Dietary Sodium Intake and Cataract: The Blue Mountains Eye Study

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A population-based cross-sectional study (n = 2,873) was conducted near Sydney, Australia, from January 1992 to January 1994 to assess the relation between dietary sodium intake and risk of cataract. Photographs of subjects' lenses were graded for cortical, nuclear, and posterior subcapsular cataracts. Dietary sodium intake was assessed with a food frequency questionnaire. The study found that higher sodium intakes were associated with greater risk of posterior subcapsular cataract (p for trend = 0.006). The adjusted relative risk was 2.0 (95% confidence interval: 1.2, 3.4) for subjects in the highest versus the lowest quintile of sodium intake. These findings suggest that a high-salt diet may increase the risk of posterior subcapsular cataract.

Cataracts are the most important cause of blindness worldwide (1). Established risk factors for cataracts include use of corticosteroids, diabetes, and smoking (1). Studies of the role of diet (mainly antioxidant vitamins) in cataract development have been inconclusive (1). Recently, an Italian hospital-based case-control study found that a high intake of dietary sodium was associated with increased risk of cataract extraction (2). High sodium intake has also been shown to cause cataracts in an animal model (3). In this paper, we report an association between dietary sodium and cataracts among subjects in the Blue Mountains Eye Study. This is a large, population-based study in which the presence and severity of various types of cataract was assessed by standardized grading of lens photographs (4).

MATERIALS AND METHODS

Subjects were recruited from the Blue Mountains region, west of Sydney, Australia, as described in detail elsewhere (4). In brief, after a door-to-door census of the region, all permanent residents with a birth date prior to January 1, 1943, were invited to attend a local clinic for a detailed eye examination. Of the 4,433 eligible people identified at our census, 3,654 attended the study clinic between January 1992 and January 1994.

Ethical approval for the study was obtained from the Western Sydney Area Health Service Human Research Ethics Committee, and written, informed consent was obtained from all subjects.

Photographs of the lens of each eye were taken after pupil dilatation with 1 percent tropicamide and 10 percent phenylephrine. The protocol for lens photography and grading closely followed the Wisconsin Cataract Grading System (5). Slit-lamp photographs were taken to assess the severity of nuclear lens cataracts using a Topcon SL-7E Photo Slit Lamp camera (Topcon Optical Co., Tokyo, Japan). Retroillumination photographs of the anterior and posterior lens were taken using a Neitz Cataract CT-R camera (Neitz Instruments Co., Tokyo, Japan) to assess presence and severity of cortical and posterior subcapsular cataracts.

The severity of nuclear cataract on a five-point scale was assessed by comparing photographs of subjects' eyes with a set of four standard photographs. The presence and severity of cortical cataract were graded by placing over the Neitz photographs a circular grid divided into eight wedges and a central circle. Graders estimated the percentage of the area of each of these segments involved by cataract. These percentages were summed to give an estimate of the total area of the lens affected by cataract. Posterior subcapsular cataract was graded similarly. All photographs were graded by one of two masked graders. The quadratic weighted kappas for intergrader reproducibility were 0.79 for nuclear cataract, 0.78 for cortical cataract, and 0.57 for posterior subcapsular cataract (6).

Participants were mailed a semiquantitative food frequency questionnaire, which they were asked to

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complete and bring with them to the eye examination. Our 145-item questionnaire has been shown to be reliable in the study population and to have reasonable validity compared with weighed food records (7).

Information on potential confounders was collected by interviewer-administered questionnaire (smoking history, diabetes, and use of inhaled or oral corticosteroids) and clinical measurement (blood pressure). Hypertension was defined as a measured systolic blood pressure of more than 160 mmHg and/or a measured diastolic blood pressure of more than 95 mmHg and/or a self-reported history of high blood pressure.

Sodium intakes were adjusted for total energy intake by regression analysis (8). Statistical analyses involved data from the most severely affected eye only. Subjects who had had bilateral cataract surgery were excluded.

Each cataract type was dichotomized: cortical (<5 and ≥5 percent of the lens involved), nuclear (less than grade 4 and grade 4 or 5), and posterior subcapsular (0 and >0 percent of the lens involved). Stratified analyses controlling for age and sex were done initially. Further analysis was by logistic regression, with adjustment for age, sex, smoking history, diabetes, hypertension, and use of oral or inhaled corticosteroids.

RESULTS

Of the 4,433 eligible subjects living in the study area, 3,654 attended the study clinic, and 2,873 provided usable data on sodium intake. Among those who attended the study clinic, subjects with missing sodium intake data (n = 781) tended to be older (mean age, 69.3 vs. 65.4 years) and were more likely to be current smokers (17 vs. 13 percent) than were those with sodium intake data. The distributions of sex and histories of diabetes, asthma, hypertension, and use of inhaled and oral corticosteroids were similar for subjects with and those without sodium intake data (data not shown).

The median age of the 2,873 subjects with data on sodium intake was 65 years and ranged from 49 to 97 years. There were 620 subjects with cortical cataracts, 350 with nuclear cataracts, and 160 with posterior subcapsular cataracts included in the analyses described in this paper.

Table 1 shows associations between sodium intake and known risk factors for cataracts. In our study, people with higher sodium intakes were more likely to have diabetes or hypertension and to have used corticosteroids.

| TABLE 1. Characteristics of subjects according to quintile of energy-adjusted sodium intake, the Blue Mountains Eye Study, January 1992 to January 1994

<table>
<thead>
<tr>
<th>Quintile of sodium intake</th>
<th>Mean age (years)</th>
<th>Female sex (%)</th>
<th>Smoking history (%)</th>
<th>Medical conditions* (%)</th>
<th>Corticosteroid use ever (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Never</td>
<td>Past</td>
<td>Current</td>
</tr>
<tr>
<td>1 (low)</td>
<td>65.6</td>
<td>54</td>
<td>49</td>
<td>38</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>65.0</td>
<td>59</td>
<td>48</td>
<td>39</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>65.1</td>
<td>55</td>
<td>51</td>
<td>37</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>64.9</td>
<td>60</td>
<td>48</td>
<td>39</td>
<td>13</td>
</tr>
<tr>
<td>5 (high)</td>
<td>66.3</td>
<td>53</td>
<td>46</td>
<td>41</td>
<td>13</td>
</tr>
</tbody>
</table>

* Diabetes was self-reported. Hypertension was defined as measured systolic blood pressure >160 mmHg and/or measured diastolic blood pressure >95 mmHg and/or self-reported history of high blood pressure.

| TABLE 2. Associations between energy-adjusted sodium intake and posterior subcapsular cataract, the Blue Mountains Eye Study, January 1992 to January 1994

<table>
<thead>
<tr>
<th>Quintile of sodium intake</th>
<th>Median intake (mg/day)</th>
<th>PSC*</th>
<th>Adjusted for age and sex OR* 95% CI*</th>
<th>Adjusted for multiple variable† OR 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No.</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>1 (low)</td>
<td>1,273</td>
<td>25</td>
<td>4.5</td>
<td>1.0 Referent</td>
</tr>
<tr>
<td>2</td>
<td>1,695</td>
<td>26</td>
<td>4.8</td>
<td>1.1 0.6, 1.9</td>
</tr>
<tr>
<td>3</td>
<td>2,060</td>
<td>30</td>
<td>5.4</td>
<td>1.2 0.7, 2.1</td>
</tr>
<tr>
<td>4</td>
<td>2,484</td>
<td>28</td>
<td>5.1</td>
<td>1.2 0.7, 2.1</td>
</tr>
<tr>
<td>5 (high)</td>
<td>3,164</td>
<td>51</td>
<td>9.3</td>
<td>2.1 1.3, 3.5</td>
</tr>
</tbody>
</table>

p for trend 0.003 0.006

* PSC, posterior subcapsular cataract; OR, odds ratio; CI, confidence interval.
† Adjusted for age, sex, smoking history, self-reported diabetes, hypertension (systolic pressure >160 mmHg and/or diastolic pressure >95 mmHg and/or self-reported history of high blood pressure), oral corticosteroid use (ever), and inhaled corticosteroid use (ever).

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We found no associations between dietary sodium and nuclear or cortical cataracts (data not shown). However, there was an association with posterior subcapsular cataract, the most visually disabling type of cataract. As shown in table 2, subjects in the highest quintile of sodium intake had approximately twice the risk of posterior subcapsular cataract as did those in the lowest quintile. The association was unchanged after adjustment for multiple potential confounders.

High blood pressure may be associated with risk of cataract (1), and people with high blood pressure may be advised to reduce their dietary sodium intake. Hence, we repeated our analyses, excluding people who reported that they had been told by a doctor that they had high blood pressure. The findings were essentially the same in this subgroup as in the total study population (data not shown).

We wondered whether a high-sodium diet might be a particular problem for people with impaired renal function. We found that a raised plasma creatinine (>125 mmol/liter) was associated with increased risk of posterior subcapsular cataract (adjusted odds ratio = 1.7, 95 percent confidence interval: 1.1, 2.6), but there was no interaction ($p = 0.95$) between dietary sodium and creatinine level.

**DISCUSSION**

We found a clear relation between a high dietary sodium intake and posterior subcapsular cataract. This confirms and extends the findings of a recent Italian epidemiologic study (2). Our study has several advantages over the Italian study: cataract diagnosis was based on carefully graded lens photographs, not cataract surgery; all subjects in our study came from the same defined population; and our validated food frequency questionnaire was more complete (145 compared with 34 foods).

A causal relation between sodium intake and cataracts is biologically plausible. Higher levels of extracellular sodium might make it more difficult for sodium pumps to maintain the low levels of intracellular sodium required for lens transparency. Support for this hypothesis comes from a case-control study involving eye clinic patients, which found that patients with cataracts had higher serum sodium levels than did controls (9). High sodium intake leads to cataract formation in Dahl salt-sensitive rats, and sodium restriction in these animals results in reversal of early cataracts (3).

The epidemiologic and pathophysiologic data suggest that a reduced salt diet may help prevent cataracts in older adults.

**ACKNOWLEDGMENTS**

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**REFERENCES**