with significant increases in tumor cell and endothelial cell apoptosis ($P \leqslant 0.05$).

Table 1. Correlation of change in p-PDGFR-β activity with clinical benefit.

Clinical outcome	No. of patients	Change in p-PDGFR-β activity
CB	8	18.2% decrease (P = 0.006) (42% decrease [P = 0.008])*
PR	2	26.1% decrease (P = 0.001)
SD	6	13.9% decrease (P = 0.04)
PD (SD < 6 months)	12	9.9% increase (P = 0.06) (23% increase [P = 0.443])*

*Change in p-PDGFR-β activity in tumor-associated endothelial cells.

Conclusions: PDGFR-β phosphorylation was significantly lower in tumor biopsies from patients with GIST who experienced CB but not in biopsies from patients with PD. Sunitinib appears to exert its antiangiogenic effects by inhibiting PDGFR-β activity in tumor-associated endothelial cells, in addition to inhibiting VEGFR-2 activity. Endothelial cell PDGFR-β phosphorylation may be a sensitive marker of sunitinib biological activity.

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Antiangiogenic and anti-invasive activities of the kinase inhibitor sunitinib malate on experimental human glioblastoma in vitro and in vivo

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Background: Angiogenesis inhibitors appear to be promising therapies for highly vascularized tumors such as glioblastoma multiform (GBM). Sunitinib (SUTENT®, SU11248) is an oral multitargeted tyrosine kinase inhibitor with both antiangiogenic and antitumor activities due to selective inhibition of various receptor tyrosine kinases, including those important for angiogenesis (VEGFRs and PDGFRs).
Material and Methods: Here we evaluated the antitumor activities of sunitinib on orthotopic models of GBM *in vitro* and *in vivo*.
Results: Sunitinib potently inhibited angiogenesis which was stimulated by implantation of U87-MG and GL15 cells into organotypic brain slices at concentrations as low as 10 nM. At high dose (10 μM), sunitinib induced direct antiproliferative and proapoptotic effects on GL15 cells and decreased invasion of these cells implanted into brain slices by 49% ($P < 0.001$). Treatment was also associated with decreases in src (60%) and FAK (73%) phosphorylation. However, anti-invasive activity was not observed *in vivo* at the highest dose level utilized (80 mg/kg/day). Survival experiments involving athymic mice bearing intracerebral U87-MG GBM demonstrated that oral administration of 80 mg/kg sunitinib (5 days on, 2 days off) improved median survival by 36% ($P < 0.0001$). Sunitinib treatment caused a 74% reduction in microvessel density ($P < 0.05$), an increase in tumor necrosis, and a decrease in number of MIB-1-positive GBM cells.
Conclusions: The main finding of the present study is that sunitinib exhibited potent antiangiogenic activity which was associated with a meaningful prolongation of survival of mice bearing intracerebral GBM. This data supports the potential utility of sunitinib in the treatment of GBM.

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Adiponectin as a novel therapy for the suppression of liver cancer growth and metastasis

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Background: Recently, adipocyte-derived factor – adiponectin has been demonstrated to be able to suppress angiogenesis in addition to its anti-inflammatory function. It will have great clinical impact to explore the possibility of the application of adiponectin in liver cancer therapy, together with the underlying liver diseases, such as liver cirrhosis and NASH. In the present study, we aim to investigate the effect of adiponectin in the suppression of liver cancer growth and metastasis.
Material and Methods: The orthotopic liver tumor nude mice models with different metastatic potential were applied. 5×10^6 MHCC97H or MHCC97L cells were injected subcutaneously into the right flank of the mice. Once the subcutaneous tumor reached 1 cm in diameter, it was removed and cut into about 1–2 mm cubes which were implanted into the left liver lobe of another group of nude mice. Ad-adiponectin (1×10^8) (treatment group) or Ad-luciferase (control group) was injected via portal vein after tumor implantation. The animals were sacrificed at day 30, 40 and 50 after tumor implantation. The tumor growth and proliferation (Ki67) and local/distant metastases were compared among the groups. Hepatic stellate cell activation in the tumor tissue was detected by α-SMA staining. Cell signaling related to invasion, migration (ROCK-Rho, CAK and FAK) and angiogenesis (VEGF) were compared. The effect of adiponectin on hepatic stellate cell was also investigated by in vitro functional study.
Results: The tumor growth was significantly inhibited by adiponectin treatment at different time points accompanied with the lower incidence of lung metastasis compared to the control groups at different time points. The hepatic stellate cell activation by α-SMA staining in the liver tumors was suppressed by adiponectin treatment. The treatment group got lower incidence of Ki67 positive tumor cells. Protein expression of CAK and FAK was down-regulated in the adponectin treatment groups by immunostaining. Gene and Protein expression of Rho, ROCK and VEGF in the liver tumors was also suppressed.
Conclusion: Adiponectin treatment significantly inhibited liver tumor growth and metastasis by suppression of hepatic stellate cell activation in tumor and down-regulation of cell invasion and angiogenesis pathways.

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Targeting the chemokine receptor CXCR4 and ligand SDF-1/CXCL12 in tumor vasculature and stroma

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Background: The chemokine receptor CXCR4 is expressed at high levels in human cancers. The CXCR4 ligand, SDF-1 (stromal-derived factor 1) is a pro-angiogenic factor secreted by stromal cells. Tumor stroma consists of a variety of cell types including endothelial cells (EC), fibroblasts, progenitor cells, and pericytes. Tumor vasculature may be targeted by therapeutics directed against this pathway.
Materials and Methods: Gene expression analysis was performed on cell lines and databases generated from normal and tumor tissues. Flow cytometry assessed CXCR4 expression; ELISA quantified SDF-1 secretion. Inhibitors were tested in tube formation assays. Progenitor cells were co-injected with colon carcinoma cells to further explore the CXCR4-SDF-1 axis in vivo.
Results: RT-PCR analysis of a 61-cell line panel revealed CXCR4 mRNA expression in EC were comparable to human carcinoma cells. Gene expression analysis confirmed CXCR4 expression in healthy artery tissue, bulk bone marrow, white blood cells, and EC that were isolated from normal lung, brain, breast, and colon samples; CXCR4 was overexpressed 2-fold in EC derived from tumors of the same patients. Comparison of CXCR4 expression in tumor tissue vs. normal counterpart revealed a 2–9-fold increase in CXCR4 mRNA expression in many tumor types. Secreted SDF-1 levels in cultured media were measured by ELISA. MSC and HDF secreted the highest levels of SDF-1 compared to pericytes and EC. Flow cytometry indicated that HUVEC, HMVEC, pericytes, and fibroblasts in vitro express CXCR4 while mesenchymal stem cells (MSC) do not.
HUVEC tube formation on Matrigel was inhibited by antibodies against SDF-1 or CXCR4. Pericyte tube formation was also affected by an antibody against CXCR4 and AMD3100. Immunohistochemistry performed on tumors arising from the co-injection of MSC that secrete SDF-1 and CXCR4-positive colon cancer cells indicate that MSC contribute not only to the stroma, but associate with EC, suggesting that SDF-1 production by MSC can influence both cancer cells and developing blood vessels.
Conclusions: While CXCR4 overexpression in malignant cells is becoming more widely recognized, the tumor vasculature offers additional therapeutic targets. Secretion of SDF-1 by fibroblasts or MSC enhances angiogenesis through the recruitment of CXCR4+ EC, progenitors, and pericytes. A dual approach with antagonists against CXCR4 and/or its ligand SDF-1 against cancer cells and stroma may provide clinical benefit.

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Participation of paxillin in the inhibition by 4-hydroxycoumarin of experimental melanoma metastases

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During the metastasic process, cancerous cells change their adhesiveness and increase their motility. Paxillin is a multidomain adapter protein that interacts with integrins as well as with cytoskeletal proteins, having a crucial participation in the reorganization of the cytoskeleton needed for adhesion and migration. Therefore, changes in paxillin expression or activation correlate with the metastatic potential of cancerous cells. Previously, we

have shown that 4-hydroxycoumarin (4-HC) reduces the motility and the adhesiveness to extracellular matrix proteins of B16-F10 melanoma cells. In this study, we have evaluated the effect of 4-HC on paxillin expression and signaling. Using Western Blot we found that 4-HC (500 μM) reduced the levels of paxillin; the alfa isoform decreased by 50% and the beta isoform diminished by 70%. RT-PCR assays showed that changes in both isoforms correlate with reductions in mRNA levels. Since tyrosine phosphorylation of paxillin is required for integrin-cytoskeleton crosstalk and can regulate its cellular localization, we analyzed the effect of 4-HC on phospho-paxillin content and on paxillin distribution. 4-HC treatment reduced the amount of tyrosine-phosphorylated paxillin and changed its distribution from a punctuate pattern to a perinuclear localization. In contrast, in the non-malignant cell line L929, 4-HC showed no effect on paxillin expression, phosphorylation or localization. Paxillin can also regulate the activation of Rac1 and RhoA; consequently, we performed pull-down assays in B16-F10 cells to evaluate the effect of 4-HC in the activation of these GTPases. 4-HC impaired the activation of both molecules; the active/total ratios were diminished by 65 and 75 % for Rac1 and RhoA respectively. Finally, in order to evaluate the importance of reduced paxillin expression and signaling in the formation of metastases, we injected *in vitro* treated B16-F10 cells into the tail vein of C57BL/6 mice. 4-HC inhibited by 85% the formation of experimental lung metastases. These results address the importance of paxillin in the formation of metastasis by melanoma cells, and suggest that 4-HC might be useful as an adjuvant in the therapy of melanoma.

Supported by PAPIIT/UNAM IN230202 and IN223806.

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hTEM1 BAC Tg mice as a potential in vivo model system for evaluation of therapeutic antibodies against human TEM1

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Background: Tumor Endothelial Marker 1 (TEM1), also known as endosialin, is a transmembrane glycoprotein originally found to be selectively expressed by tumor endothelial cells. Later, TEM1 was described as being predominantly expressed by stromal fibroblasts and a subset of pericytes associated with tumor vessels. More recently, a study using mouse Tem1 KO mice demonstrated that Tem1 plays an important role in experimental tumor progression. Therefore, TEM1 may represent a potential target for cancer treatment.
Materials and Methods: As drug candidates, we raised fully human monoclonal antibodies (mAbs) against human TEM1 (hTEM1) utilizing the KM mice™. However, most of the mAbs were not cross-reactive to mouse Tem1 (mTem1). In order to evaluate efficacy of the mAbs *in vivo*, we generated hTEM1 transgenic (Tg) mice on a C57BL/6 background by using bacterial artificial chromosome (BAC) clones that contain h*TEM1* gene, expecting that those mice show natural expression pattern of hTEM1.
Results: One mouse line estimated to have a single copy number of the transgene was used for further analyses. As expected, hTEM1 was shown to be expressed in an organ-specific manner, suggesting that the Tg mice reproduced natural expression pattern of TEM1. Among major organs, expression level of hTEM1 mRNA was relatively high in heart and ovary compared with liver and spleen. Consistent with reported data on mouse Tem1 expression in normal mouse, semi-quantative RT-PCR indicated that expression level of hTEM1 mRNA in tumor tissues was significantly higher than those in normal tissues. In addition, in tumor tissues, hTEM1 was detected predominantly on stromal fibroblasts and pericytes by immunohistochemical analysis. Interestingly, spatial patterns and levels of hTEM1 expression varied dramatically by tumor cells implanted. For instance, B16 melanoma tissue expresses hTEM1 in the vasculature, whereas MCA207 sarcoma tissue expresses it independently of the vasculature.
Conclusions: These results suggest that studies using hTEM1 BAC Tg mice may provide useful information for development of new mAb drugs targeted to hTEM1. For further convenience, the hTEM1 Tg mice are being crossbred with mTem1 KO mice and SCID mice.

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Improved antitumor activity by combining ZD6474 (ZACTIMA) with radiotherapy and irinotecan in the LoVo human colorectal cancer xenograft model

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Introduction: ZD6474 is a once-daily oral inhibitor of VEGF-dependent tumor angiogenesis and EGFR-dependent tumor cell growth. The objective of the present study was to determine the tumor growth kinetics of the human LoVo colorectal xenograft model in response to radiotherapy (RT) or irinotecan (CPT-11) or both in the presence of ZD6474.
Methods: LoVo cells were injected subcutaneously into the right hind limb (5×10^6 cells in 100 μl PBS) of athymic NCR NUM mice and tumors were grown to a volume of 200–300 mm^3 before treatment. ZD6474 was administered at 50 mg/kg daily p.o. for 14 days starting on day 1. RT was given as three fractions (3×3 Gy) on days 1, 2 and 3. CPT-11 was given at 15 mg/kg i.p. on days 1 and 3. Tumor volumes were measured on a daily basis and calculated by measuring tumor diameters with digital calipers in two orthogonal dimensions.
Results: The kinetics of daily average increase in tumor volume changed with combination therapy after completion of ZD6474 (day 14). Therefore, two analyses were performed to determine tumor growth rates with combination therapy: (1) determination of tumor volume at completion of ZD6474 treatment (day 14); (2) time in days for tumors to reach 1000 mm^3. When tumor volumes were compared on day 14, there was a significant statistical difference between ZD6474 (465 mm^3) vs. combined modality treatment with ZD6474 + RT (291 mm^3) ($p = 0.037$) vs. ZD6474 + RT + CPT-11 (187 mm^3) ($p < 0.001$). Combined treatment with all three modalities was therefore better than ZD6474 alone and also significantly better than RT alone ($p < 0.001$) and CPT-11 alone ($p < 0.001$). However, when tumor growth delay was determined using time in days for tumors to reach 1000 mm^3 (days included time without ZD6474), the combinations of ZD6474 + RT or ZD6474 + CPT-11 + RT were not statistically significantly better than ZD6474 alone.
Conclusions: The response of LoVo colorectal tumors to RT and CPT-11 is improved with the addition of ZD6474. Furthermore, this study suggests that the improvement in response is dependent upon concurrent and post-sequencing of ZD6474 with cytotoxic therapy.

Supported by a grant from AstraZeneca Pharmaceuticals.

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Phase I study of pemetrexed followed by daily enzastaurin in patients with advanced or metastatic cancer

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Background: Enzastaurin, an oral serine/threonine kinase inhibitor, targets PKC and PI3K/AKT pathways to inhibit angiogenesis and tumor cell proliferation and to induce tumor cell death. Preclinical data suggest that the combination of enzastaurin and pemetrexed (Alimta®) produced additive or synergistic antitumor activity in tumor specimens. Objectives of this phase 1b study included evaluation of the safety, and antitumor activity of enzastaurin when combined with pemetrexed.
Materials and Methods: Patients (pts) with advanced or metastatic cancer who had at least 1 prior therapy received an intravenous dose of 500 mg/m^2 pemetrexed on day 1. On day 4 of cycle 1, a loading dose of 1200 mg enzastaurin (400 mg/3×/day) was given to achieve near steady-state concentrations. Starting on day 5 of cycle 1, 500 mg enzastaurin was administered orally, once daily (after breakfast) for the duration of treatment. This combination of oral enzastaurin and standard pemetrexed infusion was given in 21-day cycles for up to 6 cycles. Additional cycles were allowed for pts who benefited from the combination. Pts were also given oral folic acid daily and vitamin B_{12} every 9 weeks during pemetrexed therapy, and 5–7 days before cycle 1.
Results: Forty-two pts (16 male, 26 female; ECOG 0–2), with a median age of 59 years (range: 34−76 years), were treated with enzastaurin plus pemetrexed. Most patients (37/42) had received at least 1 prior chemotherapy. Thirty-six pts received ⩾2 cycles of treatment, of which 8 pts continued treatment for ⩾6 cycles. Colorectal cancer was the most frequent malignancy (26.2%). Drug-related hematological toxicities ⩾ grade 3 were anemia (n = 2), leukopenia (n = 1), thrombocytopenia (n = 4) and neutropenia (n = 3). Grade 3 ulcer and gastro-intestinal and