the restriction of daily sodium intake to less than 2000 mg, while the AHA advises lower than 1500 mg sodium per day[8].

POTASSIUM

Potassium intake is inversely related to both SBP and DBP. This is well proven in many population-based studies.Patients with potassium intake of 1000 mg/day had a 0.9 mm Hg lower SBP and a 0.8 mm Hg lower DBP. Potassium depletion has been shown to be associated with decrease in sodium excretion, plasma renin activity, and plasma aldosterone concentrations with an increase of 7 mmHg of SBP and 6 mmHg of DBP. A meta-analysis of 27 trials in adults demonstrated the same relationship between BP & potassium intake[9]. The magnitude of BP reduction may be smaller but taking into the consideration of complications associated with hypertension, the benefit calculates to be a large one.

The benefit effect of potassium intake on blood pressure reduction appears to be greater in patients with hypertension, longer duration of supplementation, and concurrent high intake of sodium. And moreover, this protective effect of potassium did not differ by other dietary variables and known cardiovascular risk factors (age, sex, blood pressure, blood cholesterol level, obesity, fasting blood glucose level, and cigarette smoking. The antihypertensive effect of potassium supplementation seems to be from following:

1. Natriuresis by inhibiting sodium reabsorption in the proximal renal tubules and suppressing renin secretion.
2. Normalization of the plasma level of digitalis like substance.
3. Increased urinary volume excretion.
4. Smooth muscle relaxation by increasing nitric oxide production.
5. Suppression of free radical formation.
6. Protection against vascular injury in salt sensitive hypertension.
7. Hyperpolarization induced vasodilatation.

Which one of these mechanisms plays a predominant role in the reduction of blood pressure and/or cardiovascular mortality is not quite clear[10].

The 2003 WHO/International Society of Hypertension statement on management of hypertension supported an increased dietary potassium intake[11]. The daily intake recommended is 4700mg/day[11]. Foods rich in potassium are vegetables, fruit, dairy products, nuts, and so forth. Natural source of potassium is preferable.

Currently, pharmacological potassium supplementation is not recommended as a method of increasing daily intake of potassium[12].

CALCIUM

The relationship between calcium intake and hypertension is a complex and difficult. The evidence on benefits is inconclusive. This is largely because of the interaction with other nutrients in the diets and difficulty in reliably collecting calcium intake data. Many studies have proved an inverse relationship between dietary calcium intake and blood pressure. Supplementation with 1000 mg calcium/day has shown to decrease blood pressure, though the results were inconsistent and mainly among hypertensives. In contrast, other studies report minimal or no effect of dietary calcium or supplementation on blood pressure[13]. Whereas, contradictory results have been exemplified by the Nurses' Health Study and the NHANES[13].

Proposed mechanisms by which calcium intake regulates blood pressure include

i. Alteration in intracellular calcium which in turn affects vascular smooth muscle contraction.
ii. Increased natriuresis.
iii. Modulation of the function of the sympathetic nervous system[14].

Currently, the evidence on the benefit of calcium supplementation in prevention or treatment of hypertension is weak; therefore, there is no justification to increase the intake of calcium above the recommended dietary allowance of 1000–1300 mg/day based on age and gender. Foods rich in calcium are mainly dairy products (preferably low fat) such as milk, cheese, and yogurt.

MAGNESIUM

Relationship between magnesium & BP control is still ill defined. Some studies have shown that its deficiency results in increased blood pressure. Whereas, a meta-analysis of 29 observational studies points to a negative correlation between dietary magnesium intake and blood pressure. On the basis of these data, the relationship between magnesium and hypertension seems inconsistent and not convincing. Currently magnesium supplementation is not recommended as a means of hypertensive treatment[15].

FIBRE

Fibre is the indigestible portion from plant-based food. Increased fibre intake has inverse relationship with blood pressure. The exact mechanism of action is not clear. In a study of 30,681 male health professionals, 40–75 years old,it was found that those with a fibre intake of less than 12 g/day were at higher risk of developing hypertension. Whereas, persons taking more than 24 g/day had lower blood pressure. This relationship was independent of other nutrients including sodium, potassium, calcium, and magnesium[16].

OMEGA-3 POLYUNSATURATED FATTY ACID (FISH OIL)

Omega-3 Fatty acids aka Polyunsaturated fatty acids (PUFA) contains both Docosahexaenoic acid (DHA) and Eicosapentaenoic acid (EPA). Omega-3 fatty acids are essential nutrients that are important in preventing and managing heart diseases. It helps to lower blood pressure, reduce triglycerides, slow the development of plaque in the arteries, reduce the chance of abnormal heart rhythm, reduce the likelihood of heart attack and stroke, lessen the chance of sudden cardiac death in people with heart disease[17].

In many studies daily dietary fish consumption has shown benefits in reducing blood pressure. An analysis of 17 clinical studies using fish oil supplements found that taking 3 or more grams of fish oil daily may reduce blood pressure in people with untreated hypertension. Care should be taken for eating contaminated fish as contains very high levels of mercury. Mercury tend to raise the blood pressure due to high levels of methylmercury, which has a direct bearing on SBP & DBP.

7. GARLIC

Garlic is one of the most commonly used natural herbs. Its role in hypertension has also been explored by researchers. In patients with baseline elevated blood pressure, compared with placebo, garlic significantly reduced SBP by a mean of 16.3 mmHg and DBP by 9.3 mmHg The effect was repeatedly illustrated in another meta-analysis[18].

8. NUTS-DRY FRUITS

A. The pistachio (per 30gm) is low in sodium (3mg); high in potassium (295mg); high fibres (3gms); high magnesium (34 mg) with high levels of MUFA[19].

B. Almonds (per 30 gm) contains high magnesium (76 mg);Potassium (200mg);fibres (4 gm);high levels of vit.E (24.2mg) with low saturated fats.

C. Hazelnut (per 30 gms) contains high fats but low saturated fats & high potassium (193 mg); magnesium (46 mg) and fibres (3 gms).

D. Resins :Very high in Potassium, low in sodium, very low saturated fats.

E. Cashews: High in fat content but mostly MUFA, high in sodium (3.5 mg); high potassium (185 mg).

F. Peanuts: are not actually nuts but are legumes, but because of their similarties to nuts. Contains high levels of niacin & anti-oxidants.

G. Walnut (per 30 gms) contain higher level of PUFA (1980 mg); low in sodium (1 mg); high in fibres (4 mg), Potassium.[20]

FLAX SEEDS

Extraordinary results reported in a rare example of a double-blinded, placebo-controlled, randomized trial of a dietary intervention (flaxseeds) to combat high blood pressure, flax seeds intake every day reduce systolic blood pressure about 10 mm, and their diastolic, by about 7 mm[21].

10. GREEN TEA

Green tea contains polyphenol, an antioxidants recognized for disease prevention and anti-aging effects. Polyphenols are flavonoids, which contain catechins.Epigallocatechin-3-gallate (EGCG) is the most powerful catechin. After 12 weeks of drinking tea, blood pressure was lower by 2.6 mmHg systolic and 2.2 mmHg diastolic[22]. Matcha green tea and Tulsi—provide the maximum benefits. Besides being an excellent source of antioxidants, green tea is also packed with vitamins A, D, E, C, B, B5, H, and K, manganese, and other beneficial minerals such as zinc, chromium, and selenium. To boost the benefits of green tea, add a squirt of lemon juice to your cup. Previous research has demonstrated that vitamin C significantly increases the amount of catechins available for your body to absorb. In fact, citrus juice increased available catechin levels by more than five times, causing 80 percent of tea's catechins to remain bioavailable. EGCG acts by vasodilatation[22].

FRUITS & VEGETABLES

Starchy vegetables, such as potatoes and sweet potatoes, are high in potassium and low in sodium, hence tend to lower blood pressure.

Citrus fruits, such as oranges, tangerines and grapefruits, and berries, such as strawberries, raspberries, blueberries and blackberries, are high in potassium, vitamin C and dietary fibre, hence lower BP.

Beans, peas and lentils are legumes are good for high blood pressure because they are high in dietary fibre and potassium.

They are also good sources of magnesium.

Dark green leafy vegetables are high in dietary fibre, potassium, vitamin C and magnesium. Romaine lettuce,

spring greens and fresh spinach, broccoli, mustard greens are good examples. Opt for fresh greens because canned vegetables have added sodium. Frozen vegetables can also be used as nutrients are same as fresh vegetables and they are easy to store[22].

Berries, especially blueberries-strawberries are rich in flavonoids. Study found that flavonoids prevent hypertension and help to reduce cholesterol levels. Blueberries, raspberries, and strawberries should be added to your diet.

BEET: Beetroot juice has shown to lower BP in hypertensives & lower serum cholesterol & blood sugar levels.The study found that the nitrates in the juice brought down the participants' blood pressure within just 24 hours.

Skim milk: The DASH Diet[26] recommends increasing the amount of calcium-rich foods. Skim milk is an excellent source of calcium and is also low in fat.

High-fiber, low-fat, and low-sodium foods are ideal foods for lowering blood pressure, and oatmeal fits the scheme.

Bananas are a great way to add potassium to your diet. Eating foods that are rich in this mineral is better than taking supplements[26].

ALCOHOL

A standard drink in the USA is equal to 14 g of alcohol,which is present in 12 oz (355 ml) of regular beer (6% alcohol), 5 oz (150 ml)of wine (12% alcohol), and 3 oz (90 ml) of 42% proof whiskey or distilled spirits. This serving size can be varied in different countries. However we refer "a drink" to the US serving size.[23]

**Moderate alcohol intake, defined as a maximum of 2 alcoholic drinks/day in men and 1 alcoholic drink/day in women and lighter-weight persons (AHA 2006 scientific statement of hypertension management.[28] After adjustment for measurement error, BMI and dietary variables, the dose calculating variable is 0.68 (large BMI i.e.>28 and 0.46 in smaller BMI (>28). In a prospective cohort study involving 11,711 men with pre-existing hypertension, individuals who consumed a moderate amount of alcohol tended to have a lesser BP & decreased risk of MI.

** On the other hand, heavy drinking, generally referred to as any amount of alcohol use above the moderate level, is associated with a higher risk of hypertension in a dose-dependent manner. The risk seems more pronounced in individuals with a smaller BMI. In the INTERSALT study, compared to non-drinkers, men who drank 300–500 mL alcohol/week had higher SBP/DBP, on average 2.7/1.6 mmHg. Women who drank at least 300 mL/week had blood pressures higher by 3.9/3.1 mmHg than non-drinkers. Alcohol reduction was associated with a fall in blood pressure. Available data supports that moderate alcohol consumption should be recommended as one of the components of hypertensive therapy[23].

PRODUCTS WITH POTENTIAL HARMS

Caffeine

Caffeine, found in coffee, tea, sodas and many energy drinks, is used as a stimulant. Caffeine can elevate blood pressure in non habitual caffeine users whereas, little or no effect was seen in habitual coffee drinkers. It has been conclusively proved that chronic coffee drinkers who have hypertension need not to stop it on basis of available data, as it can potentially be harmful for irregular coffee drinkers[24].

Licorice

Licorice is used as a flavoring agent in chewing tobacco, candies, spices, and as a medical product in some gastrointestinal and upper respiratory disorders. It contains glycyrrhetinic acid which inhibits 11-beta-hydroxysteroid dehydrogenase enzyme type 2 isoform, allowing cortisol to bind to the mineralocorticoid receptors creating a status of mineralocorticoid excess and subsequently blood pressure elevation. The excessive use of licorice can be potentially dangerous in hypertensive individuals[25].

SPECIAL DIETARY SYSTEMS

DASH Diet

The DASH diet is a diet rich in fruits and vegetables (4-5 servings/day) and low-fat dairy products (2-3 servings/day) and includes whole grains, poultry, fish, and nuts. This diet is rich in potassium, magnesium, calcium, dietary fibres, and protein and has reduced fat (total and saturated) and cholesterol (<25%), red meat, sweets, and sugar-containing beverages[26].

The initial DASH trial with participants with prehypertension and stage I hypertension showed blood pressure reduction by 5.5/3.0 mmHg and 2.8/1.1 mmHg This reduction was higher among the subset of hypertensives (GR II & above) at 11.4/5.5 mmHg compared with 3.5/2.1 mmHg. In addition, the reduction in blood pressure began within two weeks and was sustained for the next six weeks. In this study salt intake was kept at constant measure.

The DASH-sodium trial[35] was a crossover trial with participants on DASH Diet but with 3 levels of sodium intake (low: 1.2 gm/day, intermediate: 2.3 gm/day, and high: 3.5 gm/day). Participants had SBP between 120 to 159 mmHg and DBP between 80 to 95 mmHg. Similar to the earlier study, the DASH diet significantly lowered blood pressure and reducing the sodium intake significantly decreased blood pressure. These effects persisted in those with and without hypertension, as well as across the different races and sex. The combination of the DASH diet and low sodium intake had the greatest impact, reducing SBP by 11.5/5.7 mmHg and 7.1/3.1 mmHg among hypertensives and –non-hypertensives.The effect was so much so that the level of BP reduction in hypertensive was comparable to that obtained with drug monotherapy.[26]

Other potential benefits of the DASH diet include reduction in cardiovascular morbidity, mortality,

CHF events, and cardiovascular risks factors as well as prevention of type 2 diabetes. AHA, JNC-7 & now 8, AACE & almost all Hypertension Education Programmes recommend DASH diet with Low sodium Intake[27].

Vegetarian Diet

Many cohort population based studies have proved the lower levels of blood pressure in vegetarians compared to persons consuming Non-vegetarian diets. It is probably low sodium intake in vegetarian diet. Vegetarian diet with increased intake of fruit and vegetables, polyunsaturated vegetable margarines, and oils, fibre, calcium, and magnesium and decreased intake of protein in mild untreated hypertensive patients resulted in a fall of 5 mmHg in SBP. This diet improved blood pressure without a change in urinary sodium or potassium excretion or body weight[28].

JNC-8 RECOMMENDATIONS[29]

1. *Grade A Recommendation*: Consume a dietary pattern that emphasizes intake of vegetables, fruits, and whole grains; includes low-fat dairy products, poultry, fish, legumes, non-tropical vegetable oils and nuts; and limits intake of sweets, sugar-sweetened beverages and red meats.[29]

   *Adapt this dietary pattern to appropriate calories requirement, cultural food preferences and nutrition therapy for other medical conditions like Diabetes.

   **Achieve this pattern by following plans such as Dash Diet, Vegetarian Diet, USFDA Food pattern or American Heart Association Diet.

2. Lower sodium intake. Consume no more than 2,400 mg of sodium per day and that a further reduction of sodium intake to 1,500 mg can result in even greater reduction in blood pressure.

3. Combine the DASH dietary pattern with lower sodium intake.

CONCLUSION

Dietary modification plays a very important therapeutic role in blood pressure control. Strong evidence supports the recommendation of a diet containing high potassium, moderate alcohol, and high fibre intake. As a whole, a DASH / Vegetarian diet rich in fruits, vegetables, low-fat dairy products, whole grains, nuts, and fish with reduced amount of red meat, fat, sugar-sweetened food and beverages is recommended. The BP lowering effect can further be compounded by Sodium restriction & high potassium intake. The recommendation is not quite definite in terms of increased intake of calcium, magnesium, fish oil, and garlic. Irregular coffee drinkers and licorice consumers face a possibility of inducing hypertension; thus, these habits need to be avoided in patients at risk. These recommendations are proven to be helpful in reducing blood pressure and hypertension-related complications and overall mortality. However, in view of the heterogeneity in risk factors, patient features, and pathogenesis of hypertension, the approach should be individualized.

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