Increased Formation of Oxidative DNA Damage, 8-Hydroxydeoxyguanosine, in Human Livers with Chronic Hepatitis

Ryuya Shimoda, Makoto Nagashima, Michie Sakamoto, Naohito Yamaguchi, Setsuo Hirohashi, Jun Yokota, and Hiroshi Kasai

ABSTRACT

8-Hydroxydeoxyguanosine (oh8dG) is a promutagenic DNA lesion produced by oxygen radicals. We examined alterations in the oh8dG level in human livers which have chronic hepatitis, liver cirrhosis, and hepatocellular carcinoma. The oh8dG content in livers with chronic hepatitis was significantly higher than the oh8dG content in normal livers (P < 0.05). There was also a significant correlation between the oh8dG content in noncancerous liver tissues with individual serum alanine aminotransferase concentration (r = 0.515; P < 0.001). Thus, chronic inflammation in the liver produces oxidative DNA damage, which may increase the risk for genomic alterations causing hepatocarcinogenesis.

INTRODUCTION

HCC3 is one of the most frequent human cancers in the world. Pathoanatomical studies have revealed that hepatocarcinogenesis occurs in multiple stages including chronic liver disease, adenomatous hyperplasia, atypical adenomatous hyperplasia, early HCC, and advanced HCC (1). It is well accepted that cancer is attributed by genetic alterations accumulating in the cells during the stage of chronic liver disease. Thus, it is very important to identify risk factors for genomic instability which is responsible for the occurrence of genetic alterations for carcinogenesis. oh8dG3 is a promutagenic DNA lesion produced from deoxyguanosine by oxygen radicals (2, 3). Formation of oh8dG in DNA induces targeted G:C-to-T:A transversions unless repaired prior to DNA replication not only in vitro (3) but also in vivo (4-6). G:C-to-T:A transversions frequently occur in the p53 gene with the development of hepatocellular carcinoma (7, 8). Aflatoxin B1 is a potential contributor to hepatocarcinogenesis, and dietary exposure to it is correlated with G:C-to-T:A transversions at the third base of codon 249 of the p53 gene (9, 10). Though Japan is, geographically, a low-exposure area and the mutation site is not accumulated at codon 249 of the p53 gene (11). Therefore, we evaluated the content of oh8dG in DNA of various types of human liver tissues and furthermore, we estimated correlation between the oh8dG content in noncancerous liver tissues and the individual serum ALT concentration to attest to the risk of chronic inflammation for carcinogenesis through the generation of oh8dG in DNA of the liver.

MATERIALS AND METHODS

Fresh human liver tumors and noncancerous liver tissues were collected in operating rooms from Japanese patients undergoing resections. Serum ALT concentrations were evaluated within 3 days before operations. Normal livers were collected from patients with metastatic liver tumors. To prevent oxidation by air exposure, all solutions and instruments which came in contact with the specimens were filled with argon gas. DNA was isolated from the homogenate of each sample (150-400 mg) using a nucleic acid extractor (Applied Biosystems). In this instrument, the homogenate was digested with proteinase K, and DNA was directly precipitated from the lysate with ethanol. Phenol/chloroform extraction was skipped, since it is known to induce oh8dG formation in DNA by subsequent exposure to the air (13). The extracted DNA was treated with nuclease P1 and alkaline phosphatase as described previously (14). oh8dG in digested DNA was assayed by an electrochemical detector, and dG concentration in DNA was assayed by UV monitor, simultaneously, coupled with high-pressure liquid chromatography. The amount of dG was calculated from the absorbance at 290 nm, and the amount of oh8dG was expressed as the number of oh8dG for every 10^3 dG in DNA. Statistical Package for Social Sciences was used for statistical analyses.

RESULTS AND DISCUSSION

The oh8dG contents in chronic hepatitis livers, cirrhosis livers, HCCs, and normal livers were evaluated by the method described above. We found that oh8dG level was increased in livers with chronic hepatitis but not in cirrhosis livers and HCCs. The oh8dG content in livers with chronic hepatitis was significantly higher than the oh8dG content in normal livers (P = 0.016) (Fig. 1). In contrast, the differences between cirrhosis livers and normal livers and between HCCs and normal livers were not statistically significant (P = 0.132 and P = 0.174, respectively).

In addition, we noticed significant correlation between the oh8dG content in livers and serum ALT concentration (r = 0.51; P < 0.001; Fig. 2). This correlation was persistently observed even when the effect of the transcatheter arterial embolization or the transluminal arterial infusion of anticancer drugs on the oh8dG level was taken into account by analysis of covariance.

Persistent infection of either HBV or HCV is epidemiologically associated with the development of HCC. Thus, we evaluated the difference in the oh8dG level in livers with the evidence of HBV and/or HCV infection (Table 1). There were no significant differences in the oh8dG level between the HBV-positive group and the HCV-positive group. There was no case which was positive for both HBV and HCV in this study. The oh8dG level in one case with no evidence of HBV and HCV infection was 2.94, which was similar to those in the virus-positive groups. Neither the multifocality (15) of tumors nor the histological grade of tumors proved to have a significant difference among the oh8dG levels in the surrounding noncancerous liver tissues. Thus, correlation of the serum ALT unit with the oh8dG
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Fig. 1. oh8dG content in human livers under various conditions. Individual data is shown with a filled oval, and the mean ± SE in each group is indicated at the bottom.

Fig. 2. Correlation of the oh8dG content in livers with the serum ALT concentration. Individual data is shown with an open oval.

c content in livers suggests that tissue inflammation may directly cause the formation of oh8dG in DNA.

We previously demonstrated that the oh8dG level in the liver DNA was elevated in Long-Evans cinnamon rats, which have abnormal copper metabolism, hereditary hepatitis, and subsequent HCCs (14). It was speculated that oxygen radicals were produced by the copper accumulated in their livers and induced oh8dG formation in DNA. In addition, it has been shown that various carcinogens, ionizing radiation, and psychological stress increase the oh8dG content in the DNA of murine livers (16, 17). Hence, we now obtained the evidence showing that tissue inflammation in the liver generates oxidative DNA damage, leading to genomic instability, and that chronic hepatitis is a potent mutagenic stage for liver cells. Clinically, high correlation of serum ALT concentration with the oh8dG content may imply that the treatment of chronic liver disease to repress serum ALT concentrations might reduce genomic instability by decreasing the oh8dG content in the liver.

REFERENCES


Table 1 oh8dG content in DNA of the liver with persistent viral infection

<table>
<thead>
<tr>
<th>Type of tissue</th>
<th>oh8dG/10^6 dG</th>
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<tr>
<td>HBV positive^a (n = 5)</td>
<td>3.22 ± 0.94^b</td>
</tr>
<tr>
<td>HCV positive^a (n = 22)</td>
<td>2.71 ± 0.39^b</td>
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^a HBs antigen positive.
^b Mean ± SE. There was not a significant difference between these groups.
^c Second generation anti-HCV antibody positive.
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