Modest Salt Reduction Lowers Blood Pressure in Isolated Systolic Hypertension and Combined Hypertension

Feng J. He, Nirmala D. Markandu, Graham A. MacGregor

Abstract—Many randomized trials have shown that a reduction in salt intake lowers blood pressure in hypertensive individuals. However, few have looked at the effects according to hypertension category. A recent analysis of the third and fourth National Health and Nutrition Examination Survey suggests that salt intake may not be related to blood pressure in isolated systolic or combined hypertension. To look at this further, we reanalyzed the data of our previous salt reduction trials. Hypertensive individuals were studied in randomized double-blind crossover studies: 1 month of usual salt intake compared with 1 month of reduced salt intake. In isolated systolic hypertension (n = 24), blood pressure was reduced from 166±19/86±7 to 156±20/85±7 mm Hg (systolic P < 0.001; diastolic P = 0.459) with a reduction in urinary sodium from 175±51 to 87±38 mmol per 24-hour period (10.3 to 5.1 g per day of salt). In combined hypertension (n = 88), blood pressure was reduced from 161±16/100±9 to 154±17/96±9 mm Hg (P < 0.001) with a reduction in urinary sodium from 176±65 to 98±51 mmol per 24-hour period (10.4 to 5.8 g per day of salt). These results demonstrate that salt reduction has a significant effect on blood pressure in isolated systolic and combined hypertension. The fall in systolic observed in isolated systolic hypertension would be predicted to reduce stroke by approximately one third, ischemic heart disease by one quarter, and heart failure by one quarter in the population between 60 and 80 years of age, in whom isolated systolic hypertension is the predominate form of hypertension and carries the highest risk. These results provide strong support for universal salt reduction in all hypertensives. (Hypertension. 2005;46:66-70.)

Key Words: blood pressure; sodium, dietary

Raised blood pressure is an important risk factor for cardiovascular disease (strokes, heart attacks, and heart failure).1 2 In the past, greater emphasis was placed on diastolic than systolic blood pressure because raised diastolic was thought to confer higher risk for cardiovascular disease than raised systolic blood pressure.3 4 However, recent epidemiological studies have demonstrated that systolic blood pressure is more strongly associated with cardiovascular disease, and raised systolic predicts cardiovascular risk better than raised diastolic.1 5 6 Unlike diastolic, systolic blood pressure increases progressively with age,7 and in the aging societies, raised systolic blood pressure is the most common form of hypertension. In the third and fourth National Health And Nutrition Examination Surveys (NHANES III and IV), isolated systolic hypertension accounts for 60% of all types of newly diagnosed hypertension (ie, isolated systolic, isolated diastolic, and combined hypertension) in the population between 20 and 70 years of age.8 This figure would be much higher if individuals >70 years of age were included. Treatment trials with antihypertensive drugs have demonstrated a clear benefit of lowering blood pressure in isolated systolic and combined hypertension.9 11 However, there is no treatment trial in isolated diastolic hypertension.

There is much evidence from epidemiological,12 migration,13 intervention,14 genetic,15 and animal studies16 that dietary salt intake plays an important role in regulating blood pressure, and our current high salt intake is responsible for the rise in blood pressure with age. Many randomized trials have shown that a reduction in salt intake lowers blood pressure in hypertensive and normotensive individuals.17 However, few have looked at the effects of salt reduction according to hypertension category. A recent analysis of NHANES III and IV showed that salt intake was associated directly with blood pressure only in individuals with isolated diastolic hypertension; however, there was no significant association between salt intake and blood pressure in combined hypertension, and there was an inverse association between salt intake and blood pressure in isolated systolic hypertension.8 Despite acknowledging that the methods of documenting dietary intakes in NHANES III and IV are subject to substantial bias, the authors of this report still suggest that salt reduction should be targeted to a subgroup of hypertension only (ie, isolated diastolic hypertension). To determine directly the effect of salt reduction on blood pressure in isolated systolic hypertension and in combined hypertension, we reanalyzed the data of our previous randomized double-blind salt reduction trials.

Methods
We combined the data of 4 previous studies of a modest reduction in dietary salt intake from ~10 to 12 g per day to 5 to 6 g per day for...
1 month.18–21 All 4 studies used the same protocol. In one of these studies, there were 3 levels of salt intakes,19 and for the purpose of this analysis, we included the high and intermediate levels; that is, when urinary sodium was 190 and 108 mmol per 24-hour period (11 and 6 g per day of salt). The methods of these studies have been reported in detail previously18–20 and summarized here.

Patients were referred to the Blood Pressure Unit by local general practitioners. They had not received previous treatment, or treatment had been stopped for ≥4 weeks, or 8 weeks for patients on diuretics before the study. We excluded individuals with secondary cause of hypertension, malignant hypertension, renal failure, ischemic heart disease, cerebrovascular disease, pregnancy, diabetes mellitus, or those taking oral contraceptives or any other drugs. Studies were approved by the local research ethics committee, and informed consent was obtained from all participants. There were 24 patients with isolated systolic hypertension (defined as systolic ≥140 mm Hg and diastolic <90 mm Hg), 5 with isolated diastolic hypertension (defined as systolic <140 mm Hg and diastolic ≥90 mm Hg), and 88 patients with combined hypertension (defined as systolic ≥140 mm Hg and diastolic ≥90 mm Hg). Patients with isolated diastolic hypertension were excluded from the present analysis because of the small number studied.

All participants underwent a period of ≈1 month of familiarization in the Blood Pressure Unit with repeated blood pressure measurements. They were then given written and verbal advice by specialist nurses on how to reduce their salt intake to 50 to 80 mmol per day (3 to 5 g per day of salt). After 2 to 4 weeks on the low-salt diet, patients entered an 8-week randomized double-blind crossover study of slow sodium tablets versus slow sodium placebo tablets while remaining on the low-salt diet throughout the study. This treatment regimen gave a salt intake of either 10 to 12 g per day (equivalent to the usual amount for the UK population) or 5 to 6 g per day (the currently recommended level of salt intake). All measurements, including blood pressure, body weight, plasma, and urinary electrolytes, were made at the end of each study period.

**Statistical Analysis**

Results are reported as mean±SD. Paired Student *t* tests were used to compare differences in continuous variables between the usual salt intake (ie, on slow sodium) and the reduced salt intake (ie, on placebo). A 2-tailed *P* value of <0.05 was regarded as statistically significant. All statistical analyses were performed using Statistical Package for Social Science.

**Results**

**Isolated Systolic Hypertension**

Baseline characteristics are summarized in Table 1. Among the 24 patients with isolated systolic hypertension, there were 11 females (9 whites and 2 blacks) and 13 males (8 whites, 4 blacks, and 1 Asian). The average age was 63±11 years (ranging from 33 to 78). Mean blood pressure was 165±18/86±3 mm Hg, and mean body weight was 78.5±12.9 kg.

On the equivalent of individuals’ usual salt intake (but on slow sodium tablets), blood pressure was 166±19/86±7 mm Hg, with a 24-hour urinary sodium excretion of 175±51 mmol (10.3 g per day of salt). On the reduced salt intake (ie, on placebo), blood pressure fell to 156±20/85±7 mm Hg with a 24-hour urinary sodium excretion of 87±38 mmol (5.1 g per day of salt; Figure). Therefore, the fall in blood pressure was 10/1 mm Hg with a reduction in urinary sodium of 88 mmol per 24-hour period (5.2 g per day of salt). The fall in systolic was highly significant, whereas the fall in diastolic was not statistically significant (Table 2). Because there was a greater fall in systolic compared with diastolic blood pressure, pulse pressure was reduced significantly.

**Combined Hypertension**

Among the 88 patients with combined hypertension, there were 42 females (16 whites, 25 blacks, and 1 Asian) and 46 males (27 whites and 19 blacks). The average age was 55±11 years (ranging from 34 to 78). Mean blood pressure was 161±14/100±7 mm Hg, and mean body weight was 77.3±12.2 kg.

On the usual salt intake (ie, on slow sodium tablets), blood pressure was 161±16/100±9 mm Hg, with a 24-hour urinary sodium excretion of 176±65 mmol (10.4 g per day of salt). On the reduced salt intake (ie, on placebo), blood pressure fell to 154±17/96±9 mm Hg, with a 24-hour urinary sodium excretion of 98±51 mmol (5.8 g per day of salt; Figure). Therefore, the fall in blood pressure was 7/4 mm Hg with a reduction in urinary sodium of 79 mmol per 24-hour period (4.6 g per day of salt). The falls in systolic and diastolic blood pressure were highly significant (Table 2). Similar to that in isolated systolic hypertension, there was a greater fall in systolic compared with diastolic blood pressure, thus pulse pressure was reduced significantly.

With the modest reduction in salt intake, there was no significant change in body weight or in urinary potassium, creatinine, or volume (Table 2). There was a small but significant increase in plasma renin activity and aldosterone. Plasma potassium showed a small but significant increase (increased by 0.14 mmol/L); however, there was no significant change in plasma sodium or creatinine (Table 2).

**Discussion**

Our studies demonstrate that a modest reduction in dietary salt intake, as currently recommended, has a significant effect on blood pressure in isolated systolic hypertension and...
combined hypertension. The magnitude of the fall in blood pressure with salt reduction is similar to that seen in trials of drug monotherapy. A reduction of 10 mm Hg in systolic blood pressure with a modest reduction in salt intake in isolated systolic hypertension observed in our study would be predicted to reduce stroke by approximately one third, ischemic heart disease by one quarter, and heart failure by just over one quarter in the population between 60 and 80 years of age,1 in whom isolated systolic hypertension is the predominant form of hypertension and carries the highest risk of cardiovascular disease.

A number of studies have shown that for a similar reduction in salt intake, blacks have a greater fall in blood pressure compared with whites.24,25 In our study, 50% of individuals were black in combined hypertension group, whereas in the isolated systolic hypertension group, only 25% were black. The smaller percentage of blacks in the isolated systolic hypertension group would have led to an underestimation of the fall in blood pressure with salt reduction in individuals with isolated systolic hypertension compared with those with systolic and diastolic hypertension.

There is much evidence that a reduction in salt intake lowers blood pressure not only in hypertensive individuals but also in those with average blood pressure (ie, normotensive individuals).17,26 and population-based intervention studies have shown that a reduction in population salt intake lowers population blood pressure.14 A reduction in population blood pressure, even by a small amount, would have a large impact on reducing cardiovascular morbidity and mortality in the whole population.27

In our study, the fall in systolic blood pressure with salt reduction is greater than the fall in diastolic blood pressure; therefore, there is a fall in pulse pressure in isolated systolic hypertension and combined hypertension. Pulse pressure is a surrogate marker for central artery stiffness, which has been suggested to be an independent risk factor for cardiovascular disease.28,29 Our results would suggest that a modest reduction in dietary salt intake may improve arterial distensibility. This finding is in agreement with that from a recently published article by Gates et al, which demonstrates that directly measured large elastic artery compliance is increased by dietary salt restriction in middle-aged and older men and women with stage 1 systolic hypertension.30 Other studies have shown that a low-salt diet improves arterial distensibility in normotensive and hypertensive individuals.31,32

It has been shown that salt and other dietary intakes estimated from dietary assessment in NHANES and other studies are subject to substantial bias and error.33,34 The claims that salt intake was not related to blood pressure in isolated systolic or combined hypertension on the basis of an inappropriate analysis from faulty data of NHANES III and IV8 are incorrect. Detailed examination of the data shows that most dietary intakes (eg, energy, total fat, protein, carbohydrates, sodium, potassium, calcium, and magnesium) were lower in isolated systolic hypertension compared with normotensives; and despite a lower energy intake, individuals with isolated systolic hypertension had a higher body mass index. This would indicate that individuals with isolated systolic hypertension might have underreported dietary intakes. Indeed, a previous publication of NHANES III33 showed that underreporting of energy intake was higher in older individuals who were also more likely to have isolated systolic hypertension. A more appropriate analysis of NHANES data by adjusting for energy intake shows that the dietary sodium/energy ratio is higher in isolated systolic hypertension and combined hypertension compared with normotensives, which suggests that salt intake is associated directly with blood pressure (ie, the higher the salt intake, the higher the blood pressure).

In conclusion, our study demonstrates that reducing salt intake from the current level of 10 to 12 g per day to the recommended level of 5 to 6 g per day lowers systolic blood pressure and 24-hour urinary sodium excretion at end of usual salt intake (ie, on slow sodium) and reduced salt intake (ie, on placebo) in isolated systolic hypertension (n=24) and combined hypertension (n=88). Results are expressed as mean and SEM.

***P<0.001 usual salt intake vs reduced salt intake.
pressure significantly in isolated systolic hypertension and lowers systolic and diastolic blood pressure significantly in combined hypertension.

**Perspectives**

There is much evidence that a reduction in dietary salt intake lowers blood pressure in hypertensive individuals. However, few have looked at the effects according to hypertension category. Our study demonstrates that a modest reduction in salt intake from the current level of 10 to 12 g per day to the recommended level of 5 to 6 g per day lowers blood pressure significantly in isolated systolic hypertension and combined hypertension. A decrease of 10 mm Hg in systolic blood pressure with salt reduction in isolated systolic hypertension observed in our study would be predicted to reduce stroke by approximately one third, ischemic heart disease by one quarter, and heart failure by just over one quarter in the population between 60 and 80 years of age, in whom isolated systolic hypertension is the predominant form of hypertension and carries the highest risk of cardiovascular disease. These results provide strong support for universal salt reduction in all hypertensive individuals irrespective of whether they have isolated systolic hypertension or raised systolic and diastolic blood pressure.

**References**


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