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Identification of differentially expressed proteins in cigarette smoke condensate-induced lung cancer cells by comparative proteome analysis

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Lung cancer remains the leading cause of cancer death world wide. Exposures to many environmental agents including the inhalation of cigarette smoke, radioactive compounds, asbestos, heavy metals, and petrochemicals constitute the risk factors to lung carcinogenesis. Since cigarette smoking is one of the highest attributable risk factor for lung cancer, we attempted to identify potentially important proteins by employing the two dimensional gel electrophoresis (2DE)-based display proteomics. In this study, we report an approach to comparatively analyze differentially expressed protein profiles between the previously described cigarette smoking condensate (CSC)-induced tumorigenic human bronchial epithelial (HBE), 1170I and the pre-malignant 1799 and 1198 cell lines (Kim et al., Cancer Research 55: 5603, 1995). At least thirty proteins showed significant quantitative alterations between the tumorigenic and the pre-malignant cell lines. The altered proteins were characterized by matrix-assisted laser desorption/ionization (MALDI) coupled with time-of-flight (TOF) mass spectrometry (MS). Some of the identified proteins are known to regulate oxidative stress, cell cycle, or energy metabolism. Others are implicated in the lung cancer susceptibilities. We are currently investigating the potential significance of the some of these identified proteins in CSC-induced lung carcinogenesis. A functional and regulatory significance of Hsp90 up-regulation in 1170I cells is under extensive investigation since Hsp90 is known to function in the retinoic receptor signal transduction pathways and our previous study showed the retinoid refractoriness in tumorigenic 1170I cells. Identification of the repertoire of other altered proteins associated with CSC-induced lung carcinogenesis should provide additional insights into the mechanism of CSC-induced lung carcinogenesis as well as to provide useful biomarkers that can be employed as intermediate end points in the chemoprevention trials. [Supported by a grant from the Korean Ministry of Health and Welfare]

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Evaluation of the antineoplastic properties of COX-2 selective inhibitors in human breast and prostate tumor cell lines: evidence for a COX-2 independent mechanism

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Nonsteroidal anti-inflammatory drugs (NSAIDs) have striking cancer chemopreventive properties and may also have applications for advanced disease. For example, epidemiological studies have shown that NSAIDs can reduce the risk of death from colorectal cancer by as much as 40-50% and clinical trials are in progress to determine combination benefits with chemotherapy. The mechanism(s) for the antineoplastic properties of NSAIDs is controversial and may not involve cyclooxygenase (COX) inhibition. COX inhibition is, however, responsible for toxicity that limits the utility of NSAIDs for chemoprevention. Derivatives that are selective for the inducible COX-2 isozyme and have less GI toxicity than conventional NSAIDs are of particular interest for chemoprevention. In this study we determined the activity of the COX-2 selective inhibitors, celecoxib and rofecoxib, and the non-selective inhibitor, sulindac sulfide, in human MDA-MB-231 breast and LNCaP prostate tumor cell lines. Celecoxib and rofecoxib were synthesized at the IDD using published methods and structures confirmed by 1H- and 13C-NMR and mass spectrometry. Celecoxib inhibited the growth of MDA-MB-231 and LNCaP cells with IC_{50} values = 137 and 54 uM, respectively, as determined by the MTS assay. Celecoxib also induced apoptosis as measured by DNA fragmentation and displayed comparable potency with sulindac sulfide. By contrast, rofecoxib was essentially inactive in both cell lines at doses up to 500 uM. These results were unexpected because rofecoxib is a more potent than celecoxib with regard to COX inhibition and suggest a COX-independent mechanism of action. In addition, the greater sensitivity of prostate tumor cells to celecoxib compared to breast tumor cells indicates there may be important tissue-specific differences that are unrelated to the expression of COX-2 and should be tested in preclinical models before drugs are tested in clinical trials. Future studies are planned to evaluate these and other NSAIDs alone and in combination with standard chemotherapeutic drugs in xenograft and bone metastasis mouse models for advanced disease.

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NCX 4016, a nitric oxide-releasing aspirin derivative, exhibits a significant antiproliferative effect and alters cell cycle progression in human colon adenocarcinoma cell lines

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Purpose: Numerous studies demonstrated that non-steroidal anti-inflammatory drugs (NSAIDs) are useful agents for prevention and cure of cancers, especially colon and rectal cancers, but side effects are a major obstacle to their assuntion. Nitric oxide releasing non-steroidal anti-inflammatory drugs (NO-NSAIDs) are reported safer than NSAIDs by their ability to decrease gastric toxicity. In our study we assessed *in vitro* the cytotoxic activity of a new aspirin derivative, NCX 4016 [2-(Acetyloxy)benzoic acid 3-(nitrooxymethyl)phenyl ester], after different exposure schedules in three colon adenocarcinoma cell lines (LoVo, WiDr, LRWZ).
Experimental design: COX-1 and COX-2 expression of all the three cell lines was evaluated as protein expression and mRNA content by Western blot and RT-PCR respectively, cytotoxic activity was evaluated by sulforhodamine B assay and the data elaborated according to Monk's model, cell cycle perturbations and apoptosis were evaluated by flow cytometry, mitotic index was evaluated by at microscope on hematoxylin-eosin stained cytospin.
Results: All the lines were positive for the presence of protein and mRNA of the isoenzymatic form COX-1. Conversely, protein expression of COX-2 was limited to one (WiDr line). Important anti-proliferative effects were induced by NCX 4016 and GI50 value, ranging from 165-to 250 μM, was already reached after 24-h drug exposure in all cell lines. The antiproliferative action resulted independent from cell lineage, exposure time, and COX-1 or COX-2 status. A significant cell killing was observed only at the highest concentrations and LC50 values were reached only after longer time exposures. NO-aspirin compound also induced an accumulation of cells in G2-M phase in all the cell lines used with a peak after 48-h treatment which still persisted after 72-h or after 48-h exposure followed by a 24-h of wash-out. Furthermore, the block resulted be charged to G2 phase whereas mitosis phase was not affected at all.
Conclusion: Our results indicate that NCX 4016 has an *in vitro* antiproliferative activity superior respect to parental compound aspirin that makes it a potential important tumor chemopreventive agent and the cytocidal effect to higher concentration with specific block in G2 phase renders it a promising candidate for drug combination regimen.

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5-aza-2'-deoxycytidine and Trichostathin A enhanced growth inhibitory effect of all trans retinoic acid by the restoration of retinoic acid receptor β expression in head and neck squamous carcinoma cells

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The growth of head and neck squamous carcinoma cells (HNSCCs) are inhibited by all-trans retinoic acid (atRA) treatment. The effects of atRA on HNSCC growth and differentiation are mediated by nuclear retinoid receptors. However, the expression of retinoic acid receptor beta; (RAR-beta) is suppressed by aberrant methylation of RAR-beta promoter region in many HNSCCs, and acquire resistance to atRA treatment in such cells. These suppression of RAR-beta expression can be reactivated by exposure to demethylating agent, such as 5-aza-2'-deoxycytidine (5-AZA-CdR). Histone acetylation also plays a role in the control of expression of tumor suppressor genes. To investigate whether the reactivation of RAR-beta gene expression reverse retinoid resistance, atRA was co-treated with 5-AZA-CdR and histone deacetylase inhibitor (trichostatin A; TSA), either alone or in combination in RA-sensitive (1483) and RA-resistant (SqCC/Y1) HNSCCs. Cells were treated with 5-AZA-CdR at concentrations ranging from 0.05 microM to 5 microM 48 h.
After removing the media, we treated these cells with TSA 50 nM and 1 microM atRA sequentially for 48 h or 72 h. The cell viability was measured spectrophotometrically at 540 nm using the MTT assay. We measured cell cycle changes by the flow cytometric analysis. RAR-beta expression were analyzed using Western and Northern blotting. Methylation-sensitive PCR analysis was used to confirm that lack of expression of RAR-beta was due

to hypermethylation of its promoter region. Both 5-AZA-CdR and TSA alone showed growth suppression in both cell lines. RA-resistant SqCC/Y1 cells did not express RAR-beta by treatment with 1 microM atRA alone. Also, 5-AZA-CdR alone did not activate the expression of RAR-beta. However, the combination of atRA and 5-AZA-CdR appeared to increase RAR-beta expression in SqCC/Y1 cells. In SqCC/Y1 cell, flow cytometric analysis indicated that TSA augumented atRA-induced cell cycle changes. Inhibition of methylation and deacetylation may reverse sensitivity of atRA by reactivation RAR-beta in RA-resistant cell line.

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COX-2 inhibition may not be related with growth inhibition and cell cycle phase-specific apoptosis by celecoxib in human NSCLC cells *in vitro*

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Background: Cyclooxygenase-2 (COX-2) is an inducible enzyme which produce prostanoids by various stimuli. Overexpression of COX-2 in many tumor types supported its association with tumor progression, which has been a target for chemoprevention and chemomodulation. Celecoxib, a specific COX-2 inhibitor, originally developed for antiinflammatory agent showed anticancer activity. We studied conc and time dependency of COX-2 inhibition, growth inhibition, and cell cycle arrest induced by celecoxib in A549 COX-2 overexpressing human NSCLC cells.
Methods: Inhibition of COX-2 activity and COX-2 expression were measured using an Enzyme Immunoassay (EIA) for PGE2 and Western blot, respectively. Growth inhibition and cell cycle distribution were determined by SRB assay and flow cytometry, respectively. Relationship between cell cycle arrest and apoptosis induction was studied using TUNEL/DNA-content two parameter flow cytometry.
Results: Inhibition of COX-2 activity was conc- and exposure-time dependent. COX-2 inhibition at 0.1μM increased with increasing exposure time i.e., 20% at 6hr to 60% at 24hr. IC_{50} and IC_{80} for 24hr exposure were approx. 0.1 and 1μM, respectively. Growth inhibitory effect was also showed conc and time dependency. Cytotoxic IC_{50} after 6hr exposure was 110 μM and decreased to 20 μM after 72hr exposure. These conc were about 600 fold higher than those of COX-2 inhibition. At 50 μM ($IC_{80,72hr}$) G1 phase block and apoptosis was induced after 24hr and the apoptotic cell population appeared from G1 phase. No significant apoptosis was shown at 20 μM ($IC_{50,72hr}$). The level of COX-2 expression was not altered when treated up to 20 μM.
Conclusion: In human NSCLC cells, the inhibitory conc of COX-2 activity and cell growth were more than 600 fold different, suggesting that these two effects may not have direct causal relationship. Growth inhibition and apoptosis induced by celecoxib are associated with G1 phase arrest, which may be important in designing of combination regimen of celecoxib. Changes in expression level of COX-2 and other factors at higher conc are under investigation to elucidate the mechanism of growth inhibition by celecoxib in human NSCLC cells.

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Regulation and function of Cyclooxygenase-2 (COX-2) in ovarian carcinoma cells

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Cyclooxygenases are enzymes involved in production of prostaglandins and play a role in the regulation of tumor development and progression in several different tumors. We have recently shown that an increased expression of COX-2 is an independent prognostic factor for poor survival in patients with ovarian carcinomas. Based on this immunohistochemical study, we performed cell culture experiments to investigate the regulation of COX-2 in the ovarian carcinoma cell line OVCAR-3. Using RT-PCR and Western blot, we observed a strong induction of COX-2 mRNA and protein levels after treatment with interleukin-1beta. In parallel, increased levels of prostaglandin E2 were measured by ELISA. In a luciferase-assay, a basal activity of the COX-2 promoter was detected, which was increased 2-fold after treatment with interleukin-1beta. Inhibition of the p38MAPK pathway with the inhibitor SB203580 (1-10μM) reduced COX-2 protein levels as well as PGE2 levels. In contrast, inhibition of the p42/44MAPK pathway induced only a slight inhibition of COX-2 protein levels at inhibitor concentrations of 50μM. Production of PGE2 was inhibited by SB203580 at inhibitor concentrations of 2μM. We used the COX-2 inhibitor NS398 to investigate the effect of COX-2 inhibition on PGE2 levels as well as cell proliferation. While NS398 completely inhibited PGE2 production at concentrations of 1μM, cell proliferation was affected only at inhibitor concentrations of 100μM. The data indicated that the p38MAPK pathway is involved in regulation of COX-2 expression in OVCAR-3 cells and that the anti-proliferative effects of the inhibitor NS-398 are most likely mediated through a non-COX target.

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Epican forte - a specific formulation of nutrients containing lysine, proline, ascorbic acid, and epigallocatechin gallate inhibits matrix metalloproteinases activity and the invasion potential of human cancer cell lines

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One of the hallmarks of cancer is its ability to invade and metastasize to distal organs. Matrix metalloproteinases (MMPs) have been identified as key players in tumor invasion and metastasis. Current treatment protocols with chemotherapy and/or radiation are toxic and have the potential to destroy healthy cells. Our approach has been to develop strategies to inhibit cancer development, progression, and metastasis using naturally-occurring nutrients. Lysine and proline are the building blocks of collagen fibers that stabilize connective tissue. Vitamin C is essential for the production of collagen, and is a scavenger of free radicals that protects cells from damage. Epigallocatechin Gallate (EGCG) is a green tea extract with antioxidant and anticarcinogenic properties. It is postulated that the combination of these nutrients exerts a very potent synergistic, anticancer activity. Based on this prediction, Epican Forte (EF) was formulated by Matthias Rath, Inc. EF contains a mixture of nutrients, including lysine, proline, ascorbic acid, and EGCG. In the present study, we investigated the effect of EF on MMP expression, invasion potential, and cytotoxicity/cell proliferation in several human cancer lines of the skin (melanoma), breast (MDA-MB-231) and liver (Hep G2). We also studied the effects of EF on normal human dermal fibroblast (NHDF) and on the co-culture of melanoma and NHDF cells. MMP expression was studied by zymography, invasion through Matrigel, and cytotoxicity/cell proliferation by MTT assay. EF inhibits the expression of MMP-2 and MMP-9 in a dose-dependent fashion. The expression of MMP-2 and MMP-9 was significantly inhibited with a concentration of 100 μg/ml of EF and virtually undetectable with a concentration of 1000 μg/ml. EF used at 10 and 100 μg/ml concentrations did not significantly affect the cells viability, and at 1000 μg/ml it showed cytotoxicity at the range of 10-40 percent, depending on the cell type. The invasion of melanoma cells, MDA-MB-231 cells, and a co-culture of melanoma cells with NHDF through Matrigel was significantly reduced in a dose-dependent manner. Thus, these results demonstrate that EF is very effective for several cancer cell lines and also in co-culture. These observations reveal that EF may provide a natural therapeutic basis that makes it a valuable and promising candidate for the treatment of human cancers. Currently, experiments are in progress to evaluate the efficacy of EF in a clinical setting.

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The chemopreventive activities of vitamin A, beta-carotene and all-trans and 9-cis retinoic acids during hepatocarcinogenesis in rats involve inhibition of cell proliferation but not induction of apoptosis

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Although data from several epidemiological studies suggest a protective role of retinoids and carotenoids against cancer, 2 large trials (CARET and ATBC) conducted with vitamin A and/or beta-carotene have yielded negative or conflicting results. Therefore, in this study vitamin A (VA), beta-carotene (BC), all-trans and 9-cis retinoic acids (ATRA and 9CRA) chemopreventive activities were evaluated on preneoplastic lesions (PNL) induced in Wistar rats by the "resistant hepatocyte" model of hepatocarcinogenesis. Thus, animals received by gavage every other day during 8 weeks VA (1mg/100g body weight [bw]; VA group), BC (7mg/100g bw; BC group), ATRA (1mg/100g bw; ATRA group), 9CRA (1mg/100g bw; 9CRA group) or corn oil (CO) (0.25 mL/100g bw; control group). The macroscopic examination of the livers (incidence and multiplicity, respectively) showed: 100% and 44$\pm$32 (control group); 82% and 7$\pm$10 ($p<0.05$; VA group); 46% ($p<0.05$) and 4$\pm$6 ($p<0.05$; BC group); 92% and 27$\pm$31 (ATRA group); 92% and 11$\pm$15 ($p<0.05$; AT9C group). Moreover, the morphometric analysis of GST-P positive PNL (area [mm^2], % of the section area occupied by PNL and number of PNL/cm^2, respectively) revealed: 0.44$\pm$0.50, 9.7$\pm$6.3