CD163

A Specific Marker of Macrophages in Paraffin-Embedded Tissue Samples

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Key Words: CD163; CD68; KP1; PG-M1; Monocyte; Macrophage; Histiocyte; Immunohistochemistry

DOI: 10.1309/QHD6YFN81KQXUUH6

Abstract

Paraffin-section immunohistochemical analysis was performed using a monoclonal antibody against CD163 to evaluate the antibody's usefulness in identifying cells of monocyte/macrophage lineage in normal and neoplastic conditions. Normal human tissue samples and samples from 211 hematopoietic disorders and 115 nonhematopoietic neoplasms were examined. The distribution of KP1 and PG-M1, monoclonal antibodies to the macrophage-associated CD68 antigen, also were evaluated for comparison. CD163 immunoreactivity was observed in resident macrophages of all normal tissue samples except splenic white pulp macrophages and germinal center tingible body macrophages. Among hematopoietic disorders and nonhematopoietic neoplasms, CD163 expression was restricted largely to cases of chronic myelomonocytic leukemia, histiocytic sarcoma, sinus histiocytosis with massive lymphadenopathy, and littoral cell angioma. Acute myeloid leukemias (AMLs) with monocytic differentiation were CD163– with the exception of 1 case of acute monoblastic leukemia. Most myeloid sarcomas also were CD163–. Compared with the CD68 antibodies, CD163 demonstrated greater specificity as a marker of disorders of monocyte/macrophage origin. However, immunohistochemical evaluation of CD163 expression does not seem to be a sensitive means of determining monocytic differentiation in AMLs in paraffin sections or establishing a diagnosis of myeloid sarcoma.

CD68 has been used widely as a means of identifying cells of monocyte/macrophage lineage in normal and pathologic conditions. Among the many monoclonal antibodies that recognize the CD68 antigen, KP1 and PG-M1 are the antibodies most commonly used in diagnostic pathology, as both display consistent immunoreactivity in paraffin-embedded sections. However, these particular CD68 antibodies lack complete specificity for cells of the monocyte/macrophage system and are immunohistochemically detectable in a wide variety of other normal and neoplastic cell types. The CD68 antigen is localized to lysosomes, phagosomes, and neutrophil primary granules, which accounts for the broad distribution of CD68 immunoreactivity observed with KP1 and PG-M1. These antibodies, therefore, generally are regarded as organelle-rather than cell lineage–specific and are not considered exclusive markers of cells of monocyte/macrophage derivation.

CD163 is a glycoprotein belonging to the scavenger receptor cysteine-rich superfamily. CD163 antigen expression is controlled by various inflammatory mediators such as interferon γ, interleukins 6 and 10, and glucocorticoids, and it is thought that CD163-expressing cells have a role in regulation of the immune response. Recently, CD163 has been found to function as a hemoglobin scavenger by binding and clearing haptoglobin-hemoglobin complexes from the blood.

CD163 is of particular interest because its expression has been shown by in situ hybridization, immunofluorescent, and immunohistochemical techniques to be largely restricted to monocytes and tissue macrophages. The various CD163 antibodies used in previous immunohistochemical studies worked only in fresh or frozen material, which limited their application as routine diagnostic markers.
A CD163 monoclonal antibody (clone 10D6) has become commercially available for use in paraffin-embedded tissue samples. The objective of the present study was to determine the usefulness of this new CD163 antibody in identifying cells of monocyte/macrophage lineage in normal and neoplastic conditions. To facilitate evaluation of the specificity of CD163, we compared its expression with that of CD68 antibodies KP1 and PG-M1.

**Materials and Methods**

Cases used in the study were obtained from the files of the Division of Pathology, City of Hope National Medical Center, Duarte, CA. The cases consisted of 211 hematopoietic disorders, 115 nonhematopoietic neoplasms, and normal human tissue samples from lymph node, spleen, bone marrow, lung, liver, and skin. The diagnoses of hematopoietic neoplasms were established on the basis of morphologic features and appropriate immunophenotypic findings and categorized according to the World Health Organization Classification of Tumors of Hematopoietic and Lymphoid tissues. In addition, cases of acute myeloid leukemia (AML) also were classified according to the French-American-British (FAB) criteria. Tissue samples from each of the cases were fixed in 10% neutral buffered formalin and embedded in paraffin, with the exception of 46 cases of AML, 12 cases of chronic myeloproliferative disease, and 10 cases of chronic myelomonocytic leukemia derived from bone marrow trephine core biopsy specimens that were fixed in B-5 with decalcification before embedding.

Immunohistochemical staining was performed using monoclonal antibodies directed against CD163 (clone 10D6, dilution 1:100; Novocastra, Newcastle upon Tyne, England) and CD68 (clone KP1, dilution 1:2,400, and clone PG-M1, dilution 1:200; DAKO, Carpinteria, CA) glycoproteins. Sections were deparaffinized in xylene and rehydrated in a graded ethanol series. Antigen retrieval was performed by steam heating slides in citrate buffer (pH 6.0) (CD163) or EDTA buffer (pH 8.0) (KP1 and PG-M1) in a steamer (Black and Decker, Shelton, CT) for 20 minutes. Staining was performed using an automated immunostainer (DAKO), followed by antibody detection using the DAKO EnVision+ System and 3,3′-diaminobenzidine as a chromogen. The slides were counterstained with hematoxylin and coverslipped.

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<th>CD68 (KP1)</th>
<th>CD68 (PG-M1)</th>
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Appropriate positive and negative tissue control samples were used throughout. A particular tumor was considered positive if more than 5% of the tumor cells reacted with any intensity.

**Results**

**CD163**

CD163 immunoreactivity was characterized by a strong, granular cytoplasmic or cytoplasmic and membrane staining patterns. Expression of CD163 in nonneoplastic tissue samples was limited to the constituent macrophages of each respective site. In lymph nodes, the CD163 antibody reacted with interfollicular macrophages and sinus histiocytes [Image 1]; however, no immunoreactivity with germinal center tingible body macrophages was observed. In the spleen, CD163 expression was present in red pulp macrophages but not in those of the white pulp [Image 2A]. Bone marrow macrophages [Image 2B], alveolar macrophages of the lung [Image 2C], Kupffer cells of the liver [Image 2D], and dermal macrophages of the skin also were CD163+. Accessory dendritic cells, including follicular dendritic cells, paracortical interdigitating dendritic cells, and Langerhans cells of the skin, were uniformly CD163−.

Among the samples from hematopoietic disorders examined (Table 1), CD163 expression was observed in 2 cases of histiocytic sarcoma [Image 3] and the histiocytes of 3 cases of sinus histiocytosis with massive lymphadenopathy (SHML). Analysis of 2 littoral cell angiomas of the spleen also demonstrated CD163 expression in the constituent lining cells of both cases [Image 4]. Of 46 cases of AMLs examined, only 1 case of acute monoblastic leukemia (AML-M5A) was CD163+. Similarly, only 1 of 13 cases of myeloid sarcoma (extramedullary myeloid tumor, granulocytic sarcoma) exhibited CD163 immunoreactivity. Increased numbers of CD163+ macrophages were observed within the bone marrow in each of the various subtypes of chronic myeloproliferative disease studied. In all cases of chronic myelomonocytic leukemia, bone marrow monocyes showed positive immunoreactivity for CD163. CD163 expression was not observed in Hodgkin lymphomas or non-Hodgkin lymphomas of B- and T-cell lineage. Cases of Langerhans cell
histiocytosis, follicular dendritic cell tumor, and mastocytosis also were consistently CD163–. All nonhematopoietic tumors studied likewise were CD163– (Table 2).

**CD68 (KP1)**

Examination of normal tissue samples with the KP1 antibody demonstrated positive immunoreactivity in constituent tissue macrophages in all sites. In addition, myeloid cells in bone marrow and tissue mast cells also were KP1+.

Of the samples from cases of hematopoietic disorders examined (Table 1), frequent KP1 immunoreactivity was observed in AML of all FAB subtypes, marking 37 (80%) of 46 cases. Similarly, KP1 positivity was present in the majority (11/13 [85%]) of myeloid sarcomas. All cases of mastocytosis also were strongly KP1+. Non-Hodgkin and Hodgkin lymphomas were largely KP1– except for 1 case of small lymphocytic lymphoma that exhibited focal, dot-like cytoplasmic staining. Increased macrophages in bone marrow specimens from all cases of chronic myeloproliferative disease were reactive with KP1. Monocytic elements of chronic myelomonocytic leukemias showed positive immunoreactivity for KP1 but often were difficult to discern from positively staining marrow granulocytes and myeloid precursors.

Among the histiocytic and dendritic cell disorders, KP1 immunoreactivity was present in cases of histiocytic sarcoma and SHML, as well as in a subset of cases of Langerhans cell
histiocytosis. Follicular dendritic cell tumors were KP1−. KP1 positivity also was observed in splenic littoral cell angiomas. KP1+ nonhematopoietic neoplasms included all cases of granular cell tumor and a variable proportion of melanomas and renal carcinomas (Table 2).

**CD68 (PG-M1)**

Immunoreactivity of PG-M1 in various nonneoplastic tissue samples was limited to resident macrophages and mast cells. In the hematopoietic disorders studied (Table 1), PG-M1 immunoreactivity was restricted largely to cases of chronic myelomonocytic leukemia, histiocytic sarcoma, SHML, and littoral cell angioma of the spleen. Of the 46 AMLs, 11 (24%) also were PG-M1+, with immunoreactivity limited to cases of acute myelomonocytic leukemia (AML-M4) and acute monoblastic/monocytic leukemia (AML-M5A/AML-M5B). In addition, PG-M1 positivity was observed in 2 of 13 myeloid sarcomas, 3 of 10 mast cell tumors, and 1 of 10 cases of Langerhans cell histiocytosis. Chronic myeloproliferative diseases showed increased PG-M1+ macrophages in all cases. Hodgkin and non-Hodgkin lymphomas, as well as follicular dendritic cell tumors, were PG-M1−. The majority of nonhematopoietic tumors lacked PG-M1 immunoreactivity with the exception of 1 of 4 granular cell tumors and a rare case of melanoma (Table 2).

**Discussion**

The CD163 antigen is a 130-kd glycoprotein that recently has been characterized as a scavenger receptor for hemoglobin that clears haptoglobin-hemoglobin complexes from the circulation.29 Previous immunohistochemical studies using fresh and frozen tissue samples with various monoclonal antibodies have shown CD163 to be expressed exclusively on monocytes and macrophages.25,30-33 Specifically, CD163 antigen expression was detected in peripheral blood monocytes and in resident macrophages in normal tissue samples from different sites, including lymph node and tonsil (interfollicular and sinus macrophages), spleen (red pulp macrophages), bone marrow, lung (alveolar macrophages), and liver (Kupffer cells).25,30-33 No immunoreactivity with other hematopoietic or nonhematopoietic tissue cell types was observed in these studies. We obtained similar results using a monoclonal CD163 antibody (clone 10D6) on paraffin-embedded normal tissue samples, confirming the specificity of CD163 for cells of monocyte/macrophage origin. Interestingly, CD163 expression was restricted to only a subpopulation of tissue macrophages, as germinal center tingible body macrophages and splenic white pulp macrophages were CD163−. Absence of CD163 immunoreactivity in these types of macrophages also has been observed previously by other investigators.25,30,32 In addition, epithelioid histiocytes and multinucleated giant cells have been noted to lack CD163 expression.25,31 These findings suggest that CD163 expression might depend on the stage of differentiation or the particular activation status of the macrophages.

In the present study involving a large number of hematopoietic disorders and nonhematopoietic neoplasms, CD163 expression was restricted largely to diseases of monocye/macrophage derivation, including chronic myelomonocytic leukemia, histiocytic sarcoma, and SHML. CD163 immunoreactivity was not observed in Hodgkin and non-Hodgkin lymphomas or in various types of carcinomas and
sarcomas, in agreement with results of previous studies using immunohistochemical analysis on frozen sections.\textsuperscript{31,32}

AMLs were largely CD163\texttextsuperscript{--}, with the exception of 1 case of AML-M5A. These results are in contrast with those obtained by Radzun et al\textsuperscript{30} and Backe et al,\textsuperscript{31} who reported CD163 expression in a large percentage of cases of AML-M4 and AML-M5, with absence of immunoreactivity in AMLs of other types. The reasons for this observed discrepancy in the frequency of positivity for CD163 in AML-M4 and AML-M5 might be methodological differences, because CD163 expression was determined by immunofluorescence or immunohistochemical analysis performed on cytocentrifuged preparations and frozen tissue samples in these previous investigations,\textsuperscript{30,31} while paraffin-embedded bone marrow samples were used for immunohistochemical analysis in the present study. Although not observed by immunohistochemical techniques in the present investigation, there is some evidence to suggest that CD163 is truly expressed in myeloid leukemias with monocytic differentiation, because Walter et al\textsuperscript{36} recently demonstrated CD163 expression by flow cytometric studies in 3 of 12 patients with AML-M4 and 16 of 19 patients with AML-M5.

It is interesting that 2 cases of littoral cell angioma of the spleen were observed to be CD163+, with immunoreactivity present in the majority of the lining cells. Although considered a vascular tumor, littoral cell angioma also exhibits immunohistochemical characteristics suggestive of histiocytic differentiation, as evidenced by positive immunoreactivity for histiocytic-associated antigens such as lysozyme and CD68.\textsuperscript{37,38}

The additional finding of CD163 positivity in littoral cell angiomas in the present study would seem to substantiate histiocytic differentiation in this particular tumor.

CD68 has been used commonly as a marker for cells of monocytic/macrophage origin in diagnostic immunohistochemical analysis.\textsuperscript{3} CD68 antibodies recognize a glycoprotein present in lysosomes, phagosomes, and primary granules of neutrophils.\textsuperscript{15,21} As such, CD68 is not regarded as a specific marker of cells of monocytic/macrophage derivation, as CD68 immunoreactivity might be observed in any type of cell that contains large numbers of these particular organelles.\textsuperscript{3} Use of CD68 expression as an indicator of monocytic/macrophage lineage also is problematic because the various available CD68 antibodies exhibit differing patterns of immunohistochemical reactivity.\textsuperscript{3}

The monoclonal antibody KP1 generally is considered the least specific of the CD68 antibodies because KP1 positivity can be observed in granulocyte precursors, mast cells, and various types of epithelial cells.\textsuperscript{16,7} In agreement with the findings of previous reports,\textsuperscript{4,5,7-20,39-43} the results of the present study demonstrated a wide variety of tumors to be KP1+. In addition to neoplasms of monocytic/macrophage lineage, KP1 immunoreactivity was observed in most AMLs, myeloid sarcomas, and cases of mast cell disease, as well as in a subset of B-cell lymphomas and cases of Langerhans cell histiocytosis. Similar to the findings of other studies,\textsuperscript{8,10,12,13,15-17,19} granular cell tumors and a subset of melanomas and renal cell carcinomas also were KP1+.

In contrast with KP1, the CD68 antibody PG-M1 is considered to be more specific for cells of monocytic/macrophage lineage.\textsuperscript{2,3} In the present study, PG-M1 immunoreactivity was restricted largely to chronic myelomonocytic leukemia, histiocytic sarcoma, SHML, AML-M4, and AML-M5A/AML-M5B. Unlike KP1, PG-M1 positivity was not observed in lymphomas or various types of epithelial tumors. However, in accordance with the results of other studies,\textsuperscript{2,14,15} some cases of mastocytosis, Langerhans cell histiocytosis, granular cell tumor, and melanoma were PG-M1+, which somewhat diminishes its value as a monocytic/macrophage lineage-specific marker.

Based on the data reported herein, it seems that CD163 is a more specific marker of disorders of monocytic/macrophage origin than KP1 and PG-M1. Compared with these particular CD68 antibodies, CD163 exhibited a far more restricted immunohistochemical expression pattern, limited to cases of chronic myelomonocytic leukemia, histiocytic sarcoma, SHML, and littoral cell angioma. Tumors that commonly can exhibit positivity for KP1 and/or PG-M1 such as mast cell disease,\textsuperscript{2,7,14,20} B-cell lymphoma,\textsuperscript{4,11,17} and Langerhans cell histiocytosis,\textsuperscript{2,5} granular cell tumor,\textsuperscript{2,10,13,15} and melanoma\textsuperscript{2,8,16,17,19} notably were negative for CD163 expression.

Although the current data suggest that CD163 is a specific marker of monocytes/macrophages, evaluation of CD163 expression is not a useful means of determining monocytic differentiation in AMLs in paraffin-embedded tissue samples because none of the cases of AML-M4 and only 1 of 8 cases of AML-M5 were CD163+. PG-M1 seems to be a much more effective marker in this particular context; the present data, as well as the results of previous studies,\textsuperscript{2,39,40} have demonstrated this antibody to be restricted primarily to AML-M4 and AML-M5, and, therefore, it is useful in separating AMLs with monocytic differentiation from AMLs of other FAB subtypes.

Also, it should be recognized that CD163 does not seem to be a particularly sensitive marker for myeloid sarcoma, because only 1 of 13 cases was positive in the present study. This observed lack of sensitivity is not entirely surprising because CD163 typically does not react with granulocytes and myeloid precursors. In contrast with CD163, KP1, which detects cells of myeloid lineage and monocytes/macrophages, proved to be a much more reliable marker for establishing a diagnosis of myeloid sarcoma: 85% of cases of myeloid sarcoma (11/13) in the present study exhibited positive immunoreactivity for KP1, a finding that is in general agreement with results reported in the literature.\textsuperscript{20,40-43}

In addition to the CD68 cluster of antibodies, other monoclonal antibodies that have been used commonly to detect macrophages in paraffin-embedded tissue samples include HAM56 and MAC 387. HAM56 strongly labels all tissue macrophages regardless of site, including tingible body macrophages, hepatic Kupffer cells, and alveolar macrophages of the
lung, and does not react with myeloid or lymphoid cells. The distribution of MAC 387 among cells of monocyte/macrophage lineage is similar, with MAC 387 positivity present in a broad variety of tissue macrophage populations.45,46 In normal tissue samples, neither HAM56 nor MAC 387 immunoreactivity is limited strictly to macrophages. HAM56 can be observed in endothelial cells and occasional tubular epithelial cells in the kidney, and MAC 387 is present in granulocytes and squamous epithelium.45-47

In the context of hematopoietic disorders, immunoreactivity for HAM56 and MAC 387 can be observed in approximately 30% to 60% of cases of AML of various FAB subtypes.39,48,49 In addition, MAC 387 seems to be a relatively effective marker for the identification of myeloid sarcoma, with reported positivity ranging from 40% to 87% of cases.42,50,51 Both HAM56 and MAC 387 can react with various nonhematopoietic neoplasms, including different types of sarcomas and a variety of adenocarcinomas of different sites.52-57 Focal staining for these particular antibodies also has been noted in a small percentage of melanomas.19 In contrast with CD163, the rather wide reactivity with normal and neoplastic cells exhibited by HAM56 and MAC 387 serves to limit the value of these particular antibodies as specific markers of cells of monocyte/macrophage origin.

The results of the present study demonstrate that CD163 is a highly specific marker for cells of monocyte/macrophage lineage. The CD163 antibody seems suitable for routine use in paraffin-embedded tissue samples and offers an alternative to CD68 antibodies for identifying cells of monocyte/macrophage derivation in normal and neoplastic conditions. Because CD163 showed no immunoreactivity with non-Hodgkin lymphomas and nonhematopoietic tumors, CD163 might be of value in separating histiocytic proliferations from morphologically similar entities that can be confused with histiocytic disorders, including non-Hodgkin lymphoma of T- or B-cell lineage, anaplastic large cell lymphoma, and poorly differentiated carcinoma. The lineage-restricted pattern of CD163 expression also might be useful, along with CD68 and lysozyme expression, for substantiating a diagnosis of histiocytic sarcoma.

References


