Mast cells positive to tryptase, endothelial cells positive to protease-activated receptor-2, and microvascular density correlate among themselves in hepatocellular carcinoma patients who have undergone surgery

Michele Ammendola,1 Rosario Sacco,1 Giuseppe Sammarco,1 Tullio Piardi,2 Valeria Zuccalà,3 Rosa Patruno,4 Alessandra Zullo,1 Nicola Zizzo,4 Bruno Nardo,5 Ilaria Marech,5 Alberto Crovace,7 Cosmo Damiano Gadaleta,4 Patrick Pessaux,8 Girolamo Ranieri6

1Department of Medical and Surgical Sciences, General Surgery Unit, University of Catanzaro “Magna Graecia” Medical School, Catanzaro, Italy; 2Department of General, Digestive and Endocrine Surgery, Hospital Robert Debre, Centre Hospitalier Universitaire de Reims, Université de Reims Champagne-Ardenne, Reims, France; 3Department of Health Science, Pathology Unit, University of Catanzano “Magna Graecia” Medical School, Catanzaro, Italy; 4Chair of Pathology, Veterinary Medical School, University “Aldo Moro”, Bari, Italy; 5Department of Medical and Surgery Sciences, S Orsola Hospital, University of Bologna, Bologna, Italy; 6Interventional Radiology Unit with Integrated Section of Translational Medical Oncology, National Cancer Research Centre, “Giovanni Paolo II”, I, 7Department of Emergency and Organ Transplantation (DETO), Veterinary Medical School, University “Aldo Moro”, Bari, Italy; 8Hepato-Biliary and Pancreatic Surgical Unit, General, Digestive and Endocrine Surgery, IRCAD, IHU Mix-Surg, Institute for Minimally Invasive Image-Guided Surgery, University of Strasbourg, Strasbourg, France

Correspondence: Girolamo Ranieri
Interventional Radiology Unit with Integrated Section of Translational Medical Oncology, National Cancer Research Centre, “Giovanni Paolo II”, I, Viale Orazio Flacco, 70124, Bari, Italy
Tel +39 080 555 5561
Fax +39 080 555 5562
Email giroran@tiscali.net.it

This article was published in the following Dove Press journal:
OncoTargets and Therapy
21 July 2016
Number of times this article has been viewed

Background: Mast cells (MCs) can stimulate angiogenesis, releasing several proangiogenic cytokines stored in their cytoplasm. In particular MCs can release tryptase, a potent in vivo and in vitro proangiogenic factor via proteinase-activated receptor-2 (PAR-2) activation and mitogen-activated protein kinase phosphorylation. Nevertheless, no data are available concerning the relationship between MC density positive to tryptase (MCDPT), endothelial cells positive to PAR-2 forming microvascular density (PAR-2-MVD), and classical MVD (C-MVD) in hepatocellular carcinoma (HCC) angiogenesis. This study analyzed the correlation between MCDPT, PAR-2-MVD, and C-MVD, each correlated to the others and to the main clinicopathological features, in early HCC patients who underwent surgery.

Methods: A series of 53 HCC patients with early stage (stage 0 according to the Barcelona Clinic Liver Cancer Staging Classification) were selected and then underwent surgery. Tumor tissue samples were evaluated by means of immunohistochemistry and image analysis methods in terms of number of MCDPT, PAR-2-MVD, and C-MVD.

Results: A significant correlation between MCDPT, PAR-2-MVD, and C-MVD groups, each correlated to the others, was found by Pearson r-test analysis (r ranged from 0.67 to 0.81; P-value ranged from 0.01 to 0.03). No other significant correlation was found.

Conclusion: Our in vivo pilot data suggest that MCDPT and PAR-2-MVD may play a role in HCC angiogenesis and could be further evaluated as a target of antiangiogenic therapy.

Keywords: tumour angiogenesis, stromal cells, translational research

Introduction

Mast cells (MCs) can play a role in tumor angiogenesis, and their involvement has been demonstrated in several animal and human malignancies.1,2 MCs can secrete several classical proangiogenic factors, including vascular endothelial growth factor, fibroblast growth factor-2, thymidine phosphorylase, and interestingly a nonclassical proangiogenic factor named tryptase, stored in their secretory granules.3–7 With special reference to tryptase, it induces in vitro microvascular endothelial cells (EC) proliferation in the matrigel assay and displays in vivo capillary growth on the chick embryo chorioallantoic membrane, which is inversely suppressed by tryptase inhibitors.8 This proangiogenic stimulus induced by tryptase is mainly mediated via protease-activated receptor-2 (PAR-2), which belongs to the G-protein-coupled receptor
family. Four forms of PARs have been reported (PAR-1 through PAR-4). In particular, PAR-2 can be activated by proteases such as trypsin and tryptase. These proteases cleave the N terminus to generate a tethered ligand, which interacts and activates the receptor. Signaling via PAR-2 expressed on ECs elicits activation of the major members of the mitogen-activated protein kinase phosphorylation family and induces EC proliferation. PAR-2 activation also leads to the production of other proangiogenic factors, such as vascular endothelial growth factor, interleukin-8 (IL-8), IL-6, granulocyte-macrophage colony-stimulating factor, and macrophage colony-stimulating factor.

In literature, no data have been published on the relationship between MC density positive to tryptase (MCDPT), ECs positive to PAR-2 forming microvascular density (PAR-2-MVD), and classical MVD (C-MVD) in hepatocellular carcinoma (HCC) angiogenesis.

In this pilot study, we analyzed the number of MCDPT, PAR-2-MVD, and C-MVD to correlate to each other in primary tumor tissue from HCC patients who underwent surgery.

Materials and methods

Study populations

A series of 53 HCC patients with early stage (stage 0 according to the Barcelona Clinic Liver Cancer staging classification) were selected and underwent curative liver resection: segmentectomies and left and right hepatectomies. The pretreatment evaluation included biochemical liver function, indocyanine green clearance test, complete blood count, coagulation profile, dose serum alpha-fetoprotein, chest X-ray, liver ultrasound with contrast medium (contrast-enhanced ultrasound), and a computed tomography scan of the abdomen. The diagnosis of HCC was histologically confirmed by echo-guided needle aspiration or, alternatively, by classic imaging findings for HCC associated with a pathological increase of alpha-fetoprotein levels higher than 200 ng/mL. In the global series, there were 53 HCC.

Table 1 Clinicopathological features of 53 patients with hepatocellular carcinoma

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years), median value</td>
<td>68</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>33/20</td>
</tr>
<tr>
<td>Etiology (HCV/HBV/alcoholic/NASH)</td>
<td>31/14/4/4</td>
</tr>
<tr>
<td>Child-Pugh A</td>
<td>53</td>
</tr>
<tr>
<td>Serum AFP (ng/mL), median value</td>
<td>69</td>
</tr>
<tr>
<td>Serum bilirubin (mg/dL), median value</td>
<td>1.7</td>
</tr>
<tr>
<td>Serum AST (IU/L), median value</td>
<td>53</td>
</tr>
<tr>
<td>Serum ALT (IU/L), median value</td>
<td>36.5</td>
</tr>
<tr>
<td>Histologic grade</td>
<td>G1; G2: 46; G3: 7</td>
</tr>
<tr>
<td>Liver segments</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>5</td>
</tr>
<tr>
<td>II</td>
<td>12</td>
</tr>
<tr>
<td>VI</td>
<td>14</td>
</tr>
<tr>
<td>V</td>
<td>9</td>
</tr>
<tr>
<td>VII</td>
<td>13</td>
</tr>
<tr>
<td>Performance status 0</td>
<td>53</td>
</tr>
<tr>
<td>BCLC stage 0</td>
<td>53</td>
</tr>
</tbody>
</table>

Abbreviations: AFP, alpha-fetoprotein; ALT, alanine aminotransferase; AST, aspartate aminotransferase; F, female; HBV, hepatitis B virus; HCV, hepatitis C virus; IU, international unit; M, male; NASH, nonalcoholic steatohepatitis.

Briefly, 4 μm thick serial sections of formalin-fixed and paraffin-embedded tumor samples and adjacent normal liver tissue were cut. Sections were then microwaved at 500 W for 10 minutes, after which endogenous peroxidase activity was blocked with 3% hydrogen peroxide solution. Tumor sections were incubated with the following primary antibodies: antitryptase (clone AA1; Dako, Glostrup, Denmark) diluted 1:100 for 1 hour at room temperature, anti-PAR-2 (C-17, sc-8205; Santa Cruz Biotechnology, Dallas, TX, USA) diluted 1:50 for 1 hour at room temperature, and anti-CD34 antibody (QB-END 10; Bio-Optica, Milan, Italy) diluted 1:50 for 1 hour at room temperature as a pan-endothelial marker, respectively. The bound antibody was visualized using a biotinylated secondary antibody, an avidin–biotin peroxidase complex and liquid permanent red (LPS, K0640; Dako). Nuclear counterstaining was performed with Gill’s hematoxylin no 2 (Polysciences, Warrington, PA, USA). The primary antibody was omitted in negative controls.

Morphometrical assay

Light microscopy integrated with an image analysis system (Quantimet-500 Leica, Wetzlar, Germany) was utilized. In both tumor sections and adjacent normal liver sections, immunostained areas (hot spots) were selected at low magnification (×100), then MCDPT (Figures 1A and 2A, respectively), PAR-2-MVD (Figures 1B and 2B, respectively), and C-MVD (Figures 1C and 2C, respectively) were assessed at ×400 magnification (0.19 mm² area).
Statistical analysis
Mean values ±1 standard deviation (SD) of all the evaluated tissue parameters are reported in Table 2. Correlations between MCDPT, PAR-2-MVD, and C-MVD were calculated using Pearson’s (r) analysis. Correlations among all the analyzed parameters and the main clinicopathological features listed in Table 1 were performed by the chi-square test. P < 0.05 was considered significant. All statistical analyses were performed with the SPSS statistical software package (SPSS, Inc., Chicago, IL, USA).

Results
The clinicopathological features of the patients with data expressed as median values are summarized in Table 1. In particular, a series of 53 HCC patients with early stage disease (stage 0 according to the Barcelona Clinic Liver Cancer staging classification) were studied.

In tumor tissue, mean values ±1 SD of MCDPT, PAR-2-MVD, and C-MVD were 11.02 ± 4.73, 22.64 ± 7.12, and 25.34 ± 8.76, respectively. In adjacent normal liver tissue, mean values ±1 SD of MCDPT, PAR-2-MVD, and C-MVD were 3.71 ± 1.22, 6.30 ± 2.28, and 11.44 ± 4.67, respectively. With special regard to tumor tissue, a significant correlation between MCDPT and C-MVD (r = 0.77, P = 0.02), between PAR-2-MVD and C-MVD (r = 0.81, P = 0.01), and between MCDPT and PAR-2-MVD (r = 0.67, P = 0.03) (Figure 3) was found. The results described above are summarized in Table 2. Furthermore, no correlation concerning MCDPT, PAR-2-MVD, and C-MVD and the main clinicopathological features was found.

Discussion
HCC is the fifth leading cause of cancer mortality in the world. HCC is a well-established hypervascular tumor with a high rate of angiogenesis. In recent years, MCs have been revealed to be involved as important players in tumor angiogenesis by means of the release of proangiogenic factors stored in their secretory granules. However, the role of
MCDPT in HCC angiogenesis has not been well investigated, and no data have been published regarding MVD in terms of PAR-2 endothelial expressing cells.39

In the tumor microenvironment, MCs can be activated in different ways such as: c-kit receptor activation and phosphorylation by stem cell factor, immunoglobulin E mechanism mediated by T lymphocyte–MC interaction, and other microenvironmental stimuli.40,41 After activation, intensive or piecemeal degranulation of secretory granules occurs depending on the MC activation mechanism, and MC-derived proangiogenic factors are released into the tumor microenvironment stimulating angiogenesis.42 Among them, tryptase has been characterized as a powerful nonclassical angiogenic factor in recent years.7,43–45

Tryptase is an agonist of PAR-2 in vascular ECs, which stimulates their proliferation. Signaling via PAR-2 on ECs elicits activation of the major members of the mitogen-activated protein kinase phosphorylation family and contributes to proliferation of ECs and then angiogenesis. Experimental data also suggest that PAR-2 activation leads to the production of other proangiogenic factors, such as vascular endothelial growth factor, interleukin-8, IL-6, granulocyte-macrophage colony-stimulating factor, and macrophage colony-stimulating factor.23–27,46–48

Table 2 MCDPT, PAR-2-MVD, and C-MVD (mean ± standard deviation) as a function of HCC primary tumor tissue adjacent to normal tissue

<table>
<thead>
<tr>
<th>Tissue</th>
<th>MCDPT 400× (0.19 mm²)</th>
<th>PAR-2-MVD 400× (0.19 mm²)</th>
<th>C-MVD 400× (0.19 mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary tumor</td>
<td>11.02±4.73</td>
<td>22.64±7.12</td>
<td>25.34±8.76</td>
</tr>
<tr>
<td>Normal control</td>
<td>3.71±1.22</td>
<td>6.30±2.28</td>
<td>11.44±4.67</td>
</tr>
</tbody>
</table>

Abbreviations: C-MVD, classical microvascular density; MCDPT, mast cell density positive to tryptase; MVD, microvascular density; PAR-2, proteinase-activated receptor-2.
Among the few available data regarding the role of MC tryptase and angiogenesis in HCC patients, Grizzi et al have demonstrated that MC accumulation at the tumor site may lead to increased rates of tumor vascularity and, consequently, increased rates of tumor growth and metastasis. In this study, no immunohistochemical method was employed in that MC density was evaluated by a histochemical method using toluidine blue stain, and tumor vascularization was also evaluated by Direct-red 80.

In order to analyze the role of MC tryptase, Goffredo et al suggested the potential biomarker role of tryptase in 30 HCC patients, and the study showed decreased serum tryptase levels after hepatic transarterial chemoembolization treatment, indicating that tryptase is concentrated in primary tumor tissue.

Here, our pilot results demonstrate an association between MCDPT, PAR-2-MVD, and C-MVD, supporting the central role of tryptase as a main proangiogenic factor in primary HCC. Based on these data, it is possible to speculate that the inhibition of tryptase by means of gabexate mesilate or nafamostat mesilate could be a novel antiangiogenic strategy worthy of clinical investigation.

Acknowledgment
The authors would like to thank Caroline Oakley for manuscript editing.

Author contribution
Michele Ammendola and Girolamo Ranieri conceived and designed the study; Rosario Sacco, Bruno Nardo, Giuseppe Sammarco, Michele Ammendola, and Alessandra Zullo performed the surgery; Cosmo Damiano Gadaleta, Ilaria Marech, Tullio Piardi, and Patrick Pessaux analyzed the data; Valeria Zuccalà, Rosa Patruno, Alberto Crovace, Nicola Zizzo, and Girolamo Ranieri contributed reagents/materials/analysis tools and immunohistochemistry. All authors contributed toward data analysis, drafting and critically revising the paper and agree to be accountable for all aspects of the work.

Disclosure
The authors report no conflicts of interest in this work.
References


