The expression of antiapoptotic proteins Bcl-2, Bcl-X₇, and Mcl-1 in benign, dysplastic, and malignant biliary epithelium

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Abstract

Aim—Cholangiocarcinoma can be cured by surgery, but only in a minority of cases. The activation of apoptosis is a major mode of action of chemotherapy and radiotherapy, which have limited benefit in the treatment of cholangiocarcinoma. The antiapoptotic members of the Bcl-2 protein family (Bcl-2, Bcl-X₇, and Mcl-1) are important inhibitors of apoptosis, but have not been investigated extensively in cholangiocarcinoma.

Methods—The expression of Bcl-2, Bcl-X₇, and Mcl-1 was investigated in normal biliary epithelium (17), biliary dysplasia (three), and invasive cholangiocarcinoma (51), in addition to three human cholangiocarcinoma cell lines, by immunohistochemistry and immunofluorescence.

Results—The expression of Bcl-2 was not detected in normal or malignant biliary tissue. In contrast, granular cytoplasmic Bcl-X₇ and Mcl-1 staining was found in 60–100% of cells in all normal, dysplastic, and malignant specimens, including the human cell lines examined in this study.

Conclusion—These findings indicate that Mcl-1 and Bcl-X₇, but not Bcl-2, are involved in the survival of normal and neoplastic cells in the biliary tree. By prolonging survival through blocking apoptosis, these proteins might be reducing the efficacy of cytotoxic anticancer treatments in cholangiocarcinoma.

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Keywords: cholangiocarcinoma; apoptosis; Bcl-2; Mcl-2; Bcl-X₇

Cholangiocarcinoma is the second most common primary malignancy of the liver. The aetiology remains unknown. Oxidative damage, oncogene activation, and impaired apoptosis have been suggested to play a part in the pathogenesis. Despite advances in diagnosis, surgery offers the only possible chance for long term survival. Resection rates are at best between 25–50%. The five year survival rate after curative resection is between 0% and 30%. The results of palliative chemotherapy and/or radiotherapy remain poor. Chemo-therapy and radiotherapy used in the treatment of a wide variety of malignancies induces apoptosis in responsive cells. Failure to initiate apoptosis is a major factor limiting the efficacy of these treatments. The Bcl-2 protein family plays a central part in the control of apoptosis. Bcl-X₇, Bcl-1, Bcl-w, and A1 are other antiapoptotic members, whereas Bad, Bid, and Bcl-X₇ are pro-apoptotic. High concentrations of Bcl-2 or Bcl-X₇ affect the susceptibility of a cell to the induction of apoptosis by altering the ratio of death promoters to suppressors, providing tumour cells with a survival advantage, and permitting expansion of transformed cells harbouring mutations within their genome. The Bcl-2 protein and other family members target intracellular organelles such as the endoplasmic reticulum and the outer mitochondrial and nuclear membranes, where they modulate responses to diverse death stimuli. This subcellular location is important for function. Some members of the Bcl-2 protein family when bound to the mitochondria regulate the function of the large polymeric channel, permeability transition pore complex, located at the point of contact between the inner and the outer mitochondrial membranes. The opening of this pore, known as mitochondrial permeability transition, is associated with the release of apoptogenic proteins.20 21

Some cases of cholangiocarcinoma have been found to express Bcl-2. Studies involving a variety of haematological and several solid malignancies have identified a correlation between high Bcl-2 or Bcl-X₇ expression, poor patient response to treatment, and overall prognosis. Such observations parallel the findings in experimental models. No such correlation has been suggested or studied in cholangiocarcinoma.

Cholangiocarcinoma is multidrug and radio-resistant. Failure to induce apoptosis after cytotoxic treatment could explain the poor response to treatment. Therefore, the expression of the Bcl-2, Bcl-X₇, and Mcl-1 proteins was investigated in normal and malignant biliary epithelium.

Materials and methods

PATIENT SPECIMENS

Cholangiocarcinoma specimens (formalin fixed, paraffin wax embedded) from 51 patients who had undergone surgery over the past 20 years in our department were examined. All 51 cases had the diagnosis verified by a consultant pathologist before being included in our study, at the same time the blocks most representative for study were selected. Normal biliary epithelium tissue comprised a combination of resected normal gallbladders (six), common bile duct (one), and bile duct brushings collected during endoscopic retrograde cholangiopancreatography (ERCP) for benign...
Table 1 Expression of Bcl-2, Bcl-XL, and Mcl-1 in normal, dysplastic, and malignant biliary epithelium

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Number of samples (unless otherwise stated)</th>
<th>Bcl-2 protein</th>
<th>Bcl-XL protein</th>
<th>Mcl-1 protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal biliary epithelium</td>
<td>7 (GB, 6; CBD, 1)</td>
<td>Negative</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>Fresh cytology and brush samples</td>
<td>10</td>
<td>Negative</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>Biliary dysplasia</td>
<td>10</td>
<td>Negative</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>Cholangiocarcinoma</td>
<td>51</td>
<td>Negative</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>Human cholangiocarcinoma cell lines</td>
<td>3</td>
<td>Negative</td>
<td>Positive</td>
<td>Positive</td>
</tr>
</tbody>
</table>

CBD, resected common bile duct; GB, resected gall bladder.

Results and Discussion
Cholangiocarcinoma cells and normal biliary epithelial cells examined did not express the Bcl-2 protein, despite positive Bcl-2 staining in control tissue and small intrahepatic regenerating bile ductules (table 1; fig 1). However, Bcl-XL and Mcl-1 were expressed in all cholangiocarcinoma specimens examined, including the three human derived cholangiocarcinoma cell lines (figs 2, 3C,D). In addition, benign biliary epithelial cells from both preserved tissue and fresh samples also expressed Bcl-XL and Mcl-1 (fig 3A,B). The distribution...
of the cytoplasmic staining at higher magnification was localised to intracellular organelles, such as the mitochondria; immunofluorescence demonstrated the distribution more clearly (fig 3C,D). Although a double staining immunohistochemical technique would be required to prove formally that both Bcl-X\(_L\) and Mcl-1 are coexpressed in the same cell, the staining from sequential sections and cell lines for both antibodies strongly suggest that this is the case.

Most studies looking at the expression of Bcl-2 in cholangiocarcinoma report varying amounts of Bcl-2 protein expression in this disease.\(^\text{24}\) In contrast, a study looking at Bcl-2 protein expression in cholangiocarcinoma recently reported that none of the cholangiocarcinoma samples examined expressed the Bcl-2 protein.\(^\text{26}\) With Bcl-2 expression detected in the internal positive controls and in regenerating intrahepatic ductular epithelium, an observation reported previously,\(^\text{37}\) our inability to detect Bcl-2 protein is unlikely to be a result of poor antigen retrieval or low Bcl-2 antibody activity. There have been suggestions that in some cell types a reciprocal expression of survival proteins Bcl-2 and Bcl-X\(_L\) occurs. Considering there are still many unanswered questions about the cellular control and preference of expression of the different Bcl-2 genes,
this might explain the differences in reported findings. It may be that as we learn more about these proteins, reasons for the differences in expression may become clearer. The number of cholangiocarcinoma samples examined (archival tissue from 51 cases and three cell lines) makes this the largest study of Bcl-2 expression in cholangiocarcinoma. In combination with the findings of the recent study by Arora and colleagues, it seems that most cases of cholangiocarcinoma do not express immunohistochemically detectable amounts of Bcl-2 protein, and its function is probably carried out by other proteins, such as Bcl-XL. What is of more interest, however, is that the expression of antiapoptotic proteins appears to be a common feature in cholangiocarcinoma.

The expression of antiapoptotic (cell survival) proteins by normal biliary epithelial cells may be an adaptive response aimed at protecting against...
excessive cellular loss as a result of apoptosis caused by biliary toxins such as bile salts, xenobiotics, drugs, and heavy metals. Because the epithelial lining of the bile ducts is a monolayer, the balance of cell loss against cell production will require tight control to avoid excessive losses as a result of apoptosis, which could lead to ulceration, scarring, and fibrosis of bile ducts. The regulation of apoptosis within the biliary tree to maintain tissue homeostasis may be one function of biliary Bcl-XL and Mcl-1 proteins. A recent study found that skin keratinocytes that are constantly exposed to the cytotoxic effects of UV light were resistant in vitro to irradiation induced apoptosis through the upregulation of Bcl-XL protein expression. That the Bcl-XL and Mcl-1 proteins are playing a similar role in the biliary tree has yet to be shown. There are some researchers who have hypothesised that high concentrations of antiapoptotic proteins, such as the Bcl-2 protein, within the biliary tree play a key role in the development of cholangiocarcinoma by allowing cells that harbour growth promoting mutations, such as mutations of K-ras, c-erb-B-2, or c-myc, to survive by evading apoptosis, which would otherwise be triggered by an unstable genome.

The role that antiapoptotic proteins play in the pathogenesis and the response of cholangiocarcinoma to cytotoxic treatment are unclear. It may be that studies looking into the effects on apoptosis sensitivities after antagonising Bcl-XL and/or Mcl-1 target function, directly or indirectly, may provide some evidence for their possible role in the resistance to anticancer treatment.

In conclusion, our study of Bcl-XL, Mcl-1, and Bcl-2 protein expression in benign and neoplastic biliary epithelium demonstrates that...
both normal and neoplastic cells coexpress the cell survival proteins Bcl-X, and Mcl-1, but not Bcl-2. Through inhibiting apoptosis, the Bcl-X, and Mcl-1 proteins expressed by cholangiocarcinoma may be contributing to the low efficacy of chemotherapy and radiotherapy in this disease.

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