Aging, Acculturation, Salt Intake, and Hypertension in the Kuna of Panama

Norman K Hollenberg, Gregorio Martinez, Marij McCullough, Terri Menking, Diane Passan, Mack Prewton, Alicia Rivera, David Taplin, Maureen Varcia-Clement

Abstract The indigenous Kuna who live on islands in the Panamanian Caribbean were among the first communities described with little age-related rise in blood pressure or hypertension. Our goals in this study were to ascertain whether isolated island-dwelling Kuna continue to show this pattern, whether migration to Panama City and its environs changed the patterns, and whether the island-dwelling Kuna have maintained their normal blood pressure levels despite partial acculturation, reflected in an increased salt intake. We enrolled 316 Kuna participants who ranged in age from 18 to 82 years. In 50, homogeneity was confirmed by documentation of an O+ blood group. In 92 island dwellers, diastolic hypertension was not identified and blood pressure levels were as low in volunteers over 60 years of age as in those between 20 and 30 years of age. In Panama City, conversely, hypertension prevalence was 10.7% and exceeded 45% in those over 60 years of age ($P < 0.01$), blood pressure levels were higher in the elderly, and there was a statistically significant positive relationship between age and blood pressure ($P < 0.01$). In Kuna Nega, a Panama City suburb designed to maintain a traditional Kuna lifestyle but with access to the city, all findings were intermediate. Sodium intake and excretion assessed in 50 island-dwelling Kuna averaged $135 \pm 15$ mEq/creatinine per 24 hours, exceeding substantially other communities free of hypertension and an age-related rise in blood pressure. Despite partial acculturation, the island-dwelling Kuna Indians are protected from hypertension and thus provide an attractive population for examining alternative mechanisms (Hypertension. 1997;29[part 2]:171-176.)

Key Words • sodium • potassium • magnesium • calcium • body mass • obesity • aging

The Kuna Indians who live in the isolated San Blas Island chain off the Caribbean Coast of Panama were among the first communities described in which hypertension is rare. In their recent review, James and Baker cited 39 such populations in Africa, the Americas, Asia, and the Pacific Region. In many of these communities, the primary evidence that the protective factor is environmental rather than genetic was the blood pressure rise following migration to an urban environment. Among the many lines of evidence suggesting a role for salt intake in the pathogenesis of hypertension, particularly compelling has been the identification of these isolated communities where salt intake is low, hypertension is rare, and blood pressure does not rise with age. By 1976, Page concluded that all low blood pressure populations have a low salt intake as part of their biology and probably as a major causal mechanism and supported that conclusion by citing nine earlier studies. Since that time, a number of confirmatory studies have been reported. Salt intake in such “protected” communities generally provided less than 40 mEq of sodium per day, and typically much less.

Our goals in this study were to ascertain whether we could confirm the absence of hypertension and age-related rise in blood pressure in isolated island-dwelling Kuna 50 years after the original observation and to extend the observation to blood pressure level in relation to age in Kuna who had moved to Panama City and its environs. Our final goal was to pursue anecdotal suggestions that the island-dwelling Kuna have maintained their benign blood pressure levels despite partial acculturation, reflected in an increased salt intake. Absence of hypertension and an age-related rise in blood pressure despite a substantial level of salt intake would not deny a role for salt but rather would facilitate the exploration of additional responsible mechanisms that are more difficult to identify or assess in the presence of a low-salt intake.

Methods

Subjects

The 316 participants, who ranged in age from 18 to 82 years, were all Kuna Indians by self-identification and community recognition. In 50 of the volunteers, homogeneity was confirmed by the assessment of blood group. All were of blood group O+. The age listed was self-proclaimed but could be confirmed approximately by community records and family relationships.

Three groups of subjects were recruited: The 142 isolated island-dwelling Kuna were recruited and studied in two San Blas islands, Astigandi and Ticantiki. Each volunteer had lived their entire life on the island with only occasional, brief visits to the city. Another 84 were recruited and studied in Panama City. They were long-term inhabitants of the city enrolled via a community center maintained by the Kuna community in Panama City. A third group of 90, labeled “suburban,” live in Kuna Nega in the outskirts of Panama City. Although many Kuna Nega dwellers work in Panama City, they live in a more traditional Kuna community and maintain a more traditional lifestyle than is possible in urban Panama City.

Informed consent was obtained from each participant after a detailed description of the protocol. The protocols and approach to informed consent were approved by the Panamanian Ministry of Health, the Sistema Integrado de Salud, San Blas, Panama, by each community’s “congresso” (a local, grassroots participatory governing body), and by the Human Subjects Committee of the Brigham and Women’s Hospital, Harvard Medical School.

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Protocols

In all subjects, blood pressure was measured by the auscultatory method in either arm after several minutes of quiet sitting. Three measurements were made, and the average was used. Measurements in the three locations were made by one physician and one nurse during the first stage of this study, at a time when the declared emphasis involved nutrition and no hypotheses involving migration and blood pressure regulation had been raised.

In 50 island-dwelling Kuna, an additional protocol was designed to assess dietary intake of protein, sodium, potassium, magnesium, calcium, fiber, and calories. A simultaneous 24-hour urine collection was made for measurement of the excretion of the same electrolytes, urea, and creatinine. For several reasons, the 50 volunteers who were selected for this element in the study belonged to nine households, and all members of each household were studied simultaneously. The Kuna are a matriarchal society, and the matriarch helped with enrollment and quality control on urine collections. An ice-filled beer cooler was placed in each home for the 24 hours of the study to hold the containers used to collect the 24-hour urine sample and as a highly visible reminder of participation. The reinforcement provided by the simultaneous involvement of all members of the household and the high visibility of the instrument employed for the collection we thought might facilitate accurate collections. Each household heard detailed instructions on collection of 24-hour urine samples both during the initial recruitment stage, during the stage when informed consent was obtained, and finally immediately prior to the active study.

Urine collections were measured, fractionated into aliquots, and stored in a dedicated, diesel-powered freezer. On the same day, a blood sample was drawn to measure serum electrolytes, and stored in a dedicated, diesel-powered freezer. On the same day, a blood sample was drawn to measure serum electrolytes, blood urea nitrogen, and serum creatinine concentration and for body mass index. When the 50 subjects had been studied on Anuala, the blood and urine samples were transferred to insulated containers containing dry ice for transport by charter flight to Panama City and then to Boston for assay.

Thermometers designed to record the highest temperature experienced during storage were employed to ensure sample stability during storage and shipment.

Measurements of plasma and urine electrolytes, urea, and creatinine were made by autoanalyzer. The normative values employed reflect the Boston-based laboratory's experience with samples obtained in that urban US setting.

Diet Assessment

Nutrient intake was estimated in two ways in the same 50 subjects. All participants collected a single 24-hour urine sample that was analyzed for Na, K, Ca, Mg, and urea. In addition, a 24-hour recall interview, which corresponded to the time period of the urine collection, was conducted to assess intake of macronutrients, fiber, and Na, K, Ca, and Mg in the group. Since this was a feasibility trial, multiple samples were not obtained.

The 24-hour recall method was chosen as it is less burdensome to participants than food records and does not require literacy. It also allows for more detailed probing about food consumption.

A Kuna nurse (M P ) and an American anthropologist from the Miami FEST Team (M V C) were trained in administration of the 24-hour recall by a registered dietitian (M M ) over a 3-day period. They then trained two other Kuna healthcare team members to assist with the interviews.

Participants were asked to recall all foods and beverages consumed during the previous day. Portion sizes were estimated using measuring spoons, measuring cups, food models, and model "nodars" (gourds) that are often used by the Kuna for serving and consuming foods. Five nodars were presented and the participant chose the nodar size that represented the portion consumed. The Kuna typically consume a stew each day. Recipes for the previous day's stew were obtained from the cook. Each family member reported the quantity of stew he or she consumed. Moisture losses during the cooking process made it difficult to estimate the nutrient density of the stew. Therefore, each ingredient was divided by the number of people in the family, thereby assuming equal portions, unless individual reports indicated vastly differing portion sizes. In this case, fractions were calculated among participating family members and multiplied by each ingredient.

The ESHA nutrient database and the Food Processor II nutritional analysis program were employed to analyze the 24-hour recalls (ESHA Research). The ESHA database derives nutrient values from many sources including USDA Handbook No 8 series, nutritional research in scientific journals, and analytic data from manufacturers. For foods similar to those in the United States, the ESHA database foods and nutrient values were used. For food items specific to the San Blas region, nutrient values were obtained from tables provided by the Institute of Nutrition for Central America and Panama (INCAP) and entered into the ESHA database. As the INCAP data contained no information for potassium and magnesium, these values were imputed from US nutrient data for foods judged to be similar.

Statistics

Mean values have been presented with the standard error of the mean as the index of dispersion. Renal excretion of electrolytes and urea was normalized to urine creatinine to adjust for incomplete collections. That adjustment also served to adjust for body size, as creatinine excretion varies with body size. Assessment of blood pressure as a function of location, age, and gender was made by ANOVA. Renal excretion of electrolytes was also examined by $\chi^2$ and by Spearman's nonparametric correlation, to examine interaction and differences based on age and gender.

Results

The island-dwelling Kuna showed neither an age-related rise in systolic, diastolic (Fig 1), or mean arterial pressure (Table 1) by JNCV criteria. Stage 1 hypertension was identified in only two subjects (2.2%) and reflected minimal criteria in each, with a systolic pressure of 140 mm Hg and a diastolic below 85 mm Hg. Body mass index (BMI) averaged 22.5 ± 6 kg/m² and did not rise with age.

Conversely, in the Kuna who resided in Panama City, blood pressure rose significantly with age ($P<0.001$; Fig 1).
and Table 1), the overall prevalence of hypertension was 10.7% (P<01) and was an especially striking 45.1% in those over 60 years of age. Body mass index averaged 23.6±0.5 kg/m², significantly more than in the island dwellers (P<0.01). Although BMI did not rise with age, there was a correlation between BMI and blood pressure in the elderly (r=18; P<01).

In the Kuna residents of the suburban community of Kuna Negra, all findings were intermediate but resembled urban Panama City more than the isolated islands in overall hypertensive prevalence (9 of 90, 10%), prevalence in those over 60 years of age (35.9%), and rise of average blood pressure with age (P<0.01). Average BMI, on the other hand, was 22.8±0.3 kg/m², almost identical to the island dwellers.

Laboratory investigation and information on dietary history to date is available for 50 island-dwelling Kuna. Average serum sodium and potassium concentrations were in the normal range (Table 1), with a serum creatinine concentration at the middle of the normal range and a blood urea nitrogen concentration at the low end of the normal range.

The sodium content of the 24-hour urine collections averaged 135±15 mEq/g creatinine (Table 2) but ranged widely. The data in Fig 2 are presented with the individual values on the ordinate and average values for each of the family households on the abscissa. Average values in individual families ranged from about 70 to about 210 mEq/g creatinine per 24 hours, and there was wide individual variation around each family’s average. Only 5 of 50 participants excreted less than 40 mEq/g creatinine per 24 hours. Neither age nor gender influenced sodium excretion.

The potassium content of the 24-hour urine collections averaged 47±3 mEq/g creatinine per 24 hours (Table 2). Family and individual variations were substantial, but both were smaller than was the case for sodium (Fig 2). As was the case for sodium, the potassium content of the urine was well within the laboratory usual range based on a western urban experience, without adjustment for creatinine excretion (Table 2). The ratio of sodium to potassium excretion averaged 2.87. The calcium content of the 24-hour urine collections averaged 53±4 mg/g creatinine per 24 hours, at the lower end of the expected range (Table 2), and the magnesium content (63±4 mg/g creatinine per 24 hours) was below the normative range (Table 2).

The excretion of urea, employed as an index of protein intake, averaged 5.3±0.3 g/g creatinine, also below the laboratory usual range (Table 2) or western standards. Variation in urea excretion (coefficient of variation of 39.6%) was less than sodium excretion (coefficient of variation of 77.8%).

Dietary history confirmed a substantial sodium intake (Table 3) and suggested a more substantial intake of potassium and magnesium than was revealed by the 24-hour urine samples. Assessment of sodium intake was much more straightforward than potassium or magnesium intakes. Table salt is the major source of sodium in the Kuna diet, since most foods consumed in the San Blas are relatively low in sodium. Of the 31 of 30 subjects who added salt to their food, the average amount consumed was 2.6 teaspoons (5542 mg or 240 mEq), with a range of 0.2 to 6 teaspoons per day. Of those salt users, added salt contributed 75% to their overall sodium intake. In comparison with typical US patterns of intake, fat and protein ingestion were low and carbohydrate and fiber intake were high. There was no ethanol use recorded.

### Discussion

In their monograph on ethnobotany, Balick and Cox provided a useful definition of "indigenous peoples" who "...follow traditional non-industrial lifestyles in areas that they have occupied for generations." In all earlier studies on blood pressure in indigenous peoples that identified a role for low-salt intake, the crucial step involved acculturation due to migration. In this study of an indigenous people, among the first identified for their special blood pressure profile, it appears that partial acculturation has occurred without migration. Salt use has become substantial in the areas that they have occupied for generations, and yet hypertension is rare and blood pressure does not rise with age.

This study answered the three questions raised. First, the rarity of hypertension and absence of an age-related rise in blood pressure was confirmed in isolated, island-dwelling Kuna. Second, the absent age-related rise in blood pressure and the low prevalence of hypertension could be attributed to environmental rather than familial

### Table 1. Kuna: Location, Demographics, and Blood Pressure by Age Group

<table>
<thead>
<tr>
<th>Island</th>
<th>Kuna Negra</th>
<th>Panama City</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>40±0.0</td>
<td>40±0.0</td>
</tr>
<tr>
<td>BMI kg/m²</td>
<td>23±0.1</td>
<td>23±0.1</td>
</tr>
<tr>
<td>MBP mmHg</td>
<td>82±14</td>
<td>82±14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study results</th>
<th>Na, mEq/L</th>
<th>K, mEq/L</th>
<th>Urea, g/dL</th>
<th>Creatinine, mg/dL</th>
<th>Volume, mL</th>
<th>Na, mEq/g Creatinine</th>
<th>K, mEq/g Creatinine</th>
<th>Mg, mg/g Creatinine</th>
<th>Ca, mg/g Creatinine</th>
<th>Urea, g/g Creatinine</th>
</tr>
</thead>
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<tr>
<td>Study results</td>
<td>138±0.2</td>
<td>39±0.0</td>
<td>9±0.4</td>
<td>1±0.0</td>
<td>1320±84</td>
<td>135±15</td>
<td>47±3</td>
<td>83±4</td>
<td>104±9</td>
<td>5±0.3</td>
</tr>
<tr>
<td>Lab usual Range</td>
<td>136-142</td>
<td>35-5.0</td>
<td>9-25</td>
<td>0.8-1.3</td>
<td>75-300</td>
<td>40-80*</td>
<td>120-240*</td>
<td>50-400*</td>
<td>6.0-17.0*</td>
<td></td>
</tr>
</tbody>
</table>

*Not normalized to gram creatinine

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**Table 2. Chemical Findings in Serum and Urine in Island-Dwelling Kuna**

**Serum**

<table>
<thead>
<tr>
<th>Na, mEq/L</th>
<th>K, mEq/L</th>
<th>Urea, g/dL</th>
<th>Creatinine, mg/dL</th>
<th>Volume, mL</th>
<th>Na, mEq/g Creatinine</th>
<th>K, mEq/g Creatinine</th>
<th>Mg, mg/g Creatinine</th>
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<td>40-80*</td>
<td>120-240*</td>
<td>50-400*</td>
<td>6.0-17.0*</td>
</tr>
</tbody>
</table>

*Not normalized to gram creatinine
or genetic factors, as blood pressure rose with age and hypertension prevalence rose strikingly among Kuna who had moved to Panama City. This observation confirms a range of studies on the migration experience and blood pressure. Indeed, there appear to be no reported exceptions in which migration to an urban setting did not lead to changes in the blood pressure pattern. The third observation, involving sodium intake and excretion, is novel. The source of the salt ingested involves trade with fishermen, largely from neighboring Colombia. Shellfish are traded for bags of table salt, which is added to the food, especially the stew, according to individual taste. The stew is still prepared in the traditional manner and contains neither salt nor salty ingredients. Lore has it that the most dramatic changes in lifestyle have occurred in the past two decades.

There are several limitations of this study. An objective measurement was not employed for the blood pressure measurement. We think it unlikely that bias can account for the differences in hypertension prevalence in the three communities. The data were collected as part of a program that was designed to examine nutrition, and the emphasis was on the body height and weight measurement, rather than blood pressure or age. Indeed, the absence of hypertension among Kuna in the islands is widely recognized and shapes Panamanian health policy. The blood pressure elevation in Panama City was routinely confirmable, and the striking correlation with age and concordance between the findings in Kuna Nega, where no prior hypothesis could have existed, and Panama City are supportive. Future studies will require an objective, bias-free blood pressure measurement, however, as these arguments no longer apply with the analysis of the data, but even these can be a problem. The 24-hour urine collections are also suspect. Despite substantial effort, more than 50% of the 24-hour urine collections contained less than 1000 mg of creatinine and probably reflect incomplete collections. Although normalization to creatinine content provides a reasonable estimate, there are limitations. One is more likely to underestimate than overestimate content. Thus, we can have far more confidence in the likelihood that the sodium intake is high than we can in values characterizing potassium, magnesium, and calcium intake and excretion. In their case, the dietary assessment may have provided a more accurate measure of intake than did the 24-hour urine collections, although there were several limitations with this as well. Imputation of the potassium and magnesium content of several food items was necessary and may have resulted in overestimation or underestimation. In addition, recipe analysis involved several assumptions, including consumption of equal portions of all stew ingredients by all household members and assumptions about the nutrient density of the stew. It is exceedingly unlikely that the very low urea content, on the other hand, can be attributed to

![Graph](http://hyper.ahajournals.org/)

**Fig 2.** Relation between average excretion of sodium, potassium, and urea in nine island-dwelling families (abscissa) versus the individual values in each family (ordinate). Salt intake and excretion were substantial in island-dwelling Kuna who are protected from hypertension and age-related rise in blood pressure. Only 5 of the 50 subjects showed a sodium excretion level similar to those reported for other isolated, normotensive cultures. Note that potassium and urea excretions vary less in families and in individuals. Potassium excretion differs little from that in western urban cultures, but urea excretion is well below a typical urban western sample, suggesting a sharply lower protein intake.

### TABLE 3. Kuna Nutrient Intake in San Bias Islands

<table>
<thead>
<tr>
<th>Index</th>
<th>Mean±SEM*</th>
<th>Average US Intake (Mean±SEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilocalories</td>
<td>2221±117</td>
<td>1914±10</td>
</tr>
<tr>
<td>Protein, g</td>
<td>67±8</td>
<td>75±3</td>
</tr>
<tr>
<td>Protein, %</td>
<td>12±2</td>
<td>15±7</td>
</tr>
<tr>
<td>Total fat, g</td>
<td>56±3</td>
<td>76±4</td>
</tr>
<tr>
<td>Fat, %</td>
<td>23±2</td>
<td>36±9</td>
</tr>
<tr>
<td>Cholesterol, g</td>
<td>36±23</td>
<td>209±11</td>
</tr>
<tr>
<td>Cholesterol, %</td>
<td>7±2</td>
<td>44</td>
</tr>
<tr>
<td>Dietary fiber, g</td>
<td>23±2</td>
<td>18±9</td>
</tr>
<tr>
<td>Calcium, mg</td>
<td>517±50</td>
<td>736±64</td>
</tr>
<tr>
<td>Potassium, mEq</td>
<td>98±6</td>
<td>62±4</td>
</tr>
<tr>
<td>Magnesium, mg</td>
<td>368±22</td>
<td>296±28</td>
</tr>
<tr>
<td>Sodium, mEq</td>
<td>210±22</td>
<td>121±57</td>
</tr>
</tbody>
</table>

*Based on single 24-hour recall
†All averages calculated from NHANES II, except magnesium and fiber, which were calculated using advanced data from NHANES III (male and female adults, all income levels)
anything other than a rather low protein intake, as the values were very low.

Sodium intake and excretion have been the subject of substantial investigation in many communities, including a number of those that share characteristics of the Kuna. 2,8-12 8

Without exception, in such communities studied hitherto the sodium intake and the sodium content of the urine has been very low, and where migration has occurred, one of the elements in acculturation has been an increase in sodium intake and excretion. 2,8-12 8

Despite the limitations of this study, it is clear that these factors are not operative in the Kuna. This is not to deny the importance of salt intake, but rather to point out that even those convinced that salt intake is important recognize that additional factors are likely to play a role. Teasing out such factors in populations in which a large change in salt intake follows migration is difficult because the signal-to-noise ratio is unfavorable. The Kuna, therefore, provide a special opportunity for exploring additional factors that contribute.

Diet pattern has provided an array of alternatives beyond sodium intake. The vegetarian diet22-26 has been especially consistent in its association with lower blood pressure, and the indigenous communities in which hypertension is rare typically ingest a diet that resembles far more a vegetarian than a western, urban diet. The low protein intake and high fiber content of the Kuna diet documented in this study certainly are consistent. Vegetarians in industrial countries have lower blood pressures and less hypertension than comparable neighbors who are not vegetarians, 26 and intake of animal products tends to correlate directly with blood pressure level. 26

Increasing the protein content of a diet with protein supplements did not affect blood pressure, 27-29 but the protein supplement may not match the shift in proteins ingested with acculturation. Vegetarian diets are generally rich in potassium and magnesium, and there is substantial epidemiological evidence of an inverse relationship between their respective intake and blood pressure levels. 30-33 30-33

Their contribution to maintaining normal blood pressure remains controversial. 34 34 The limited ability of the current 24-hour urine collection to estimate potassium, magnesium, or calcium ingestion was discussed above, but that limitation does not extend to the Na/K ratio, thought by some to be protective. 11 11 The Na/K ratio in this study, 2.87, is closer to typical urban than to typical indigenous levels. 11

Other candidates for the environmental contribution include alcohol use, obesity, physical activity, and psychosocial stress. 16 Alcohol use is uncommon in island-dwelling Kuna, with the exception of a quarterly festival, the “Cheche.” The Kuna living in Panama City on average had a BMI that was significantly higher than on the island, but obesity per se was rare, and a weak correlation was found between BMI and blood pressure. BMI did not increase with age in any of the communities. Whether a reduction in physical activity, alcohol use, or increased psychosocial stress contributes requires further investigation.

As pointed out in a recent review, 16 “Psychosocial stress has the credentials for the missing factor, although it remains an elusive quantity to measure.” The measurement will not be less difficult in a different culture.

The Kuna reside in the San Blas Islands, an archipelago off the Caribbean coast of Panama comprising about 360 islands, of which 66 are populated by the Kuna. 35 They have lived on these islands for centuries, 35 but their origin is not completely understood. Recent studies have revealed a remarkably low level of mitochondrial gene diversity, suggesting that there has been remarkably little genetic admixture. 36 36 Both of these features could be helpful in attempts to dissect the pathogenesis of hypertension.

Substantial evidence favors a complex series of factors in blood pressure homeostasis. The fact that the Kuna are generally normotensive and lack the usual age-related rise in blood pressure while residing on the islands, despite a substantial salt intake, provides an opportunity to examine alternative factors that might make a contribution. The Kuna provide an attractive model for another reason: between the island-dwelling Kuna who are protected and the Kuna who have migrated to Panama City, there are Kuna residing in suburban communities who maintain some but not all of their traditional lifestyle. In this preliminary study, for example, they had not gained weight, and yet blood pressure rose with age and hypertension prevalence almost matched that in Panama City. This group should provide an attractive opportunity for future investigation.

Acknowledgments

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