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Review Article

Calcium, Vitamin-D and Hypertension: Interaction, Risk and Benefit

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Abstract

Hypertension is an anomaly when the blood pressure exerted by the blood on the blood vessels is higher than normal. Severe complications associated with hypertension include heart diseases, stroke and death. Blood pressure is generally the force exerted by the blood against the walls of the blood vessels. The pressure depends on the work being done by the heart and the resistance of the blood vessels. When a patient has a blood pressure higher than 130/80mmHg, such patient is considered hypertensive according to guidelines issued by the American Heart Association (AHA) in November 2017. The current review is to examine the interaction between hypertension and Calcium and Vitamin D. It's been observed that Calcium and Vitamin D may separately and collectively protect the cardiovascular system (CVS) and reduce risks of developing hypertension. While calcium binds to fatty acids and bile acids in the gut, resulting in malabsorption of fat, and a direct effect on adipocytes with increased lipolysis, vitamin D binds with vitamin-D receptors on the cells produced by many cells in the muscle that lines the blood vessels cells preventing free flow of blood in the vessels. Their beneficial effects alone are however not sufficient to make them sole antihypertensive drugs in the treatment/management of hypertension.

Keywords: Hypertension; High Blood Pressure; Vitamin D; Calcium; Calcification; Vascular Events

Introduction

Hypertension

Hypertension, also known as high blood pressure, is a chronic medical condition in which the blood pressure in the arteries is elevated, causing the arteries to stretch beyond normal.

When arteries are stretched due to high pressure exerted on them by blood, scars are formed on which debris such as cholesterol, calcium or blood cells could get stuck, thereby causing eventual build-up of the debris along the vessel and blocking the arteries and preventing smooth flow of blood to all parts of the body. This resistance in blood flow can constitute additional demand on the heart as it will have to do more work to get blood across to different parts of the body [1]. This can increase the risk of other complications, such as myocardial infarction.

Some risk factors can increase chances of developing hypertension. They could be associated with individual's lifestyle and can be controlled, like diet. Others such as race, age or gender can't be controlled.

Symptoms

Hypertension often has no symptoms but can cause other complications like heart and artery damage, vision and memory loss, stroke, and kidney damage.

In rare cases of extremely high blood pressure, hypertension can give rise to what is described as hypertensive crisis and occurs in about 1% to 5% of people with hypertension [2]. Headaches, nosebleed, severe anxiety, and respiratory stress are some symptoms of hypertensive crisis [1].

Prevalence

Approximately 4 out of every 10 persons have hypertension across the world. Factors like family history, age, diet, gender, race, and obesity will increase the risk of developing hypertension. Sedentary lifestyle, smoking and diabetes could also constitute a serious risk.

To determine an individual's blood pressure, systolic blood pressure is measured against diastolic blood pressure, and the unit is mmHg. Systolic blood pressure is the pressure exerted on the arteries by blood when the heart beats and pumps the blood, while diastolic blood pressure is the pressure exerted on the arteries when the heart is at rest before the next beat.

A systolic blood pressure higher than 140 millimeters of mercury (mmHg) and a diastolic blood pressure higher than 90 mmHg results in a condition diagnosed as high blood pressure [1].

Calcium

Calcium, a mineral that is essential for bones and teeth development, is equally needed by the heart, nerves, and blood-clotting systems to carry out their functions.

Calcium is used in the treatment and prevention of hypocalcaemia, a condition of low calcium level that results in bone conditions, such as osteoporosis, and osteomalacia. It is also used to manage premenstrual syndrome, pre-eclampsia, and reducing the risk of cancer of the colon and rectus.

It also functions to resolve complications that may arise after intestinal bypass surgery, high blood pressure, high cholesterol, Lyme disease, to reduce high fluoride levels in children, and to reduce high lead levels.

In the form of calcium carbonate, calcium it is used as an antacid to reduce condition of "heartburn". Calcium carbonate and calcium acetate are taken to reduce phosphate levels in patient suffering from kidney disease.

Foods such as milk and dairy products are rich in calcium.

As calcium is released from the body through skin cells, waste and sweat, its concentration in the body tends to decline over time with age. Also, absorption of calcium tends to drop as women age due to declining estrogen concentration levels. Gender, race, and age are some of the factors that affect calcium absorption. Also, lowering level of estrogen in women due to age also lowers calcium absorption.

Vitamin D

Vitamin D, a well-known vitamin for its essential role in maintaining healthy bones, is found in small amounts in a few foods, including fatty fish. A food is said to be fortified with vitamin D when vitamin D is added to such food. About 80% of the vitamin D that the body gets is obtained through exposure to sunlight and from medicine.

The Vitamin is used for preventing and treating rickets, a condition that is caused by deficiency of vitamin D. Calcium is also used in the treatment of osteoporosis, osteomalacia, and an inherited disease in which the bones are vulnerable to breaking.

Vitamin D is used to manage conditions of the heart and blood vessels, including hypertension and high cholesterol. It is also used for arthritis, obstructive pulmonary disease (OPD), and bronchitis.

Calcium is highly involved in the regulation of phosphorous and calcium. In fact, it is used to manage conditions caused by low levels of phosphorous and calcium.

In the form of calcitriol or calcipotriene, Vitamin D is applied directly to the skin for a particular type of psoriasis. It is also involved also involved in maintaining proper bone structure.

Interaction between Calcium, Vitamin D and Hypertension

*Vitamin D and Hypertension

Researches have shown that there is a link between vitamin D and hypertension. Vitamin D level is inversely proportional to blood pressure/hypertension. Persons with higher vitamin D levels tend to have lower blood pressure and are less likely to develop hypertension [4]. Taking a vitamin D supplement may help people lower their blood pressure [5].

Vitamin D certainly will not make hypertension worse as long as it is taken in appropriate dose. However, a hypertensive patient or someone trying to prevent hypertension cannot depend solely on vitamin D in place in the place of treatment medication as its effects may not be sufficient to manage the conditions [4].

Some experiments have revealed that vitamin D supplement may lower systolic blood pressure but may not have similar effect on diastolic blood pressure [5].

A review of many studies involving people with hypertension revealed that [6]:

1. For each 10 mg/ml increase in someone's vitamin D levels, they had a 12% lower risk of developing hypertension.
2. The people with the highest vitamin D levels had a 30% lower risk of developing hypertension compared to the people with the lowest levels.

Another previous work looked at the effects of taking a vitamin D supplement on risk of hypertension in African Americans who had normal blood pressure. The researchers assigned 250 people to receive either 1,000 IU per day, 2,000 IU per day, 4,000 IU per day, or a placebo for 3 months. Here is what the researchers found [7]:

1. For every increase in vitamin D supplementation and vitamin D levels in the body, systolic blood pressure decreased.
2. Diastolic blood pressure didn't change in any group.

Also, in 2008, a study used data from a large experiment that assigned women to either receive 1,000 mg per day of calcium plus 400 IU per day of vitamin D or a placebo pill. For this study, the researchers took those results and looked at how it changed their blood pressure and risk of getting hypertension. The results showed [8]:

1. There was no difference in blood pressure changes be tween the groups.

The study used only a small dose of vitamin D and also included calcium, which makes it hard to say whether or not vitamin D on its own would have had an effect.

Another research looked at the effects of vitamin D supplements on lowering blood pressure in people with hypertension. For 20 weeks, people either took 3,000 IU per day of vitamin D or a placebo pill [9]. The researchers measured a few different types of blood pressure and found that:

1. The people in the vitamin D group had lowered blood pressure than the people getting the dummy pill.

2. People in the vitamin D group who had low levels of vitamin D at the beginning of the study had a further reduction in their blood pressures.

Vitamin D may be more effective in lowering blood pressure in people who have low levels of vitamin D.

Other studies on the role of vitamin D supplementation on regulating the blood pressure system in the body were conducted, and it was found that [10]:

1. Vitamin D levels increased throughout the study.
2. The blood pressure system was greatly reduced.

Generally, and from the various researches, it can be inferred that:

1. People with higher vitamin D levels are more likely to have lower blood pressure and are less likely to develop hypertension.

2. Taking a vitamin D supplement can reduce blood pressure in people with hypertension.

3. Taking a vitamin D supplement helps regulate the blood pressure system in the body.

Vitamin D and Hypertension: Mechanism of Interaction

The body sometimes could produce too many cells in the muscle that line the blood vessels. A build-up of these cells makes it difficult for blood to travel through the vessels round the body. But vitamin D binds with vitamin-D receptors on these cells. This may help to reduce the risk of cells building up in the blood vessels thereby allowing free flow of blood round the body [11].

Also, studies ranging from animal to clinical trials have shown that pharmacological doses of vitamin D notably reduce inflammation [12], improve endothelial function [13], control the secretion of insulin and improve insulin sensitivity [14]. These put together will act to reduce the blood pressure.

Vitamin D may help in reducing the activity of the system that controls the blood pressure. This system called the Renin-Angiotensin System (RAS), when overactive, causes blood pressure to increase. The interaction between vitamin D and RAS tends to help control the activities of RAS thereby reducing the blood pressure.

Calcium and Hypertension

An inverse relationship between calcium and blood pressure has been observed in several studies. In a meta-analysis of randomized controlled trials, both dietary calcium intake and calcium supplements were associated with reduced blood pressure, with a trend towards larger effects with dietary intake [14].

Similarly, another trial showed significantly lower rates of hypertension amongst women aged over 45 years with a dietary calcium intake of at least 679 mg/day. In women in the highest quintile of dietary calcium intake (1,000 to 2,560 mg calcium/day), the relative risk reduction was 13% (RR 0.87, 95% CI 0.81 to 0.93). However, in women taking calcium supplements, even in the highest dosed quintile (1,000 - 2,100 mg), the risk of hypertension was unchanged (RR 1.07, 95% CI 0.97 to 1.18) [14,15]. It will therefore be correct to say that the relationship between calcium intake and vascular diseases is that of inverse proportion.

Calcium and Hypertension: Mechanism of Interaction

Reduction in serum lipid concentration and body weight might be involved in the observed Calcium's protection against vascular diseases, and potential beneficial effects of calcium on a number of vascular risk factors [15].

Calcium may have bound to fatty acids and bile acids in the gut, resulting in malabsorption of fat, thereby reducing serum lipid concentration, and also by a direct effect on adipocytes with increased lipolysis [6,17-19].

In a randomized controlled trial in men, a calcium-fortified diet significantly reduced total cholesterol, Low Density Lipoprotein cholesterol (bad cholesterol) and apolipoprotein-B [18]. Also, in a randomized placebo-controlled trial in postmenopausal women, a supplement of 1,000 mg calcium during 12 months increased high-density lipoprotein (good cholesterol) levels, and also increased the ration of HDL to LDL cholesterol [20,21]. The HDL is generally known to mop up the LDL (bad cholesterol) from the blood vessels, such that it protects the blood vessels from congestion, thereby protecting the cardiovascular system.

Reduced body weight has been implicated as well; several large epidemiological studies have revealed that dietary calcium intake and calcium supplements may be associated with weight loss [22,23], an effect that might be mediated by the same mechanisms affecting lipid profile [23].

Calcium and cardiovascular risk

Spontaneous calcium intake, up to 800 mg/day, may not be associated with any detrimental cardiovascular effects, however, the cardiovascular safety of calcium supplements has been questioned; rather than having a neutral or even beneficial effect, increased exposure to calcium supplements may actually increase cardiovascular risk [24].

In a meta-analysis published in 2010 by Bolland and colleagues in the British Medical Journal, more than 12,000 individuals from 15 double-blind placebo-controlled randomised trials were enrolled, and an increase in the incidence of myocardial

infarction of about 30% was seen in individuals on calcium supplements (≥ 500 mg daily) compared to those on placebo [25-27]. More specifically, the analysis of patient level data showed that the relative risk of incident myocardial infarction in individuals allocated to calcium increased by 31% (HR 1.31, 95% CI 1.02 to 1.67) and trial level analysis showed a similar increase in risk by 27% (HR 1.27, 95% CI 1.01 to 1.59). However, no significant increase was observed in the incidence of a number of related vascular endpoints, including the incidence of stroke (HR 1.20, 95% CI 0.96 to 1.50), death (HR 1.09, 95% CI 0.96 to 1.23) and the composite end point of myocardial infarction, stroke and sudden death (HR 1.18, 95% CI 1.00 to 1.39).

The findings of this meta-analysis were partly driven by a previous randomised placebo-controlled trial from the same group that contributed 17% to the overall weight [28]. In this trial, calcium supplements were associated with a significant increase in High Density Lipoprotein cholesterol levels, but, however, with also an increased risk of myocardial infarction [20,28].

Calcium supplements may acutely elevate serum calcium levels and thereby enhance vascular calcification [28,29]. Studies have shown that high serum calcium levels are associated with vascular calcification and an increased risk of vascular events, including myocardial infarction, stroke and death [30,31]. Detrimental effects of acute increase in serum calcium is also seen in the meta-analysis, dietary intake which was not associated with myocardial infarction, in support of the observations that calcium from dairy products hardly affects serum calcium levels [27].

Calcium combined with Vitamin D and Hypertension

Studies that combined calcium and vitamin D supplements showed that Calcium combined with vitamin D did not cause an increase in cardiovascular risk but rather improved it [32,33]. Potential detrimental vascular effect of calcium supplements may have been countered by correction of vitamin D deficiency [34,35].

Conclusion

Calcium and Vitamin D may individually protect the cardiovascular system (CVS) and reduce risks of developing hypertension. Their benefits may even be better appreciated when they are combined.

While Calcium may achieve that by reducing body's serum lipid concentration and consequently body weight by binding to fatty acids and bile acids in the gut, resulting in malabsorption of fat, and by a direct effect on adipocytes with increased lipolysis, thereby protecting against vascular diseases, Vitamin D does so by binding with vitamin-D receptors on accumulated cells in the vessels thereby helping to reduce the risk of cells building up in the blood vessels and allowing free flow of blood round the body.

However, use of vitamin D may not be primary endpoint to cardiovascular diseases. Recommendation of supplemental vitamin D intake for the prevention of cardiovascular diseases or hypertension in place of antihypertensive drugs may therefore not be advised, as it may not be sufficient to achieve that.

Supplement calcium could also have some risk effects on the CVS as high exposure to it could acutely elevate serum calcium levels and, as a result, may enhance vascular calcification and an increased risk of vascular events, including myocardial infarction, stroke and death.

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