Meat Consumption Is a Risk Factor for Colorectal Cancer: Meta-Analysis of Case-Control Studies

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Abstract: Meat has been associated with an increased risk of colorectal cancer in most, but not all, studies. Findings have shown conflicting results and inconclusive with regard to meat consumption in the colorectal cancers. To resolve these inconsistencies, we conducted a meta-analysis of published data on the association between meat and the incidence of colorectal cancer. Meta-analysis method was conducted to estimate the combined odds ratio (OR) between meat consumption and colorectal cancer from case-control studies published between 1989 and 2005. The combined odds ratio (OR) was 1.68 (95% CI: 1.34-2.12) in the 12 published case-control studies. The combined OR varied little by types of meat. Additionally, we evaluated the possible risk factors in meat for colorectal cancer. In conclusion, we found a positive association between meat consumption and colorectal cancer.

Key words: Meat, colorectal cancer, red meat

Introduction
Colorectal cancer is the second most common cancer, next to lung cancer for men and breast cancer for women, in Europe and North America (Boyle and Langman, 2000). Colorectal cancer is the second leading cause of cancer-related death in the United States and accounts for about 11% of all cancer-related deaths (American Cancer Society, 2003). The 5-year relative survival rate is 90% for people whose colorectal cancer is treated in an early stage, but only 37% of cases are found early. Risk does not differ between men and women, but it does increase by age 40, rises sharply at 50-55, and then doubles with each following decade. Colorectal cancer has an incidence rate of 54 per 100,000 and a death rate of 22 per 100,000, but both rates vary by racial/ethnic group (National Cancer Institute, 1996).

Most, but not all, studies show meat eaters have a high risk of colorectal cancer (Giovannucci et al., 1994; Willet et al., 1990; O’Keefe et al., 1999). In some colon cancer studies, the association has been limited to consumption of sausage or other processed meats (Goldbohm et al., 1994; Gaard et al., 1996). A number of studies have found an association between red meat consumption and colorectal cancer (American Cancer Society, 2005; Ries et al., 1998; Sinha et al., 1999).

Taking into account the above discrepancy, we decided to conduct a meta-analysis study on the relationship between meat consumption and colorectal cancer. This article is assessed whether whole meat and red meat are main risk of developing colorectal cancer. Also, whether there is any difference between red meat consumption and whole meat.

Materials and Methods
We performed a meta-analysis 12 case-control studies that examined the association between meat consumption and colorectal cancer risk (Benito et al., 1990; Yeh et al., 2003; Tavani et al., 2000; Boutron-Ruault et al., 1999; Levi et al., 1999; Gerhardsson de Verdier, 1995; Neugut et al., 1993; Maureen et al., 2004; Le Marchand et al., 2002; Lee et al., 1989; Deno-Pellegrini et al., 2005; Kulidoreff et al., 2000). The outcome of all published studies was regarding the OR of colorectal cancer. The disease was colorectal cancer and did not refer to any stage or classification of cancer. Case-control studies were identified through a Medline search for the period between Feb 1989 and January 2005. The searches were limited to studies published in English. Titles, abstracts, and subject headings in the database were investigated using the keywords colorectal cancer and meat. Over the period of 16 years, 69 articles were found using the keywords colorectal cancer and meat, and 12 articles were found using case control method. In order not to omit relevant articles, the titles, abstracts, and subject headings identified by the keywords colon, rectal, cancer and meat were scanned. The cited references in obtained studies were also reviewed to include all relevant articles.

In all of the case-control studies we found, if the study sample was found to overlap or come from the same study project, only the paper with the largest sample size was retained. When colorectal cancer risk was reported separately by different types of meat, whole meat was chosen because it contains all meat substances and thus reflects the true nature of meat. If both hospital and population controls were used for comparison separately, the result of the population control was chosen for the analysis. Two researchers performed data collection and extraction independently. Differences in data extraction were resolved by discussion. Meta-analysis is a statistical analysis that combines or integrates the results of several studies to provide increased power for the quantitative identification of
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Table 1: Characteristic of case-control studies related to meat consumption and colorectal cancer risk from published studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Kind of meat</th>
<th>Case (n)</th>
<th>Control (n)</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boutron-Ruault, 1999</td>
<td>Whole meat</td>
<td>171</td>
<td>309</td>
<td>1.2</td>
</tr>
<tr>
<td>Benito, 1990</td>
<td>Whole meat</td>
<td>286</td>
<td>498</td>
<td>2.85</td>
</tr>
<tr>
<td>Gerhardtson, 1995</td>
<td>Whole meat</td>
<td>347</td>
<td>505</td>
<td>2.8</td>
</tr>
<tr>
<td>Yeh, 2003</td>
<td>Whole meat</td>
<td>727</td>
<td>736</td>
<td>2.44</td>
</tr>
<tr>
<td>Lee, 1989</td>
<td>Whole meat</td>
<td>203</td>
<td>425</td>
<td>1.78</td>
</tr>
<tr>
<td>Combined</td>
<td>Whole meat</td>
<td>1734</td>
<td>2473</td>
<td>2.13</td>
</tr>
<tr>
<td>Tavani, 2000</td>
<td>Red meat</td>
<td>498</td>
<td>7990</td>
<td>1.7</td>
</tr>
<tr>
<td>Maureen, 2004</td>
<td>Red meat</td>
<td>952</td>
<td>1205</td>
<td>1.33</td>
</tr>
<tr>
<td>Levi, 1999</td>
<td>Red meat</td>
<td>327</td>
<td>491</td>
<td>1.55</td>
</tr>
<tr>
<td>Neugut, 1993</td>
<td>Red meat</td>
<td>286</td>
<td>480</td>
<td>1.9</td>
</tr>
<tr>
<td>Le Marchand, 2002</td>
<td>Red meat</td>
<td>727</td>
<td>727</td>
<td>8.8</td>
</tr>
<tr>
<td>Deneo-Pellegrini, 2005</td>
<td>Red meat</td>
<td>556</td>
<td>1112</td>
<td>3.1</td>
</tr>
<tr>
<td>Kulidoff, 2000</td>
<td>Red meat</td>
<td>148</td>
<td>228</td>
<td>1.3</td>
</tr>
<tr>
<td>Combined</td>
<td>Red meat</td>
<td>3492</td>
<td>12233</td>
<td>2.2</td>
</tr>
<tr>
<td>Combined All</td>
<td>All meat</td>
<td>5226</td>
<td>14706</td>
<td>2.17</td>
</tr>
</tbody>
</table>

Table 2: Effect-equality test for meat consumption and colorectal cancer risk from published studies

<table>
<thead>
<tr>
<th>Kind of meat</th>
<th>Outcome Measure</th>
<th>Cochran’s Q</th>
<th>df</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole meat</td>
<td>Odds Ratio</td>
<td>15.0979</td>
<td>4</td>
<td>0.0045</td>
</tr>
<tr>
<td>Red meat</td>
<td>Odds Ratio</td>
<td>173.3718</td>
<td>6</td>
<td>0.0000</td>
</tr>
<tr>
<td>Combined</td>
<td>Odds Ratio</td>
<td>188.4835</td>
<td>11</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Trends (Egger and Davey Smith, 1997). In the present study, the meta-analysis was performed using NCSS and PASS 2000 Released December 2005. This software requires the input of the number of cases and controls into a two-by-two table to calculate the combined odds ratio (OR) and 95% confidence interval (CI).

Additional subgroup analyses were carried out to examine the effects of the type of control, the kind of meat.

**Results**

The results of the meta-analysis including number of cases and controls, odds ratios are shown in Table 1. A total of 5226 cases and 14706 controls constitute the subjects of meta-analysis. The principal outcome measured was odds ratio (OR) for the risk of whole meat and red meat consumption related to colorectal cancer.

Table 2 shows the null hypothesis that all effects are equal (homogeneous) versus the alternative that at least one effect has a different effect (heterogeneous). The Table shows that the odds ratio for whole meat studies, red meat studies as well as combined studies are statistically different.

Table 3 shows the odds ratio of whole meat consumption related to colorectal cancer is 2.20. As well as, the odds ratio for red meat consumption is 2.13. The upper and lower confidence intervals show there are not any statistical significance between odds ratios for whole meat and red meat consumption related to colorectal cancer.

Fig. 1 shows odds ratio of case-control studies related to meat consumption and colorectal cancer risk from published studies.

**Discussion**

This study showed that whole meat and red meat were associated with colorectal cancer. Also, there was not any difference between whole meat and red meat related to colorectal cancer.

Meta-analysis is used to improve the statistical efficiency to evaluate the disadvantages of formulated researches, and hypothesis to reach reliable conclusions from the mixed assortment of the potentially relevant studies to determine the most promising directions for future researchers (Chen et al., 2003; Qing et al., 2004).

The risk of colon cancer is greatest in persons who eat diets high in meat and fat and lowest in those who choose high-fiber diets rich in vegetables and fruit (American Institute for Cancer Research, 1997; Potter et al., 1993).

Some studies showed, frequent consumption of meat, particularly red meat, is associated with an increased risk of colon cancer (Singh and Fraser, 1998; Giovannucci et al., 1994). Statistics show meat-eaters develop colon cancer at triple the rate vegetarians do. Total fat and saturated fat, which tend to be substantially higher in animal products than in plant-derived foods, and refined sugar, all heighten colon cancer risks. Researchers zeroed in on red meat, finding that
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Table 3: Odds ratio and confidence interval for meat consumption and colorectal cancer risk from published studies

<table>
<thead>
<tr>
<th>Type of meat</th>
<th>Odds Ratio</th>
<th>95% Upper Confidence interval</th>
<th>95% Lower Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole meat</td>
<td>2.13</td>
<td>1.57</td>
<td>2.90</td>
</tr>
<tr>
<td>Red meat</td>
<td>2.20</td>
<td>1.86</td>
<td>4.08</td>
</tr>
<tr>
<td>Combined</td>
<td>2.17</td>
<td>1.49</td>
<td>3.16</td>
</tr>
</tbody>
</table>

Fig. 1: Odds Ratio of case-control studies related to meat consumption and colorectal cancer risk from published studies

individuals eating beef, pork, or lamb daily have approximately three times the colon cancer risk, compared to people who generally avoid these products (Willett et al., 1990; Giovannucci et al., 1994). A recent review of 32 case-control and 13 cohort studies concluded that meat consumption is associated with an increase in colorectal cancer risk, with the association being more consistently found with red meat and processed meat (Giovannucci et al., 1994). According to the results of our study, whole meat and red meat were associated with a significant increase in risk for colorectal cancer. These findings are in accordance with most of the previous case-controls studies (Norat and Riboli, 2001; Manousos et al., 1983; Chao et al., 2005; Gerhardsson et al., 1991; Bailar and Mosteller, 1992).

The strength of our study was the ability to compare red meat and whole meat, as risk factors for colorectal cancer using meta analysis. Although, combined OR for red meat was more than whole meat but the differences was not statistically significant. Since, other risk factors like cigarette smoking, physical activity and processed meat may influence on colorectal cancer. Processed meat includes foods preserved by salting, or the addition of nitrates or nitrates, and high consumption of these foods can increase exposure to nitrosamines and their precursors. The amount of these substances in processed meat likely varied by region and over time but we had no information to assess the impact of these differences in our study results.

Our study had several limitations. We had no information on meat cooking methods to estimate exposure to heterocyclic amines or other specific carcinogens produced from pyrolysis of meat; because our study was meta-analysis of conducted case-control studies. Also, we had no information on family history of colorectal cancer from the studies. In conclusion, our findings strongly support a relationship between meat consumption and increased risk of colorectal cancer.

References


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