[Document Name] Description

[Title of Invention] GPC3-TARGETING DRUG WHICH IS ADMINISTERED TO PATIENT RESPONSIVE TO GPC3-TARGETING DRUG THERAPY

[Technical Field]

[0001]

The present invention provides a method for determining the efficacy of GPC3-targeting drug therapy for cancer in a patient or determining the continuation of GPC3-targeting drug therapy for a patient. The present invention also provides a GPC3-targeting drug or a preparation which is to be further administered to a patient for the efficacy of the GPC3-targeting drug therapy has been determined or the continuation of the GPC3-targeting drug therapy has been determined.

[Background Art]

[0002]

Hepatocellular cancer is reportedly the fifth leading cause of cancer deaths worldwide, accounting for approximately 600,000 deaths each year (Non Patent Literature 1). Most patients with hepatocellular cancer die within 1 year after being diagnosed with the disease. Unfortunately, hepatocellular cancer cases are frequently diagnosed at a late stage which rarely responds to

curative therapy. Still, medical treatments including chemotherapy, chemoembolization, ablation, and proton beam therapy are insufficiently effective for such patients. Many patients exhibit recurrence of the disease with vascular invasion and multiple intrahepatic metastases, which rapidly progresses to the advanced stage. Their 5-year survival rates are only 7% (Non Patent Literature 2). Patients with hepatocellular cancer amenable to the resection of local foci have relatively good prognosis, though their 5-year survival rates still remain at a level of 15% and 39% (Non Patent Literature 3). Thus, there has been a demand in the art for novel therapy for such a malignant disease hepatocellular cancer.

[0003]

Hepatocellular cancer is reportedly responsible for more than 90% of primary liver cancer cases in Japan. Medical methods for treating such hepatocellular cancer include, for example, chemotherapy-based transcatheter arterial embolization (TAE) therapy, which involves inducing the selective necrosis of the hepatocellular cancer by the injection of a mixture of an oil-based contrast medium (Lipiodol), an anticancer agent, and an obstructing substance (Gelfoam) into the hepatic artery (which serves as a nutrient supply pathway to the tumor) resulting in the obstruction of the nutrient artery. In addition, invasive approaches are used, such as

percutaneous ethanol injection, percutaneous microwave coagulation therapy, and radiofrequency ablation. Also, clinical trials have been conducted on systemic chemotherapy using chemotherapeutic agents such as fluorouracil (5-FU), uracil-tegafur (UFT), mitomycin C (MMC), mitoxantrone (DHAD), adriamycin (ADR), epirubicin (EPI), and cisplatin (CDDP) either alone or in combination with interferon (IFN) (Non Patent Literature 4).

[0004]

Meanwhile, an orally active form of sorafenib (Nexavar, BAY43-9006) has been approved, which is more advantageously effective than the chemotherapeutic agents described above in such a way that this agent blocks the growth of cancer cells by inhibiting Raf kinase in the Raf/MEK/ERK signal transduction while the agent exerts antiangiogenic effects by targeting VEGFR-2, VEGFR-3, and PDGFR-β tyrosine kinases. The efficacy of sorafenib has been studied in two phase-III multicenter placebo-controlled trials (Sorafenib HCC Assessment Randomized Protocol (SHARP) trial and Asia-Pacific trial) targeting advanced hepatocellular cancer. Sorafenib was confirmed to prolong survival durations, with HR of 0.68, in both of these trials. In the SHARP trial, sorafenib prolonged the survival duration to 10.7 months versus 7.9 months with the placebo. In the Asian trial, this agent prolonged the survival duration to 6.5 months versus 4.2

months with the placebo. The agent, however, had a low objective response rate and showed no prolongation of a time to symptomatic progression, though the agent prolonged a time to tumor progression (5.5 months versus 2.8 months in the European and American trial and 2.8 months versus 1.4 months in the Asian trial) on the images. The Asian cohorts exhibited a short duration of life prolongation, which is probably because their treatments were started at a slightly later stage during the disease process in the Asian region compared with Europe and the United States (Non Patent Literatures 5 and 6).

[0005]

As liver cancer progresses, its specific symptoms associated with liver dysfunction are generally observed, such as anorexia, weight loss, general malaise, palpable right hypochondrial mass, right hypochondrial pain, sense of abdominal fullness, fever, and jaundice. The chemotherapeutic agents (e.g., sorafenib), however, have complications to be overcome, including their inherent adverse reactions such as diarrhea or constipation, anemia, suppression of the immune system to cause infection or sepsis (with lethal severity), hemorrhage, cardiac toxicity, hepatic toxicity, renal toxicity, anorexia, and weight loss.

[0006]

Although particular early-stage symptoms are not initially observed in liver cancer, its specific symptoms associated with liver dysfunction, such as anorexia, weight loss, general malaise, palpable right hypochondrial mass, right hypochondrial pain, sense of abdominal fullness, fever, and jaundice, are generally observed with progression of the liver cancer. According to clinical observation, such symptoms are enhanced by use of the chemotherapeutic agents. For example, anorexia in a patient with detectable liver cancer cells and symptoms such as weight loss associated with or independent of the anorexia may be more enhanced by the administration of the chemotherapeutic agents to the patient than without the use of the chemotherapeutic agents. In some cases, the use of the chemotherapeutic agents must be discontinued for the patient having such symptoms. These enhanced symptoms are impediments to treatments with the chemotherapeutic agents. Thus, there has been a demand for the establishment of excellent therapy from the viewpoint of, for example, improving therapeutic effects or improving QOL of patients to be treated.

[0007]

Glypican 3 (GPC3) is frequently expressed at a high level in liver cancer and as such, seems to be useful in the identification of its functions in liver cancer or as a therapeutic or diagnostic target of liver cancer.

[0008]

Under the circumstances described above, drugs are under development with GPC3 as a therapeutic target of liver cancer. A liver cancer drug comprising an anti-GPC3 antibody as an active ingredient has been developed, the antibody having antibody-dependent-cellular cytotoxicity (hereinafter, referred to as "ADCC") activity and/or complement-dependent-cytotoxicity (hereinafter, referred to as "CDC") activity against cells expressing GPC3 (Patent Literature 1). Also, a GPC3-targeting drug comprising a humanized anti-GPC3 antibody having ADCC activity and CDC activity as an active ingredient has been developed (Patent Literature 2). Further GPC3-targeting drugs have been developed, which comprise a humanized anti-GPC3 antibody with enhanced ADCC activity (Patent Literatures 3 and 4) or an anti-GPC3 antibody having ADCC activity and CDC activity as well as improved plasma dynamics (Patent Literature 5). These anti-GPC3 antibodies in combination therapy with the chemotherapeutic agents such as sorafenib have been found to attenuate the adverse reactions, for example, brought about by the sole therapy of the chemotherapeutic agents (e.g., sorafenib) and also found to exhibit synergistic effects based on these agents (Patent Literature 6). Accordingly, excellent methods for treating liver cancer are in the process of being established using GPC3-targeting drugs as the nucleus

from the viewpoint of, for example, improving therapeutic effects or improving QOL of patients to be treated.

[0009]

Meanwhile, GPC3-targeting methods for diagnosing liver cancer are also under development. GPC3 is known to be processed, at the particular site, by convertase, phospholipase D, Notum, or an unidentified mechanism during or after expression on cell surface (Non Patent Literatures 7 and 8). By use of such a phenomenon, a diagnostic agent or a diagnostic method for liver cancer has been developed, which involves an antibody capable of binding to an epitope in a soluble form of GPC3 secreted into the plasma of a patient after processing (Patent Literature 7). Also, a diagnostic agent or a diagnostic method for liver cancer has been developed, which involves an antibody capable of binding to an epitope in an anchored form of GPC3 still existing on cell surface after processing in a tissue preparation or the like isolated from a patient (Patent Literature 8). These diagnostic agents or diagnostic methods, however, are means for detecting the presence of liver cancer in a patient to be tested. Neither a method for determining the efficacy of GPC3-targeting drug therapy for a patient treated with the GPC3-targeting drug therapy nor a method for determining the continuation of GPC3-targeting drug therapy for the patient has been known yet.

[0010]

References cited herein are as listed below. The contents described in these literatures are incorporated herein by reference in their entirety. It should be noted that none of these literatures are admitted to be the prior art to the present invention.

[Citation List]

[Patent Literature]

[0011]

[Patent Literature 1] WO2003/000883

[Patent Literature 2] WO2006/006693

[Patent Literature 3] WO2006/046751

[Patent Literature 4] WO2007/047291

[Patent Literature 5] WO2009/041062

[Patent Literature 6] WO2009/122667

[Patent Literature 7] WO2004/038420

[Patent Literature 8] WO2009/116659

[Non Patent Literature]

[0012]

[Non Patent Literature 1] Llovet JM, Burroughs A, Bruix J; Lancet (2003), 362, 1907-17

[Non Patent Literature 2] Bosch FX, Ribes J, Cleries R; Gastroenterology (2004), 127, S5-16

[Non Patent Literature 3] Takenaka K, Kawahara N, Yamamoto K, Kajiyama K, Maeda T, Itasaka H, Shirabe K, Nishizaki T, Yanaga K, Sugimachi K; Arch Surg (1996), 131, 71-6

[Non Patent Literature 4] Yeo W, Mok TS, Zee B, Leung TW, Lai PB, Lau WY, Koh J, Mo FK, Yu SC, Chan AT, Hui P, Ma B, Lam KC, Ho WM, Wong HT, Tang A, Johnson PJ; J Natl Cancer Inst (2005), 97, 1532-8

[Non Patent Literature 5] Llovet J, Ricci S, Mazzaferro V, Hilgard P, Gane E, et al. Sorafenib in advanced hepatocellular carcinoma. New Eng. J. Med. (2008) 359, 378-90

[Non Patent Literature 6] Cheng AL, Chen Z, Tsao CJ, Qin S, Kim JS, et al. Efficacy and safety of sorefanib in patients in the Asia-Pacific region with advanced hepatocellular carcinoma: a phase III randomized, double-blind, placebo- controlled trial. Lancet Oncol. (2009) 10, 25-34

[Non Patent Literature 7] De Cat B, Muyldermans S-Y, Coomans C, Degeest G, Vanderschueren B, et al. Processing by proprotein convertases is required for glypican-3 modulation of cell survival, Wnt signaling, and gastrulation movements. J. Cell. Biol. (2003) 163, 625-635

[Non Patent Literature 8] Traister A, Shi W and Filmus J. Mammalian Notum induces the release of glypicans and other GPI-anchored proteins from the cell surface. Biochem. J. (2008) 410, 503-511

[Summary of Invention]

[Technical Problem]

[0013]

The present invention has been made in light of the situations as described above, and an object of the present invention is to provide a method for determining the efficacy of GPC3-targeting drug therapy for a patient treated with the GPC3-targeting drug therapy or determining the continuation of GPC3-targeting drug therapy for the patient. Another object of the present invention is to provide a GPC3-targeting drug or a preparation which is to be further administered to a patient for which the efficacy of the GPC3-targeting drug therapy has been determined or the continuation of the GPC3-targeting drug therapy has been determined.

[Solution to Problem]

[0014]

The present inventors have conducted diligent studies under the situations as described above and consequently created a method comprising measuring the number of an immunocyte or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from a patient treated with GPC3-targeting drug therapy, wherein when the number of an immunocyte or the expression level is a predetermined value or when the number of an immunocyte or the expression level is a predetermined value as a result of receiving the GPC3-targeting drug therapy, the efficacy

of the GPC3-targeting drug therapy is determined or the continuation of the GPC3-targeting drug therapy is determined. The present inventors have also created a GPC3-targeting drug or a preparation which is to be administered to a patient for which the efficacy of the GPC3-targeting drug therapy has been determined or the continuation of the GPC3-targeting drug therapy has been determined.

[0015]

More specifically, the present invention provides the following aspects:

[1] a method for determining the efficacy of GPC3-targeting drug therapy for cancer in a patient or determining the continuation of GPC3-targeting drug therapy for a patient, comprising measuring the number of an immunocyte or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the patient before the start of GPC3-targeting drug therapy and/or the patient treated with the GPC3-targeting drug therapy, wherein when the number of an immunocyte or the expression level of a molecule expressed on the immunocyte is a predetermined value, the efficacy of the GPC3-targeting drug therapy is determined or the continuation of the GPC3-targeting drug therapy is determined,

[2] the method according to [1], wherein the biological sample is peripheral blood isolated from the patient,

[3] the method according to [1] or [2], wherein the immunocyte is at least one cell selected from a leukocyte, a monocyte, a neutrophil, and a lymphocyte,

[4] the method according to [3], wherein the lymphocyte is at least one lymphocyte cell selected from a CD45+ lymphocyte, a CD3+ T cell, a CD4+ T cell, and a CD8+ T cell,

[5] the method according to [3], wherein the lymphocyte is at least one lymphocyte cell selected from a CD16+ NK cell, an NKp46+ NK cell, and a CD56-/CD16+ NK cell,

[6] the method according to [1] or [2], wherein the molecule expressed on the immunocyte is CD16 or CD107a,

[7] the method according to any of [1] to [7], wherein the patient has a polymorphism at least one allele having Val at amino acid residue 158 of FcγRIIIA and/or at least one allele having His at amino acid residue 131 of FcγRIIA,

[8] the method according to any of [1] to [7], wherein the cancer is liver cancer,

[9] the method according to any of [1] to [8], wherein the GPC3-targeting drug is administered to achieve a blood trough level of 200 μg/ml or higher in the cancer patient,

[10] the method according to any of [1] to [9], wherein the GPC3-targeting drug comprises an anti-GPC3 antibody as an active ingredient,

[11] the method according to [10], wherein the anti-GPC3 antibody has antibody-dependent cellular cytotoxicity (ADCC) activity and/or complement-dependent cytotoxicity (CDC) activity,

[12] the method according to [10] or [11], wherein the anti-GPC3 antibody is an anti-GPC3 chimeric antibody or a humanized anti-GPC3 antibody comprising any of the following (1) to (5):

(1) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 4, 5, and 6, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 7, 8, and 9, respectively;

(2) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 12, 13, and 14, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 15, 16, and 17, respectively;

(3) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 20, 21, and 22, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 23, 24, and 25, respectively;

(4) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 28, 29, and 30, respectively, and light chain CDR1, light chain CDR2, and

light chain CDR3 represented by SEQ ID NOs: 31, 32, and 33, respectively; and

(5) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 36, 37, and 38, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 39, 40, and 41, respectively,

[13] The method according to any of [10] to [12], wherein the anti-GPC3 antibody comprises any of the following (1) to (6):

(1) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region represented by SEQ ID NO: 51;

(2) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region selected from the group of light chain variable regions represented by SEQ ID NOs: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, and 66;

(3) a heavy chain variable region represented by SEQ ID NO: 67 and a light chain variable region represented by SEQ ID NO: 68;

(4) a heavy chain variable region represented by SEQ ID NO: 69 and a light chain variable region represented by SEQ ID NO: 70;

(5) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 72; and

(6) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 73,

[14] the method according to [10], wherein the GPC3-targeting drug comprises an anti-GPC3 antibody conjugated with a cytotoxic substance,

[15] a GPC3-targeting drug which is to be administered to a cancer patient in which the number of an immunocyte or an expression level of a molecule expressed on the immunocyte is a predetermined value,

[16] the GPC3-targeting drug according to [15], wherein the number of an immunocyte or the expression level of a molecule expressed on the immunocyte is the number of an immunocyte or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the cancer patient,

[17] the drug according to [16], wherein the biological sample is peripheral blood isolated from the cancer patient,

[18] the drug according to any of [15] to [17], wherein the immunocyte is at least one cell selected from a leukocyte, a monocyte, a neutrophil, and a lymphocyte,

[19] the drug according to [18], wherein the lymphocyte is at least one lymphocyte cell selected from a CD45+

lymphocyte, a CD3+ T cell, a CD4+ T cell, and a CD8+ T cell,

[20] the drug according to [18], wherein the lymphocyte is at least one lymphocyte cell selected from a CD16+ NK cell, an NKp46+ NK cell, and a CD56-/CD16+ NK cell,

[21] the drug according to any of [15] to [17], wherein the molecule expressed on the immunocyte is CD16 or CD107a,

[22] the drug according to any of [15] to [21], wherein the patient has a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA and/or a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA,

[23] the drug according to any of [15] to [22], wherein the cancer patient is a liver cancer patient,

[24] the drug according to any of [15] to [23], wherein the GPC3-targeting drug is administered to achieve a blood trough level of 200 μg/ml or higher in the cancer patient,

[25] the drug according to any of [15] to [24], wherein the GPC3-targeting drug comprises an anti-GPC3 antibody as an active ingredient,

[26] the drug according to [25], wherein the anti-GPC3 antibody has antibody-dependent cellular cytotoxicity (ADCC) activity and/or complement-dependent cytotoxicity (CDC) activity,

[27] the drug according to [25] or [26], wherein the anti-GPC3 antibody is an anti-GPC3 chimeric antibody or a humanized anti-GPC3 antibody comprising any of the following (1) to (5):

(1) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 4, 5, and 6, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 7, 8, and 9, respectively;

(2) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 12, 13, and 14, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 15, 16, and 17, respectively;

(3) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 20, 21, and 22, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 23, 24, and 25, respectively;

(4) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 28, 29, and 30, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 31, 32, and 33, respectively; and

(5) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 36, 37, and 38, respectively, and light chain CDR1, light chain CDR2, and

light chain CDR3 represented by SEQ ID NOs: 39, 40, and 41, respectively,

[28] the drug according to any of [25] to [27], wherein the anti-GPC3 antibody comprises any of the following (1) to (6):

(1) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region represented by SEQ ID NO: 51;

(2) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region selected from the group of light chain variable regions represented by SEQ ID NOs: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, and 66;

(3) a heavy chain variable region represented by SEQ ID NO: 67 and a light chain variable region represented by SEQ ID NO: 68;

(4) a heavy chain variable region represented by SEQ ID NO: 69 and a light chain variable region represented by SEQ ID NO: 70;

(5) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 72; and

(6) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 73,

[29] the drug according to [25], wherein the GPC3-targeting drug comprises an anti-GPC3 antibody conjugated with a cytotoxic substance,

[30] a preparation for GPC3-targeting treatment, comprising an instruction stating that the preparation is to be further administered to a cancer patient having a predetermined value of the number of an immunocyte or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the cancer patient before the start of GPC3-targeting drug therapy,

[31] a preparation for GPC3-targeting treatment, comprising an instruction stating that the preparation is to be further administered to a cancer patient having a predetermined value of the number of an immunocyte or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the cancer patient after the start of GPC3-targeting drug therapy,

[32] the preparation according to [30] or [31], wherein the biological sample is peripheral blood isolated from the cancer patient,

[33] the preparation according to any of [30] to [32], wherein the immunocyte is at least one cell selected from a leukocyte, a monocyte, a neutrophil, and a lymphocyte,

[34] the preparation according to [33], wherein the lymphocyte is at least one lymphocyte cell selected from

a CD45+ lymphocyte, a CD3+ T cell, a CD4+ T cell, and a CD8+ T cell,

[35] the preparation according to [33], wherein the lymphocyte is at least one lymphocyte cell selected from a CD16+ NK cell, an NKp46+ NK cell, and a CD56-/CD16+ NK cell,

[36] the preparation according to any of [30] to [32], wherein the molecule expressed on the immunocyte is CD16 or CD107a,

[37] the preparation according to any of [30] to [36], wherein the patient has a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA and/or a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA,

[38] the preparation according to any of [30] to [37], wherein the cancer patient is a liver cancer patient,

[39] the preparation according to any of [30] to [38], wherein the GPC3-targeting drug is administered to achieve a blood trough level of 200 μg/ml or higher in the cancer patient,

[40] the preparation according to any of [30] to [39], wherein the GPC3-targeting drug comprises an anti-GPC3 antibody as an active ingredient,

[41] the preparation according to [40], wherein the anti-GPC3 antibody has antibody-dependent cellular

cytotoxicity (ADCC) activity and/or complement-dependent cytotoxicity (CDC) activity,

[42] the preparation according to [40] or [41], wherein the anti-GPC3 antibody is an anti-GPC3 chimeric antibody or a humanized anti-GPC3 antibody comprising any of the following (1) to (5):

(1) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 4, 5, and 6, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 7, 8, and 9, respectively;

(2) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 12, 13, and 14, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 15, 16, and 17, respectively;

(3) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 20, 21, and 22, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 23, 24, and 25, respectively;

(4) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 28, 29, and 30, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 31, 32, and 33, respectively; and

(5) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 36, 37, and 38, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 39, 40, and 41, respectively,

[43] the preparation according to any of [40] to [42], wherein the anti-GPC3 antibody comprises any of the following (1) to (6):

(1) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region represented by SEQ ID NO: 51;

(2) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region selected from the group of light chain variable regions represented by SEQ ID NOs: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, and 66;

(3) a heavy chain variable region represented by SEQ ID NO: 67 and a light chain variable region represented by SEQ ID NO: 68;

(4) a heavy chain variable region represented by SEQ ID NO: 69 and a light chain variable region represented by SEQ ID NO: 70;

(5) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 72; and

(6) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 73,

[44] the preparation according to [40], wherein the GPC3-targeting drug comprises an anti-GPC3 antibody conjugated with a cytotoxic substance,

[45] a method for treating cancer, comprising administering a GPC3-targeting drug to a patient determined by a method according to any of [1] to [14].

[Advantageous Effect of Invention]

[0016]

According to the present invention, whether GPC3-targeting drug therapy has efficacy or whether GPC3-targeting drug therapy should be continued can be determined conveniently and accurately. This can improve the effects of the GPC3-targeting drug therapy and improve QOL of a patient to be treated. As a result, the better treatment of cancer is achieved.

[Brief Description of Drawings]

[0017]

[Figure 1] Figure 1 is a diagram showing the progression-free survival duration or overall survival duration of patients treated with GPC3-targeting drug therapy or placebo. The broken line represents the progression-free survival duration or overall survival duration of a GC33-

administered group. The solid line represents the progression-free survival duration or overall survival duration of a placebo group.

[Figure 2] Figure 2 is a diagram showing the progression-free survival duration or overall survival duration of patients treated with GPC3-targeting drug therapy or placebo. The solid line represents the progression-free survival duration or overall survival duration of a placebo group. The dotted line represents the progression-free survival duration or overall survival duration of a high-GC33-exposed group. The broken line represents the progression-free survival duration or overall survival duration of a low-GC33-exposed group.

[Figure 3] Figure 3 is a diagram showing the correlation between the number of neutrophils in blood collected from patients before the start of GPC3-targeting drug therapy and the progression-free survival duration of the patients in a group with the number of neutrophils smaller than, or equal or larger than the median value (3,607 cells/μL). The broken line represents the progression-free survival duration of a GC33-administered group. The solid line represents the progression-free survival duration of a placebo group. The hazard ratio of the GC33-administered group to the placebo group among the groups with a smaller number of neutrophils was 1.229 ($p = 0.369$), whereas the hazard ratio of the GC33-

administered group to the placebo group among the groups with a larger number of neutrophils was 0.607 (p = 0.030).

[Figure 4] Figure 4 is a diagram showing the correlation between the number of CD4-positive T cells in blood collected from patients before the start of GPC3-targeting drug therapy and the progression-free survival duration of the patients in a group with the number of neutrophils smaller than or larger than the median value (490 cells/μL). The broken line represents the progression-free survival duration of a GC33-administered group. The solid line represents the progression-free survival duration of a placebo group. The hazard ratio of the GC33-administered group to the placebo group among the groups with a smaller number of CD4-positive T cells was 1.273 (p = 0.307), whereas the hazard ratio of the GC33-administered group to the placebo group among the groups with a larger number of CD4-positive T cells was 0.635 (p = 0.05).

[Figure 5] Figure 5 is a diagram showing the correlation between the number of CD56-negative and CD16-positive NK cells in blood collected from patients before the start of GPC3-targeting drug therapy and the progression-free survival duration of the patients in a group with the number of CD56-negative and CD16-positive NK cells smaller than or larger than the median value (6.3 cells/μL). The broken line represents the progression-free survival duration of a GC33-administered group. The

solid line represents the progression-free survival duration of a placebo group. The hazard ratio of the GC33-administered group to the placebo group among the groups with a smaller number of CD56-negative and CD16-positive NK cells was 1.259 (p = 0.344), whereas the hazard ratio of the GC33-administered group to the placebo group among the groups with a larger number of CD56-negative and CD16-positive NK cells was 0.571 (p = 0.022).

[Figure 6] Figure 6 is a diagram showing the correlation between the expression level (MESF) of CD16 on NK cells in blood collected from patients before the start of GPC3-targeting drug therapy and the progression-free survival duration of the patients in a group with the expression level lower than or higher than the median value (372,254 mesf). The broken line represents the progression-free survival duration of a GC33-administered group. The solid line represents the progression-free survival duration of a placebo group. The hazard ratio of the GC33-administered group to the placebo group among the groups with a lower level of CD16 expression was 1.130 (p = 0.612), whereas the hazard ratio of the GC33-administered group to the placebo group among the groups with a higher level of CD16 expression was 0.668 (p = 0.101).

[Figure 7] Figure 7 is a diagram showing the correlation between the amount of change in CD16 expression and the

progression-free survival duration of a group with the amount of change smaller than (high-ADCC activity group) or larger than (low-ADCC activity group) the median value (-64.33%), wherein the amount of change in CD16 expression was obtained by evaluating the level of ADCC activity against blood cells collected from patients before the start of GPC3-targeting drug therapy on the basis of change in CD16 expression level on cell surface. The solid line represents the progression-free survival duration of a placebo group. The dotted line represents the progression-free survival duration of a high-GC33-exposed group. The broken line represents the progression-free survival duration of a low-GC33-exposed group.

[Figure 8] Figure 8 is a diagram showing the correlation between the amount of change in CD107a expression and the progression-free survival duration of a group with the amount of change larger than (high-ADCC activity group) or smaller than (low-ADCC activity group) the median value (34.15%), wherein the amount of change in CD107a expression was obtained by evaluating the level of ADCC activity against blood cells collected from patients before the start of GPC3-targeting drug therapy on the basis of change in CD107a expression level on cell surface. The solid line represents the progression-free survival duration of a placebo group. The dotted line represents the progression-free survival duration of a

high-GC33-exposed group. The broken line represents the progression-free survival duration of a low-GC33-exposed group.

[Description of Embodiments]

[0018]

Definition

Chemical terms and technical terms used in relation to the present invention have meanings generally understood by those skilled in the art, unless otherwise defined herein.

[0019]

Indefinite article

In the present invention, the indefinite articles "a" and "an" refer to one or two or more (i.e., at least one) object(s) grammatically represented by the indefinite articles. For example, "a factor" means one factor or two or more factors.

[0020]

Amino acid

Each amino acid is indicated herein by single-letter code or three-letter code, or both, as represented by, for example, Ala/A, Leu/L, Arg/R, Lys/K, Asn/N, Met/M, Asp/D, Phe/F, Cys/C, Pro/P, Gln/Q, Ser/S, Glu/E, Thr/T, Gly/G, Trp/W, His/H, Tyr/Y, Ile/I, and Val/V.

[0021]

Amino acid modification

An amino acid in the amino acid sequence of an antigen-binding molecule can be modified by an appropriately adopted method known in the art such as site-directed mutagenesis (Kunkel et al., Proc. Natl. Acad. Sci. USA (1985) 82, 488-492) or overlap extension PCR. Also, a plurality of methods known in the art can be adopted as methods for modifying an amino acid to substitute the amino acid by an amino acid other than natural one (Annu. Rev. Biophys. Biomol. Struct. (2006) 35, 225-249; and Proc. Natl. Acad. Sci. U.S.A. (2003) 100 (11), 6353-6357). For example, a tRNA-containing cell-free translation system (Clover Direct (Protein Express, an R & D oriented company)) comprising a non-natural amino acid bound with an amber suppressor tRNA complementary to UAG codon (amber codon), which is a stop codon, is also preferably used.

[0022]

The term "and/or" used herein to represent amino acid modification sites is meant to include every combination appropriately represented by "and" and "or". Specifically, for example, the phrase "amino acids 43, 52, and/or 105 are substituted" includes the following variations of amino acid modification:
(a) position 43, (b) position 52, (c) position 105, (d) positions 43 and 52, (e) positions 43 and 105, (f) positions 52 and 105, and (g) positions 43, 52, and 105.

[0023]

EU numbering and Kabat numbering

According to a method used in the present invention, amino acid positions assigned to antibody CDRs and FRs are defined by the Kabat method (Sequences of Proteins of Immunological Interest, National Institute of Health, Bethesda, Md., 1987 and 1991). When the antigen-binding molecule described herein is an antibody or an antigen-binding fragment, amino acids in variable and constant regions are indicated according to the Kabat numbering and the EU numbering conforming to the Kabat amino acid positions, respectively.

[0024]

Biological sample

In the present invention, the term "biological sample" refers to a sample of a tissue or a fluid isolated from a subject. In a non-limiting aspect, examples of such samples include plasma, serum, spinal fluid, lymph, external sections of skin, respiratory tract, intestinal tract, and genitourinary tract, tear, saliva, sputum, milk, whole blood or any blood fraction, blood derivatives, blood cells, tumor, nervous tissues, organs or any type of tissue, any sample obtained by lavage (e.g., samples derived from the bronchi), and samples of components constituting cell cultures *in vitro*.

[0025]

The number of an immunocyte or the expression level of a molecule expressed on the immunocyte can be measured

in a biological sample isolated from a patient. In the case of using, for example, blood as the biological sample, peripheral blood is preferred. The number of an immunocyte or the expression level of a molecule expressed on the immunocyte can be measured in isolated peripheral blood. In a non-limiting aspect, the number of an immunocyte in peripheral blood isolated from the patient may be measured using, for example, giemsa-stained leukocyte fractions or an automatic blood cell counter. In another non-limiting aspect, the expression level of a molecule expressed on the immunocyte in peripheral blood isolated from the patient may be measured by, for example, flow cytometry using a specific antibody.

[0026]

The term "isolated" refers to causing "artificial" change from a natural state, i.e., shifting and/or removing a naturally occurring substance from its original environment. In the present invention, the term "isolated" means that, for example, a cell, a polynucleotide or a polypeptide present in an organism is unisolated, whereas the same cell, polynucleotide or polypeptide thereas is isolated when separated from a material present with the cell, the polynucleotide or the polypeptide in a natural state. A polynucleotide or a polypeptide introduced into an organism by transformation, genetic manipulation, or any other recombination method

is in an isolated state even when present in the organism (regardless of being alive or dead).

[0027]

Immunocyte

In the present invention, the "immunocyte" means a cell involved in *in vivo* immune response, such as a leukocyte. Specific examples thereof include granulocytes (neutrophils, basophils, and eosinophils), monocytes (macrophages), lymphocytes (T cells, B cells, and NK cells), and dendritic cells.

[0028]

Method for measuring the number of immunocyte

In the present invention, the method for measuring the number of an immunocyte in the peripheral blood of the patient is not limited. For example, blood is collected as a biological sample from the patient, and the collected blood can be assayed as a sample using an automatic blood cell counter. Alternatively, for example, erythrocytes or leukocytes are counted using a hemacytometer, while blood cells can be stained by giemsa staining and then classified into neutrophils, eosinophils, basophils, monocytes, and lymphocytes depending on the difference in staining pattern or shape. The respective numbers of these cells can be calculated from the ratios thereof. In this context, the biological sample to be collected is not limited as long as the sample permits assay for patient-derived immunocytes.

Examples thereof include peripheral blood. Specifically, the assay may be conducted by a method described in, for example, Examples.

[0029]

Method for measuring expression level of molecule expressed on immunocyte

In the present invention, the method for measuring the expression level of a molecule expressed on the immunocyte of the patient is not limited. For example, blood can be collected as a biological sample from the patient, then reacted with an antibody specific for the molecule expressed on the immunocyte, and assayed using flow cytometry or the like. In addition, molecules of equivalent soluble fluorochrome (MESF) can be set using fluorescently labeled calibration beads to convert the flow cytometry measurement value of fluorescence intensity of a cell population to an MESF value for quantification. Specifically, the expression level (MESF) can be measured according to a method described in, for example, Journal of Research of the National Institute of Standard and Technology, vol. 107, No. 4 (2002) pp. 339-353. In this context, the biological sample to be collected is not limited as long as the sample permits assay for patient-derived immunocytes. Examples thereof include peripheral blood. Specifically, the assay may be conducted by a method described in, for example, Examples.

[0030]

Confirmation of Fcγ receptor gene polymorphism

In the present invention, the method for confirming the presence or absence of an Fcγ receptor gene polymorphism in the patient is not limited. For example, a biological sample is collected from the patient, and the genomic gene is isolated from the collected sample. The nucleotide sequence of a gene corresponding to the Fcγ receptor can be determined to confirm the presence or absence of the polymorphism. Specifically, this assay can be conducted according to a method described in, for example, Journal of Clinical Oncology, vol. 21, No. 21 (2003) pp. 3940-3947. In this context, the biological sample to be collected is not limited as long as the sample permits obtainment of the patient-derived genomic gene. Examples thereof include peripheral blood and skin sections.

[0031]

In the present invention, preferred examples of biological samples used for detecting the expression level of GPC3 in tissues include test subject-derived preparations. The test subject-derived preparation is preferably a tissue obtained from the test subject, more preferably a liver cancer or hepatocellular cancer tissue of the test subject. The liver cancer or hepatocellular cancer tissue is collected preferably using a biopsy method known in the art. The liver biopsy refers to a

method of directly inserting a thin long needle into the liver from skin surface and collecting liver tissues. The needling site is typically the intercostal space of the right lower chest. The safety of the needling site is confirmed before operation using an ultrasonic examination apparatus. Then, the needling site is disinfected. A region from the skin to the surface of the liver is subjected to anesthesia. After small incision of the skin at the needling site, a puncture needle is inserted thereto.

[0032]

For microscopic observation by transmitted beams, the tissue preparation is sliced to a degree that allows beams of light for use in the microscope to sufficiently penetrate the tissue slice. At a stage prior to the slicing, the tissue preparation is fixed. Specifically, proteins in tissues or cells are coagulated by dehydration or denaturation to thereby rapidly kill the cells constituting the tissues. The resulting structure is stabilized and insolubilized. First, the tissue preparation to be fixed is cut into a fragment with a size and a shape suitable for the preparation of paraffin-embedded sections by use of a knife such as a surgical knife. Subsequently, the fragment is dipped in a fixative, which is a reagent used for carrying out fixation. Formalin, more preferably neutral buffered formalin, is preferably used as the fixative. The

concentration of the neutral buffered formalin is appropriately selected according to the characteristics or physical properties of the tissue preparation. The concentration used may be appropriately changed between 1 and 50%, preferably 5 and 25%, more preferably 10 and 15%. The fixative with the tissue preparation dipped therein is appropriately degassed using a vacuum pump. For fixation, the tissue preparation is left for several hours in the fixative under conditions of ordinary pressure and room temperature. The time required for the fixation can be appropriately selected within the range of 1 hour to 7 days, preferably 2 hours to 3 days, more preferably 3 hours to 24 hours, further preferably 4 hours to 16 hours. The tissue preparation thus fixed is appropriately dipped in a phosphate buffer solution or the like for additional several hours (which can be appropriately selected within the range of 2 hours to 48 hours, preferably 3 hours to 24 hours, more preferably 4 hours to 16 hours).

[0033]

Next, sections can be preferably prepared by freeze sectioning or paraffin sectioning from the tissue preparation thus fixed. Preferred examples of the freeze sectioning include a method which involves adding tissues into O.C.T. Compound (Miles Inc.), freezing the mixture, and slicing the frozen mixture using a cryostat (frozen section preparation apparatus). In the paraffin

sectioning, the fixed tissue preparation is dipped in an embedding agent, which is then solidified to thereby impart thereto uniform and appropriate hardness. Paraffin can be preferably used as the embedding agent. The fixed tissue preparation is dehydrated using ethanol. Specifically, the tissue preparation is dipped in 70% ethanol, 80% ethanol, and 100% ethanol in this order and thereby dehydrated. The time required for the dipping and the number of runs can be appropriately selected within the ranges of 1 hour to several days and 1 to 3 times, respectively. The tissue preparation may be dipped therein at room temperature or 4°C. In the case of dipping at 4°C, a longer dipping time (e.g., overnight) is more preferred. After replacement of the liquid phase with xylene, the tissue preparation is embedded in paraffin. The time required for the replacement of the liquid phase with xylene can be appropriately selected within the range of 1 hour to several hours. This replacement may be performed at room temperature or 4°C. In the case of replacement at 4°C, a longer replacement time (e.g., overnight) is more preferred. The time required for the embedding in paraffin and the number of runs can be appropriately selected within the ranges of 1 hour to several hours and 1 to 4 times, respectively. This embedding may be performed at room temperature or 4°C. In the case of embedding at 4°C, a longer embedding time (e.g.,

overnight) is more preferred. Alternatively, the tissue preparation may be preferably embedded in paraffin using paraffin embedding apparatus (EG1160, Leica, etc.) that automatically performs paraffin embedding reaction.

[0034]

The tissue preparation thus paraffin-embedded is bonded to a block base to prepare a "block". This block is sliced into the desired thickness selected from thicknesses of 1 to 20 μm by use of a microtome. The sliced tissue section is left standing on a glass slide as a permeable support and thereby fixed thereon. In this case, the glass slide coated with 0.01% poly-L-lysine (Sigma-Aldrich Corp.) and then dried may be preferably used in order to prevent the tissue section from coming off. The fixed tissue section is dried in air for an appropriate time selected from between several minutes and 1 hour.

[0035]

Epitope retrieval

In a preferred aspect, an epitope in an antigen whose reactivity with an antibody has been attenuated due to formalin fixation is retrieved. In the present invention, protease-induced epitope retrieval (PIER) or heat-induced epitope retrieval (HIER) may be applied to the retrieval. In a non-limiting aspect, PIER may be applied to one of "two identifiable tissue preparations" prepared as shown below, while HIER may be applied to the

other preparation. In this case, a difference in the degree of staining between these preparations reacted with antibodies can be digitized.

[0036]

In a non-limiting aspect, a set of two tissue preparations is prepared, which are prepared as shown in the paragraph "Biological sample" and attached onto permeable supports. The tissue preparations are desirably two histologically identifiable tissue preparations. The term "identifiable" means that two tissue preparations to be mutually compared are composed of substantially the same cells or tissues in test subject-derived preparations serving as origins of the tissue preparations. For example, two tissue preparations prepared as adjacent sections correspond to two identifiable tissue preparations. In the present invention as well, the "two identifiable tissue preparations" refer to two tissue preparations prepared as adjacent sections, unless otherwise specified. In addition, two tissue preparations composed of cells or tissues structurally identifiable between the preparations correspond to "two identifiable tissue preparations", even if the tissue preparations are not prepared as adjacent sections. Preferred examples of such two tissue preparations composed of cells or tissues structurally identifiable therebetween include (1) tissue sections containing cells derived from the same cells at

the same positions on plane coordinates in the sections, and (2) tissue sections in which at least 50% or more, preferably 60% or more, more preferably 70% or more, further preferably 80% or more, still further preferably 90% or more, particularly preferably 95% or more of the cells are present at the same positions on the plane coordinates.

[0037]

The heat-induced epitope retrieval appropriately employs, for example, a heating method using microwave, a heating method using an autoclave, or a heating method using boiling treatment. In the case of boiling treatment at an output of 780 W so as to keep a liquid temperature at approximately 98°C, the time required for the retrieval including the treatment is appropriately selected from between 5 minutes and 60 minutes and is, for example, 10 minutes. The epitope retrieval treatment can be performed in a 10 mM sodium citrate buffer solution as well as commercially available Target Retrieval Solution (DakoCytomation), for example. Target Retrieval Solution is used in Examples described below. Any buffer solution or aqueous solution is preferably used as long as an epitope in the antigen that is recognized by an anti-GPC3 antibody acquires the ability to bind to the antibody as a result of the retrieval treatment so that an antigen-antibody complex mentioned later can be detected.

[0038]

The protease for use in the protease-induced epitope retrieval is not limited by its type or origin. Generally available protease can be appropriately selected for use. Preferred examples of the protease used include pepsin with 0.05% concentration in 0.01 N hydrochloric acid, trypsin with 0.1% concentration further containing $CaCl_2$ with 0.01% concentration in a tris buffer solution (pH 7.6), and protease K with a concentration of 1 to 50 μg/ml in a 10 mM tris-HCl buffer solution (pH 7.8) containing 10 mM EDTA and 0.5% SDS. In the case of using protease K, the pH of the reaction solution is appropriately selected from between 6.5 and 9.5, and an SH reagent, a trypsin inhibitor, or a chymotrypsin inhibitor may be appropriately used. Specific examples of such preferred protease also include protease attached to Histofine HER2 kit (MONO) (Nichirei Biosciences Inc.). The protease-induced epitope retrieval is usually performed at 37°C. The reaction temperature may be appropriately changed within the range of 25°C to 50°C. The reaction time of the protease-induced epitope retrieval performed at 37°C is appropriately selected from between, for example, 1 minute and 5 hours and is, for example, 15 minutes, 30 minutes, 45 minutes, 1 hour, 2 hours, 3 hours, or 4 hours. After the completion of the retrieval treatment, the tissue preparation thus treated is washed with a washing

buffer solution. Phosphate-buffered saline (PBS) is preferably used as the washing buffer solution. Alternatively, a tris-HCl buffer solution may be preferably used. The washing conditions adopted in this method usually involve three runs of washing at room temperature for 5 minutes. The washing time and temperature may be appropriately changed.

[0039]

Reaction between tissue preparation and anti-GPC3 antibody

The tissue preparation thus treated by the heat-induced epitope retrieval and/or the tissue preparation thus treated by the protease-induced epitope retrieval are reacted with an anti-GPC3 antibody mentioned later as a primary antibody. The reaction is carried out under conditions appropriate for the recognition of an epitope in the antigen by the anti-GPC3 antibody and the subsequent formation of an antigen-antibody complex. The reaction is usually carried out overnight at 4°C or at 37°C for 1 hour. The reaction conditions may be appropriately changed within a range appropriate for the recognition of an epitope in the antigen by the antibody and the subsequent formation of an antigen-antibody complex. For example, the reaction temperature may be changed within the range of 4°C to 50°C, while the reaction time may be changed between 1 minute and 7 days. A longer reaction time is more preferred for the reaction

carried out at a low temperature. After the completion of the primary antibody reaction, each tissue preparation is washed with a washing buffer solution. Phosphate-buffered saline (PBS) is preferably used as the washing buffer solution. Alternatively, a tris-HCl buffer solution may be preferably used. The washing conditions adopted in this method usually involve three runs of washing at room temperature for 5 minutes. The washing time and temperature may be appropriately changed.

[0040]

Subsequently, each tissue preparation thus reacted with the primary antibody is reacted with a secondary antibody that recognizes the primary antibody. A secondary antibody labeled in advance with a labeling material for visualizing the secondary antibody is usually used. Preferred examples of the labeling material include: fluorescent dyes such as fluorescein isothiocyanate (FITC), Cy2 (Amersham Biosciences Corp.), and Alexa 488 (Molecular Probes Inc.); enzymes such as peroxidase and alkaline phosphatase; and gold colloid.

[0041]

The reaction with the secondary antibody is carried out under conditions appropriate for the formation of an antigen-antibody complex between the anti-GPC3 antibody and the secondary antibody that recognizes the anti-GPC3 antibody. The reaction is usually carried out at room temperature or 37°C for 30 minutes to 1 hour. The

reaction conditions may be appropriately changed within a range appropriate for the formation of an antigen-antibody complex between the anti-GPC3 antibody and the secondary antibody. For example, the reaction temperature may be changed within the range of 4°C to 50°C, while the reaction time may be changed between 1 minute and 7 days. A longer reaction time is more preferred for the reaction carried out at a low temperature. After the completion of the secondary antibody reaction, each tissue preparation is washed with a washing buffer solution. Phosphate-buffered saline (PBS) is preferably used as the washing buffer solution. Alternatively, a tris-HCl buffer solution may be preferably used. The washing conditions adopted in this method usually involve three runs of washing at room temperature for 5 minutes. The washing time and temperature may be appropriately changed.

[0042]

Next, each tissue preparation thus reacted with the secondary antibody is reacted with a substance capable of visualizing the labeling material. When peroxidase is used as the labeling material in the secondary antibody, a 0.02% aqueous hydrogen peroxide solution and a diaminobenzidine (DAB) solution concentration-adjusted to 0.1% with a 0.1 M tris-HCl buffer solution (pH 7.2) are mixed in equal amounts immediately before incubation and the tissue preparation is incubated in the resulting

reaction solution. A chromogenic substrate such as DAB-Ni or AEC+ (both from Dako Japan Inc.) may be appropriately selected instead of DAB. During the course of incubation, the visualization reaction can be stopped by the dipping of the tissue preparation in PBS at the stage where appropriate color development is confirmed by the occasional microscopic observation of the degree of color development.

[0043]

When alkaline phosphatase is used as the labeling material in the secondary antibody, each tissue preparation is incubated in a 5-bromo-4-chloro-3-indolyl phosphoric acid (BCIP)/nitro blue tetrazolium (NBT) (Zymed Laboratories, Inc.) substrate solution (solution of NBT and BCIP dissolved at concentrations of 0.4 mM and 0.38 mM, respectively, in a 50 mM sodium carbonate buffer solution (pH 9.8) containing 10 mM $MgCl_2$ and 28 mM NaCl). Alternatively, for example, Permanent Red, Fast Red, or Fuchsin+ (all from Dako Japan Inc.) may be appropriately used instead of BCIP and NBT. Prior to the incubation, the tissue preparation may be preincubated at room temperature for 1 minute to several hours with a 0.1 M tris-HCl buffer solution (pH 9.5) containing levamisole chloride (Nacalai Tesque, Inc.), an inhibitor of endogenous alkaline phosphatase, with a concentration of 1 mM, 0.1 M sodium chloride, and 50 mM magnesium chloride. During the course of incubation, the tissue preparation

is washed with water or with TBST (TBS containing 0.1% Tween 20) after stop of the reaction by the addition of TBS containing 2% polyvinyl alcohol, at the stage where the deposition of a final reaction product purple formazan is confirmed by occasional microscopic observation. When gold colloid is used as the label in the secondary antibody, metallic silver is attached to gold particles by silver intensification to thereby visualize the gold colloid. The silver intensification method is generally known to those skilled in the art.

[0044]

When a fluorescent dye such as fluorescein isothiocyanate (FITC), Cy2 (Amersham Biosciences Corp.), or Alexa 488 (Molecular Probes Inc.) is used as the labeling material in the secondary antibody, the reaction step of the visualizing substance is unnecessary. Each tissue preparation is irradiated with light at an excitation wavelength for the fluorescent material. Emitted light can be appropriately detected using a fluorescence microscope.

[0045]

Immunohistochemical staining score

In a non-limiting aspect, the present invention also provides a method for determining the efficacy of GPC3-targeting drug therapy or determining the continuation of GPC3-targeting drug therapy from the concentration of free GPC3 as well as the expression level of GPC3

detected in tissues by the method described above. In a non-limiting aspect, the expression of GPC3 detected in tissues by the method described above is digitized by, for example, a non-limiting method exemplified below. In the present invention, such a digitized expression level of GPC3 in tissues is referred to as an "immunohistochemical staining score of GPC3".

[0046]

The respective scores of positive cell rate (PR), staining intensity of cytoplasm (SI-cp) or staining intensity of cell membrane (SI-cm), and staining pattern of cell membrane (Sp-cm) are calculated according to the criteria shown in Table 1 by a method described in WO2009116659 and added on the basis of calculation expressions 1 and 2. The resulting score is exemplified as the non-limiting immunohistochemical staining score of GPC3 (referred to as "composite score 1" for the sake of convenience) of the present invention.

[0047]

[Table 1-1]

Criterion	Evaluation	Score
Positive cell rate (PR)	0	0
	1% or more and less than 20%	1
	20% or more and less than 50%	2
	50% or more	3
Staining intensity (SI) - Cytoplasm (SI-cp) - Cell membrane (SI-cm)	Slightly positive	0
	Weakly positive	1
	Moderately positive and/or weakly positive with strong positivity	2
	Moderately positive	3
	Strongly positive	4
Staining pattern of cell membrane (SP-cm)	Negative	0
	When only a portion of the cell membranes of cells was stained	1
	When a portion of the cell membranes of most of these cells was stained and the cell membranes of some of the cells were circumferentially stained	2
	When the cell membranes of most of these cells were circumferentially stained	3

(Sp-cm scores were calculated by the evaluation of cell staining in the visual field under microscope using an objective lens with a magnification of 4 or 10.)

[0048]

[Expression 1]

IHC total = PR + SI-Cp + SI-Cm + Sp-Cm

[0049]

[Expression 2]

IHC cm = PR + SI-Cm + Sp-Cm

[0050]

[Table 1-2]

Composite score 1	IHC total score
High expression	7 or higher
Low or moderate expression	Lower than 7

[0051]

In addition, the H-score is known (literature: KS. McCarty Jr. et al., Use of a monoclonal anti-Estrogen receptor antibody in the immunohistochemical evaluation of human tumors. Cancer Res. Suppl. (1986) 46, 4244s-4248s), which is calculated on the basis of the proportion of cells that exhibit each staining intensity (staining intensity of cell membrane or cytoplasm) classified into 0 to 3.

[0052]

Another example of the immunohistochemical staining score includes the following scoring algorithm for classification of 0 to 3+ on the basis of the staining intensity of membrane, the staining intensity of cytoplasm, and the degree of staining, and an evaluation score based on the algorithm (composite score 2).

[0053]

[Table 2]

Score (Composite score 2)	Evaluation
0	When cell membranes were not stained
	When less than 10% of tumor cells exhibited intracytoplasmic staining
1+	When less than 10% of tumor cells exhibited cell membrane staining
	and/or
	When 10% or more of tumor cells exhibited intracytoplasmic staining (note that strong intracytoplasmic staining, if any, remains at less than 50% of the tumor cells)
2+	When 10% or more of tumor cells exhibited weak or moderate cell membrane staining (note that strong cell membrane staining, if any, remains at less than 10% of the tumor cells) regardless of the presence or absence of intracytoplasmic staining in 10% or more of the tumor cells (note that intracytoplasmic staining, if any, remains at less than 50% of the tumor cells)
3+	When 10% or more of tumor cells exhibited strong cell membrane staining regardless of the presence or absence of intracytoplasmic staining
	or
	When 50% or more of tumor cells exhibited strong intracytoplasmic staining

[0054]

In the present invention, for example, the composite score 1, the H-score, and the composite score 2 may be used alone or in combination as the "immunohistochemical staining score of GPC3". In a non-limiting aspect, the composite score 1 may be used as the "immunohistochemical staining score of GPC3". In another non-limiting aspect, the composite score 2 may be used as the "immunohistochemical staining score of GPC3".

[0055]

GPC3-targeting drug

In the present invention, the term "GPC3-targeting drug" refers to every molecule that blocks, suppresses, inhibits, or reduces the biological activity of GPC3 including a signal pathway mediated by GPC3 or is cytotoxic to cells expressing GPC3. The term "targeting treatment" does not suggest a certain mechanism having biological effects and conceptually includes every possible effect of the pharmacological, physiological, and biochemical interactions of GPC3. Examples of the GPC3-targeting drug include: (1) antagonistic or non-antagonistic inhibitors of the binding of GPC3 to a GPC3-binding ligand, i.e., active substances that interfere with the binding of GPC3 to its ligand; (2) active substances that do not interfere with the binding of GPC3 to its ligand but instead inhibit or decrease activity brought about by the binding of GPC3 to its ligand; (3) active substances that decrease GPC3 expression; and (4) active substances capable of eliciting cytotoxic activity against cells expressing GPC3. In a non-limiting aspect, examples of the ligand can include wnt (Cancer Res. (2005) 65, 6245-6254), IGF-II (Carcinogenesis (2008) 29 (7), 1319-1326), and fibroblast growth factor 2 (Int. J. Cancer (2003) 103 (4), 455-465). In a non-limiting aspect, such active substances can include, for example, antibodies (including their antigen-binding domains), nucleic acid molecules (antisense or RNAi molecules,

etc.), peptides, non-peptidic low-molecular-weight organic materials.

[0056]

In a non-limiting aspect, examples of the non-peptidic low-molecular-weight organic material that may be used as the GPC3-targeting drug of the present invention include non-peptidic low-molecular-weight quinoline derivatives (WO2008/046085) which act on methylation suppressor genes. Further examples thereof can include HLA-A2-restricted GPC3 peptide 144-152 (SEQ ID NO: 2) and HLA-A24-restricted GPC3 peptide 298-306 (SEQ ID NO: 3) (Clin. Cancer Res. (2006) 12 (9), 2689-2697) which elicit the cytotoxic activity of cytotoxic T cells.

[0057]

Anti-GPC3 antibody

In a non-limiting aspect, examples of the anti-GPC3 antibody that may be used as the GPC3-targeting drug of the present invention can include an antibody-drug conjugate (ADC) (WO2007/137170) comprising a 1G12 antibody (WO2003/100429) (sold under catalog No. B0134R by BioMosaics Inc.) conjugated with a cytotoxic substance.

[0058]

In an alternative non-limiting aspect, examples of the anti-GPC3 antibody include a humanized anti-GPC3 antibody described in WO2006/006693 or WO2009/041062. Specifically, a humanized anti-GPC3 antibody comprising

heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 4, 5, and 6, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 7, 8, and 9, respectively, can be used as the GPC3-targeting drug of the present invention. The humanized anti-GPC3 antibody can be prepared using, as templates for humanization, appropriately selected human framework sequences having high sequence identity to a heavy chain framework sequence represented by SEQ ID NO: 10 or a light chain framework sequence represented by SEQ ID NO: 11.

[0059]

In a further alternative non-limiting aspect, an anti-GPC3 chimeric antibody or a humanized anti-GPC3 antibody comprising heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 12, 13, and 14, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 15, 16, and 17, respectively, can be used as the GPC3-targeting drug of the present invention. The humanized anti-GPC3 antibody can be prepared using, as templates for humanization, appropriately selected human framework sequences having high sequence identity to a heavy chain framework sequence represented by SEQ ID NO: 18 or a light chain framework sequence represented by SEQ ID NO: 19.

[0060]

In an alternative non-limiting aspect, an anti-GPC3 chimeric antibody or a humanized anti-GPC3 antibody comprising heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 20, 21, and 22, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 23, 24, and 25, respectively, can be used as the GPC3-targeting drug of the present invention. The humanized anti-GPC3 antibody can be prepared using, as templates for humanization, appropriately selected human framework sequences having high sequence identity to a heavy chain framework sequence represented by SEQ ID NO: 26 or a light chain framework sequence represented by SEQ ID NO: 27.

[0061]

In a further alternative non-limiting aspect, an anti-GPC3 chimeric antibody or a humanized anti-GPC3 antibody comprising heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 28, 29, and 30, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 31, 32, and 33, respectively, can be used as the GPC3-targeting drug of the present invention. The humanized anti-GPC3 antibody can be prepared using, as templates for humanization, appropriately selected human framework sequences having high sequence identity to a heavy chain framework sequence represented by SEQ ID NO: 34 or a

light chain framework sequence represented by SEQ ID NO: 35.

[0062]

In an alternative non-limiting aspect, an anti-GPC3 chimeric antibody or a humanized anti-GPC3 antibody comprising heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 36, 37, and 38, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 39, 40, and 41, respectively, can be used as the GPC3-targeting drug of the present invention. The humanized anti-GPC3 antibody can be prepared using, as templates for humanization, appropriately selected human framework sequences having high sequence identity to a heavy chain framework sequence represented by SEQ ID NO: 42 or a light chain framework sequence represented by SEQ ID NO: 43.

[0063]

In a further alternative non-limiting aspect, a humanized anti-GPC3 antibody comprising a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region represented by SEQ ID NO: 51 can be used as the GPC3-targeting drug of the present invention. In a further alternative non-limiting aspect, a humanized anti-GPC3 antibody comprising a heavy chain variable region

selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region selected from the group of light chain variable regions represented by SEQ ID NOs: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, and 66 can be used as the GPC3-targeting drug of the present invention.

[0064]

In a further alternative non-limiting aspect, a humanized anti-GPC3 antibody comprising a heavy chain variable region represented by SEQ ID NO: 67 and a light chain variable region represented by SEQ ID NO: 68, a humanized anti-GPC3 antibody comprising a heavy chain variable region represented by SEQ ID NO: 69 and a light chain variable region represented by SEQ ID NO: 70, a humanized anti-GPC3 antibody comprising a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 72, or a humanized anti-GPC3 antibody comprising a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 73 can also be used as the GPC3-targeting drug of the present invention.

[0065]

Cytotoxic activity

Alternative examples of the anti-GPC3 antibody of the present invention include an anti-GPC3 antibody

having cytotoxic activity. In the present invention, non-limiting examples of the cytotoxic activity include antibody-dependent cell-mediated cytotoxicity or antibody-dependent cellular cytotoxicity (ADCC) activity, complement-dependent cytotoxicity (CDC) activity, and cytotoxic activity based on T cells. In the present invention, the CDC activity means cytotoxic activity brought about by the complement system. On the other hand, the ADCC activity means the activity of damaging target cells by, for example, immunocytes, through the binding of the immunocytes via Fcγ receptors expressed on the immunocytes to the Fc regions of antigen-binding molecules comprising antigen-binding domains capable of binding to membrane molecules expressed on the cell membranes of the target cells. Whether or not the antigen-binding molecule of interest has ADCC activity or has CDC activity can be determined by a method known in the art (e.g., Current protocols in Immunology, Chapter 7. Immunologic studies in humans, Coligan et al., ed. (1993)).

[0066]

Specifically, effector cells, a complement solution, and target cells are first prepared.

(1) Preparation of effector cells

The spleens are excised from CBA/N mice or the like, and spleen cells are separated therefrom in an RPMI1640 medium (Invitrogen Corp.). The spleen cells can be

washed with this medium containing 10% fetal bovine serum (FBS, HyClone Laboratories, Inc.) and then concentration-adjusted to 5 x 10^6 cells/mL to prepare the effector cells.

[0067]

(2) Preparation of complement solution

Baby Rabbit Complement (CEDARLANE Laboratories Ltd.) can be diluted 10-fold with a medium (Invitrogen Corp.) containing 10% FBS to prepare the complement solution.

[0068]

(3) Preparation of target cells

Antigen-expressing cells can be cultured at 37°C for 1 hour, together with 0.2 mCi ^{51}Cr-sodium chromate (GE Healthcare Bio-Sciences Corp.), in a DMEM medium containing 10% FBS to thereby radiolabel the target cells. The cells thus radiolabeled can be washed three times with an RPMI1640 medium containing 10% FBS and then concentration-adjusted to 2 x 10^5 cells/mL to prepare the target cells.

[0069]

The ADCC or CDC activity can be assayed by a method described below. For the ADCC activity assay, the target cells and the antigen-binding molecule (each 50 μl/well) are added to a U-bottom 96-well plate (Becton, Dickinson and Company) and reacted for 15 minutes on ice. Then, 100 μl of the effector cells is added to each well, and the plate is left standing for 4 hours in a CO_2 incubator.

The final concentration of the antibody (antigen-binding molecule) can be set to, for example, 0 or 10 μg/ml. The radioactivity of 100 μl of the supernatant recovered from each well of the plate thus left standing is measured using a gamma counter (COBRA II AUTO-GAMMA, MODEL D5005, Packard Instrument Company). The cytotoxic activity (%) can be calculated on the basis of the calculation expression (A - C) / (B - C) x 100 using the measurement value, wherein A represents radioactivity (cpm) from each sample; B represents radioactivity (cpm) from a sample supplemented with 1% NP-40 (Nacalai Tesque, Inc.); and C represents radioactivity (cpm) from a sample containing only the target cells.

[0070]

For the CDC activity assay, the target cells and the antigen-binding molecule (each 50 μl/well) are added to a flat-bottomed 96-well plate (Becton, Dickinson and Company) and reacted for 15 minutes on ice. Then, 100 μl of the complement solution is added to each well, and the plate is left standing for 4 hours in a CO_2 incubator. The final concentration of the antibody (antigen-binding molecule) can be set to, for example, 0 or 3 μg/ml. The radioactivity of 100 μl of the supernatant recovered from each well of the plate thus left standing is measured using a gamma counter. The cytotoxic activity based on the CDC activity can be calculated in the same way as in the ADCC activity assay.

[0071]

Cytotoxic substance

In a non-limiting aspect, alternative examples of the anti-GPC3 antibody of the present invention include an anti-GPC3 antibody conjugated with a cytotoxic substance. Such an anti-GPC3 antibody-drug conjugate (ADC) is specifically disclosed in, for example, WO2007/137170, though the conjugate of the present invention is not limited to those described therein. Specifically, the cytotoxic substance may be any of chemotherapeutic agents listed below or may be a compound disclosed in Alley et al. (Curr. Opin. Chem. Biol. (2010) 14, 529-537) or WO2009/140242. Antigen-binding molecules are conjugated with these compounds via appropriate linkers or the like.

[0072]

Examples of chemotherapeutic agents that may be conjugated to the anti-GPC3 antibody of the present invention can include the following: azaribine, anastrozole, azacytidine, bleomycin, bortezomib, bryostatin-1, busulfan, camptothecin, 10-hydroxycamptothecin, carmustine, Celebrex, chlorambucil, cisplatin, irinotecan, carboplatin, cladribine, cyclophosphamide, cytarabine, dacarbazine, docetaxel, dactinomycin, daunomycin glucuronide, daunorubicin, dexamethasone, diethylstilbestrol, doxorubicin, doxorubicin glucuronide, epirubicin, ethinyl estradiol,

estramustine, etoposide, etoposide glucuronide, floxuridine, fludarabine, flutamide, fluorouracil, fluoxymesterone, gemcitabine, hydroxyprogesterone caproate, hydroxyurea, idarubicin, ifosfamide, leucovorin, lomustine, maytansinoid, mechlorethamine, medroxyprogesterone acetate, megestrol acetate, melphalan, mercaptopurine, methotrexate, mitoxantrone, mithramycin, mitomycin, mitotane, phenylbutyrate, prednisone, procarbazine, paclitaxel, pentostatin, semustine, streptozocin, tamoxifen, taxanes, Taxol, testosterone propionate, thalidomide, thioguanine, thiotepa, teniposide, topotecan, uracil mustard, vinblastine, vinorelbine, and vincristine.

[0073]

In the present invention, a preferred chemotherapeutic agent is a low-molecular-weight chemotherapeutic agent. The low-molecular-weight chemotherapeutic agent is unlikely to interfere with the functions of the anti-GPC3 antibody even after forming the anti-GPC3 antibody-drug conjugate of the present invention. In the present invention, the low-molecular-weight chemotherapeutic agent has a molecular weight of usually 100 to 2000, preferably 200 to 1000. All of the chemotherapeutic agents listed herein are low-molecular-weight chemotherapeutic agents. These chemotherapeutic agents according to the present invention include prodrugs that are converted to active chemotherapeutic

agents *in vivo*. The prodrugs may be activated through enzymatic conversion or nonenzymatic conversion.

[0074]

Alternative examples of the conjugated cytotoxic substance in the anti-GPC3 antibody-drug conjugate of the present invention can include toxic peptides (toxins) such as *Pseudomonas* exotoxin A, saporin-s6, diphtheria toxin, and cnidarian toxin, radioiodine, and photosensitizers. Examples of the toxic peptides preferably include the following:

diphtheria toxin A chain (Langone et al., Methods in Enzymology (1983) 93, 307-308);

Pseudomonas exotoxin (Nature Medicine (1996) 2, 350-353);

ricin A chain (Fulton et al., J. Biol. Chem. (1986) 261, 5314-5319; Sivam et al., Cancer Res. (1987) 47, 3169-3173; Cumber et al., J. Immunol. Methods (1990) 135, 15-24; Wawrzynczak et al., Cancer Res. (1990) 50, 7519-7562; and Gheeite et al., J. Immunol. Methods (1991) 142, 223-230);

deglycosylated ricin A chain (Thorpe et al., Cancer Res. (1987) 47, 5924-5931);

abrin A chain (Wawrzynczak et al., Br. J. Cancer (1992) 66, 361-366; Wawrzynczak et al., Cancer Res. (1990) 50, 7519-7562; Sivam et al., Cancer Res. (1987) 47, 3169-3173; and Thorpe et al., Cancer Res. (1987) 47, 5924-5931);

gelonin (Sivam et al., Cancer Res. (1987) 47, 3169-3173; Cumber et al., J. Immunol. Methods (1990) 135, 15-24; Wawrzynczak et al., Cancer Res., (1990) 50, 7519-7562; and Bolognesi et al., Clin. exp. Immunol. (1992) 89, 341-346);

pokeweed anti-viral protein from seeds (PAP-s) (Bolognesi et al., Clin. exp. Immunol. (1992) 89, 341-346);

bryodin (Bolognesi et al., Clin. exp. Immunol. (1992) 89, 341-346);

saporin (Bolognesi et al., Clin. exp. Immunol. (1992) 89, 341-346);

momordin (Cumber et al., J. Immunol. Methods (1990) 135, 15-24; Wawrzynczak et al., Cancer Res. (1990) 50, 7519-7562; and Bolognesi et al., Clin. exp. Immunol. (1992) 89, 341-346);

momorcochin (Bolognesi et al., Clin. exp. Immunol. (1992) 89, 341-346);

dianthin 32 (Bolognesi et al., Clin. exp. Immunol. (1992) 89, 341-346);

dianthin 30 (Stirpe F., Barbieri L., FEBS letter (1986) 195, 1-8);

modeccin (Stirpe F., Barbieri L., FEBS letter (1986) 195, 1-8);

viscumin (Stirpe F., Barbieri L., FEBS letter (1986) 195, 1-8);

volkensin (Stirpe F., Barbieri L., FEBS letter (1986) 195, 1-8);

dodecandrin (Stirpe F., Barbieri L., FEBS letter (1986) 195, 1-8);
tritin (Stirpe F., Barbieri L., FEBS letter (1986) 195, 1-8);
luffin (Stirpe F., Barbieri L., FEBS letter (1986) 195, 1-8); and
trichokirin (Casellas et al., Eur. J. Biochem. (1988) 176, 581-588; and Bolognesi et al., Clin. exp. Immunol., (1992) 89, 341-346).

[0075]

In the case of assaying the cytotoxic activity of the anti-GPC3 antibody-drug conjugate of the present invention, the target cells and the anti-GPC3 antibody-drug conjugate (each 50 μl/well) are added to a flat-bottomed 96-well plate (Becton, Dickinson and Company) and reacted for 15 minutes on ice. The plate is incubated for 1 to 4 hours in a CO_2 incubator. The anti-GPC3 antibody-drug conjugate can be appropriately used at a final concentration ranging from 0 to 3 μg/ml. After the culture, 100 μl of the supernatant is recovered from each well, and the radioactivity of the supernatant is measured using a gamma counter. The cytotoxic activity can be calculated in the same way as in the ADCC activity assay.

[0076]

Fc region

An Fc region contained in a constant region contained in the anti-GPC3 antibody of the present invention may be obtained from human IgG, though the Fc region of the present invention is not limited by a particular subclass of IgG. The Fc region refers to an antibody heavy chain constant region comprising a hinge region and CH2 and CH3 domains from the hinge region N terminus which is a papain cleavage site (about amino acid 216 based on the EU numbering). Preferred examples of the Fc region include Fc regions having binding activity against Fcγ receptors as mentioned later. In a non-limiting aspect, examples of such Fc regions include Fc regions contained in constant regions represented by SEQ ID NO: 74 for human IgG1, SEQ ID NO: 75 for IgG2, SEQ ID NO: 76 for IgG3, and SEQ ID NO: 77 for IgG4.

[0077]

Fcγ receptor (FcγR)

The Fcγ receptor (also referred to as FcγR) refers to a receptor capable of binding to the Fc region of an IgG1, IgG2, IgG3, or IgG4 monoclonal antibody and substantially means even any member of protein family encoded by Fcγ receptor genes. In humans, this family includes, but not limited to: FcγRI (CD64) including isoforms FcγRIa, FcγRIb, and FcγRIc; FcγRII (CD32) including isoforms FcγRIIa (including allotypes H131 and R131; i.e., FcγRIIa (H) and FcγRIIa (R)), FcγRIIb (including FcγRIIb-1 and FcγRIIb-2), and FcγRIIc; FcγRIII

(CD16) including isoforms FcγRIIIa (including allotypes V158 and F158; i.e., FcγRIIIa (V) and FcγRIIIa (F)) and FcγRIIIb (including allotypes FcγRIIIb-NA1 and FcγRIIIb-NA2); and even any unfound human FcγR or FcγR isoform or allotype. FcγR includes human, mouse, rat, rabbit, and monkey Fcγ receptors. The FcγR of the present invention is not limited to these receptors and may be derived from any organism. The mouse FcγR includes, but not limited to, FcγRI (CD64), FcγRII (CD32), FcγRIII (CD16), and FcγRIII-2 (FcγRIV, CD16-2), and even any unfound mouse FcγR or FcγR isoform or allotype. Preferred examples of such Fcγ receptors include human FcγRI (CD64), FcγRIIa (CD32), FcγRIIb (CD32), FcγRIIIa (CD16), and/or FcγRIIIb (CD16). The polypeptide sequence of human FcγRI is described in SEQ ID NO: 78 (NP_000557.1); the polypeptide sequence of human FcγRIIa (allotype H131) is described in SEQ ID NO: 79 (AAH20823.1) (allotype R131 has a sequence with substitution by Arg at amino acid 166 in SEQ ID NO: 79); the polypeptide sequence of FcγRIIb is described in SEQ ID NO: 80 (AAI46679.1); the polypeptide sequence of FcγRIIIa is described in SEQ ID NO: 81 (AAH33678.1); and the polypeptide sequence of FcγRIIIb is described in SEQ ID NO: 82 (AAI28563.1) (registration numbers of a database such as RefSeq are shown within the parentheses). Whether or not the Fcγ receptor has binding activity against the Fc region of an IgG1, IgG2, IgG3, or IgG4 monoclonal antibody can be confirmed by a method known in

the art such as FACS or ELISA formats as well as BIACORE method using amplified luminescent proximity homogeneous assay (ALPHA) screening or surface plasmon resonance (SPR) phenomena (Proc. Natl. Acad. Sci. U.S.A. (2006) 103 (11), 4005-4010).

[0078]

In FcγRI (CD64) including isoforms FcγRIa, FcγRIb, and FcγRIc and FcγRIII (CD16) including isoforms FcγRIIIa (including allotypes V158 and F158) and FcγRIIIb (including allotypes FcγRIIIb-NA1 and FcγRIIIb-NA2), an α chain capable of binding to the IgG Fc region associates with a common γ chain having ITAM that transduces activating signals into cells. On the other hand, FcγRII (CD32) including isoforms FcγRIIa (including allotypes H131 and R131) and FcγRIIc contains ITAM in its cytoplasmic domain. These receptors are expressed in many immunocytes, such as macrophages, mast cells, and antigen-displaying cells. These receptors bind to IgG Fc regions and thereby transduce activating signals, which in turn promote the phagocytic capacity of macrophages, the production of inflammatory cytokines, the degranulation of mast cells, and the increased function of antigen-displaying cells. The Fcγ receptors that are able to transduce activating signals as described above are referred to as active Fcγ receptors herein.

[0079]

On the other hand, FcγRIIb (including FcγRIIb-1 and FcγRIIb-2) contains ITIM that transduces inhibitory signals, in its intracytoplasmic domain. In B cells, activating signals from B cell receptors (BCRs) are inhibited by the cross-linking of BCR with FcγRIIb, resulting in the suppressed antibody production of BCR. The phagocytic capacity of macrophages or their ability to produce inflammatory cytokines is suppressed by the cross-linking of FcγRIII and FcγRIIb. The Fcγ receptors that are able to transduce inhibitory signals as described above are referred to as inhibitory Fcγ receptors herein.

[0080]

Binding activity of Fc region against FcγR

As mentioned above, examples of the Fc region contained in the anti-GPC3 antibody of the present invention include Fc regions having binding activity against Fcγ receptors. In a non-limiting aspect, examples of such Fc regions include Fc regions contained in constant regions represented by SEQ ID NO: 74 for human IgG1, SEQ ID NO: 75 for IgG2, SEQ ID NO: 76 for IgG3, and SEQ ID NO: 77 for IgG4. Whether or not the Fcγ receptor has binding activity against the Fc region of an IgG1, IgG2, IgG3, or IgG4 monoclonal antibody can be confirmed by a method known in the art such as FACS or ELISA formats as well as BIACORE method using amplified luminescent proximity homogeneous assay (ALPHA) screening

or surface plasmon resonance (SPR) phenomena (Proc. Natl. Acad. Sci. U.S.A. (2006) 103 (11), 4005-4010).

[0081]

The ALPHA screening is carried out on the basis of the following principles according to ALPHA technology using two beads, a donor and an acceptor. Luminescence signals are detected only when these two beads are located in proximity through the biological interaction between a molecule bound with the donor bead and a molecule bound with the acceptor bead. A laser-excited photosensitizer in the donor bead converts ambient oxygen to singlet oxygen in an excited state. The singlet oxygen diffuses around the donor bead and reaches the acceptor bead located in proximity thereto to thereby cause chemiluminescent reaction in the bead, which finally emits light. In the absence of the interaction between the molecule bound with the donor bead and the molecule bound with the acceptor bead, singlet oxygen produced by the donor bead does not reach the acceptor bead. Thus, no chemiluminescent reaction occurs.

[0082]

For example, a biotin-labeled anti-GPC3 antibody comprising the Fc region is bound to the donor bead, while a glutathione S transferase (GST)-tagged Fcγ receptor is bound to the acceptor bead. In the absence of a competing anti-GPC3 antibody comprising a modified Fc region, the anti-GPC3 antibody having the native Fc

region interacts with the Fcγ receptor to generate signals of 520 to 620 nm. An anti-GPC3 antibody comprising an untagged modified Fc region competes with the anti-GPC3 antibody having the native Fc region for the interaction with the Fcγ receptor. Decrease in fluorescence caused as a result of the competition can be quantified to thereby determine relative binding affinity. The antibody biotinylation using sulfo-NHS-biotin or the like is known in the art. The Fcγ receptor can be tagged with GST by an appropriately adopted method which involves, for example: fusing a polynucleotide encoding the Fcγ receptor in flame with a polynucleotide encoding GST; operably ligating the resulting fusion gene with a vector; and allowing cells or the like carrying the vector to express the GST-tagged Fcγ receptor, which is then purified using a glutathione column. The obtained signals are preferably analyzed using, for example, software GRAPHPAD PRISM (GraphPad Software, Inc., San Diego) adapted to a one-site competition model based on nonlinear regression analysis.

[0083]

One (ligand) of the substances between which the interaction is to be observed is immobilized on a thin gold film of a sensor chip. The sensor chip is irradiated with light from the back such that total reflection occurs at the interface between the thin gold film and glass. As a result, a site having a drop in

reflection intensity (SPR signal) is formed in a portion of reflected light. The other (analyte) of the substances between which the interaction is to be observed is flowed on the surface of the sensor chip and bound to the ligand so that the mass of the immobilized ligand molecule is increased to change the refractive index of the solvent on the sensor chip surface. This change in the refractive index shifts the position of the SPR signal (on the contrary, the dissociation of the bound molecules gets the signal back to the original position). The Biacore system plots on the ordinate the amount of the shift, i.e., change in mass on the sensor chip surface, and displays time-dependent change in mass as assay data (sensorgram). Kinetics: an association rate constant (ka) and a dissociation rate constant (kd) can be determined from the curve of the sensorgram, and affinity (KD) can be determined from the ratio between these constants. Inhibition assay is also preferably used in the BIACORE method. Examples of the inhibition assay are described in Lazor et al. (Proc. Natl. Acad. Sci. U.S.A. (2006) 103 (11), 4005-4010).

[0084]

Fcγ receptor (FcγR)-binding modified Fc region

In addition to the Fc regions contained in constant regions represented by SEQ ID NO: 74 for human IgG1, SEQ ID NO: 75 for IgG2, SEQ ID NO: 76 for IgG3, and SEQ ID NO: 77 for IgG4, an FcγR-binding modified Fc region

having higher binding activity against Fcγ receptors than that of the Fc region of native human IgG against Fcγ receptors may be appropriately used as the Fc region contained in the anti-GPC3 antibody of the present invention. The "Fc region of native human IgG" described herein means an Fc region having a fucose-containing sugar chain as a sugar chain bound to position 297 (EU numbering) of the Fc region contained in the human IgG1, IgG2, IgG3, or IgG4 constant region represented by SEQ ID NO: 74, 75, 76, or 77. Such an FcγR-binding modified Fc region can be prepared by the amino acid modification of the native human IgG Fc region. Whether or not the FcγR-binding modified Fc region has higher binding activity against FcγR than that of the native human IgG Fc region against FcγR can be appropriately confirmed by a method known in the art such as FACS or ELISA formats as well as BIACORE method using amplified luminescent proximity homogeneous assay (ALPHA) screening or surface plasmon resonance (SPR) phenomena as described above.

[0085]

In the present invention, the "modification of amino acid(s)" or "amino acid modification" of the Fc region includes modification to an amino acid sequence different from the amino acid sequence of the starting Fc region. Any Fc region can be used as the starting Fc region as long as the modified form of the starting Fc region can bind to the human Fcγ receptor in a neutral region of pH.

Alternatively, an Fc region further modified from an already modified Fc region as the starting Fc region may be preferably used as the Fc region of the present invention. The starting Fc region may mean the polypeptide itself, a composition containing the starting Fc region, or an amino acid sequence encoding the starting Fc region. The starting Fc region can include Fc regions known in the art produced by recombination reviewed in the paragraph about the antibody. The starting Fc region is not limited by its origin and can be obtained from an arbitrary nonhuman animal organism or a human. Preferred examples of the arbitrary organism include an organism selected from mice, rats, guinea pigs, hamsters, gerbils, cats, rabbits, dog, goats, sheep, cattle, horses, camels, and nonhuman primates. In another aspect, the starting Fc region may be obtained from a cynomolgus monkey, a marmoset, a rhesus monkey, a chimpanzee, or a human. Preferably, the starting Fc region can be obtained from human IgG1, though the starting Fc region of the present invention is not limited by a particular class of IgG. This means that the Fc region of human IgG1, IgG2, IgG3, or IgG4 can be appropriately used as the starting Fc region. Likewise, this means herein that the Fc region of arbitrary IgG class or subclass from the arbitrary organism can be preferably used as the starting Fc region. Examples of variants of naturally occurring IgG or manipulated forms

thereof are described in literatures known in the art (Curr. Opin. Biotechnol. (2009) 20 (6), 685-91; Curr. Opin. Immunol. (2008) 20 (4), 460-470; Protein Eng. Des. Sel. (2010) 23 (4), 195-202; and International Publication Nos. WO2009/086320, WO2008/092117, WO2007/041635, and WO2006/105338), though the variants or the manipulated forms of the present invention are not limited to those described therein.

[0086]

Examples of the modification include one or more variations, for example, a variation that substitutes amino acid(s) in the starting Fc region by amino acid residue(s) different therefrom, the insertion of one or more amino acid residues into the amino acid sequence of the starting Fc region, and/or the deletion of one or more amino acids from the amino acid sequence of the starting Fc region. Preferably, the amino acid sequence of the Fc region thus modified comprises an amino acid sequence containing at least a nonnatural portion of the Fc region. Such a variant inevitably has less than 100% sequence identity or similarity to the starting Fc region. In a preferred embodiment, the variant has an amino acid sequence with approximately 75% to less than 100% sequence identity or similarity, more preferably approximately 80% to less than 100%, further preferably approximately 85% to less than 100%, still further preferably approximately 90% to less than 100%, most

preferably approximately 95% to less than 100% sequence identity or similarity to the amino acid sequence of the starting Fc region. In a non-limiting aspect of the present invention, the starting Fc region and the FcγR-binding modified Fc region of the present invention differ by at least one amino acid. The difference in amino acid between the starting Fc region and the FcγR-binding modified Fc region of the present invention may be preferably determined by a difference in amino acid with the identified position of its amino acid residue defined particularly by the EU numbering.

[0087]

The amino acid(s) in the Fc region can be modified by an appropriately adopted method known in the art such as site-directed mutagenesis (Kunkel et al., Proc. Natl. Acad. Sci. USA (1985) 82, 488-492) or overlap extension PCR. Also, a plurality of methods known in the art can be adopted as methods for modifying an amino acid to substitute the amino acid by an amino acid other than natural one (Annu. Rev. Biophys. Biomol. Struct. (2006) 35, 225-249; and Proc. Natl. Acad. Sci. U.S.A. (2003) 100 (11), 6353-6357). For example, a tRNA-containing cell-free translation system (Clover Direct (Protein Express, an R & D oriented company)) comprising a non-natural amino acid bound with an amber suppressor tRNA complementary to UAG codon (amber codon), which is a stop codon, is also preferably used.

[0088]

The FcγR-binding modified Fc region (contained in the antigen-binding molecule of the present invention) having higher binding activity against Fcγ receptors than that of the native human IgG Fc region against Fcγ receptors can be obtained by any method. Specifically, the FcγR-binding modified Fc region can be obtained by the amino acid modification of a human IgG immunoglobulin Fc region used as the starting Fc region. Examples of the IgG immunoglobulin Fc region preferred for the modification include Fc regions contained in human IgG (IgG1, IgG2, IgG3, and IgG4, and modified forms thereof) constant regions represented by SEQ ID NOs: 74, 75, 76, and 77.

[0089]

The modification to other amino acids can include amino acid modification at any position as long as the resulting Fc region has higher binding activity against Fcγ receptors than that of the native human IgG Fc region against Fcγ receptors. When the antigen-binding molecule contains a human IgG1 Fc region as a human Fc region, the modification preferably allows the Fc region to contain a fucose-containing sugar chain as a sugar chain bound to position 297 (EU numbering) and is effective for producing higher binding activity against Fcγ receptors than that of the native human IgG Fc region against Fcγ receptors. Such amino acid modification has been

reported in, for example, International Publication Nos. WO2007/024249, WO2007/021841, WO2006/031370, WO2000/042072, WO2004/029207, WO2004/099249, WO2006/105338, WO2007/041635, WO2008/092117, WO2005/070963, WO2006/020114, WO2006/116260, and WO2006/023403.

[0090]

Examples of amino acids that may undergo such modification include at least one or more amino acids selected from the group consisting of position 221, position 222, position 223, position 224, position 225, position 227, position 228, position 230, position 231, position 232, position 233, position 234, position 235, position 236, position 237, position 238, position 239, position 240, position 241, position 243, position 244, position 245, position 246, position 247, position 249, position 250, position 251, position 254, position 255, position 256, position 258, position 260, position 262, position 263, position 264, position 265, position 266, position 267, position 268, position 269, position 270, position 271, position 272, position 273, position 274, position 275, position 276, position 278, position 279, position 280, position 281, position 282, position 283, position 284, position 285, position 286, position 288, position 290, position 291, position 292, position 293, position 294, position 295, position 296, position 297, position 298, position 299, position 300,

position 301, position 302, position 303, position 304, position 305, position 311, position 313, position 315, position 317, position 318, position 320, position 322, position 323, position 324, position 325, position 326, position 327, position 328, position 329, position 330, position 331, position 332, position 333, position 334, position 335, position 336, position 337, position 339, position 376, position 377, position 378, position 379, position 380, position 382, position 385, position 392, position 396, position 421, position 427, position 428, position 429, position 434, position 436 and position 440 based on the EU numbering. The modification of these amino acids can yield the Fc region (FcγR-binding modified Fc region) having higher binding activity against Fcγ receptors than that of the native human IgG Fc region against Fcγ receptors.

[0091]

Examples of particularly preferred modification for use in the present invention include at least one or more amino acid modifications selected from the group consisting of modifications of

amino acid 221 to Lys or Tyr,

amino acid 222 to Phe, Trp, Glu, or Tyr,

amino acid 223 to Phe, Trp, Glu, or Lys,

amino acid 224 to Phe, Trp, Glu, or Tyr,

amino acid 225 to Glu, Lys, or Trp,

amino acid 227 to Glu, Gly, Lys, or Tyr,

amino acid 228 to Glu, Gly, Lys, or Tyr,

amino acid 230 to Ala, Glu, Gly, or Tyr,

amino acid 231 to Glu, Gly, Lys, Pro, or Tyr,

amino acid 232 to Glu, Gly, Lys, or Tyr,

amino acid 233 to Ala, Asp, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,

amino acid 234 to Ala, Asp, Glu, Phe, Gly, His, Ile, Lys, Met, Asn, Pro, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,

amino acid 235 to Ala, Asp, Glu, Phe, Gly, His, Ile, Lys, Met, Asn, Pro, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,

amino acid 236 to Ala, Asp, Glu, Phe, His, Ile, Lys, Leu, Met, Asn, Pro, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,

amino acid 237 to Asp, Glu, Phe, His, Ile, Lys, Leu, Met, Asn, Pro, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,

amino acid 238 to Asp, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,

amino acid 239 to Asp, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Gln, Arg, Thr, Val, Trp, or Tyr,

amino acid 240 to Ala, Ile, Met, or Thr,

amino acid 241 to Asp, Glu, Leu, Arg, Trp, or Tyr,

amino acid 243 to Leu, Glu, Leu, Gln, Arg, Trp, or Tyr,

amino acid 244 to His,

amino acid 245 to Ala,

amino acid 246 to Asp, Glu, His, or Tyr,

amino acid 247 to Ala, Phe, Gly, His, Ile, Leu, Met, Thr, Val, or Tyr,

amino acid 249 to Glu, His, Gln, or Tyr,

amino acid 250 to Glu, or Gln,

amino acid 251 to Phe,

amino acid 254 to Phe, Met, or Tyr,

amino acid 255 to Glu, Leu, or Tyr,

amino acid 256 to Ala, Met, or Pro,

amino acid 258 to Asp, Glu, His, Ser, or Tyr,

amino acid 260 to Asp, Glu, His, or Tyr,

amino acid 262 to Ala, Glu, Phe, Ile, or Thr,

amino acid 263 to Ala, Ile, Met, or Thr,

amino acid 264 to Asp, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Gln, Arg, Ser, Thr, Trp, or Tyr,

amino acid 265 to Ala, Leu, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,

amino acid 266 to Ala, Ile, Met, or Thr,

amino acid 267 to Asp, Glu, Phe, His, Ile, Lys, Leu, Met, Asn, Pro, Gln, Arg, Thr, Val, Trp, or Tyr,

amino acid 268 to Asp, Glu, Phe, Gly, Ile, Lys, Leu, Met, Pro, Gln, Arg, Thr, Val, or Trp,

amino acid 269 to Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Arg, Ser, Thr, Val, Trp, or Tyr,

amino acid 270 to Glu, Phe, Gly, His, Ile, Leu, Met, Pro, Gln, Arg, Ser, Thr, Trp, or Tyr,

amino acid 271 to Ala, Asp, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,

amino acid 272 to Asp, Phe, Gly, His, Ile, Lys, Leu, Met, Pro, Arg, Ser, Thr, Val, Trp, or Tyr,

amino acid 273 to Phe, or Ile,

amino acid 274 to Asp, Glu, Phe, Gly, His, Ile, Leu, Met, Asn, Pro, Arg, Ser, Thr, Val, Trp, or Tyr,
amino acid 275 to Leu, or Trp,
amino acid 276 to Asp, Glu, Phe, Gly, His, Ile, Leu, Met, Pro, Arg, Ser, Thr, Val, Trp, or Tyr,
amino acid 278 to Asp, Glu, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Gln, Arg, Ser, Thr, Val, or Trp,
amino acid 279 to Ala,
amino acid 280 to Ala, Gly, His, Lys, Leu, Pro, Gln, Trp, or Tyr,
amino acid 281 to Asp, Lys, Pro, or Tyr,
amino acid 282 to Glu, Gly, Lys, Pro, or Tyr,
amino acid 283 to Ala, Gly, His, Ile, Lys, Leu, Met, Pro, Arg, or Tyr,
amino acid 284 to Asp, Glu, Leu, Asn, Thr, or Tyr,
amino acid 285 to Asp, Glu, Lys, Gln, Trp, or Tyr,
amino acid 286 to Glu, Gly, Pro, or Tyr,
amino acid 288 to Asn, Asp, Glu, or Tyr,
amino acid 290 to Asp, Gly, His, Leu, Asn, Ser, Thr, Trp, or Tyr,
amino acid 291 to Asp, Glu, Gly, His, Ile, Gln, or Thr,
amino acid 292 to Ala, Asp, Glu, Pro, Thr, or Tyr,
amino acid 293 to Phe, Gly, His, Ile, Leu, Met, Asn, Pro, Arg, Ser, Thr, Val, Trp, or Tyr,
amino acid 294 to Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Arg, Ser, Thr, Val, Trp, or Tyr,
amino acid 295 to Asp, Glu, Phe, Gly, His, Ile, Lys, Met,

Asn, Pro, Arg, Ser, Thr, Val, Trp, or Tyr,
amino acid 296 to Ala, Asp, Glu, Gly, His, Ile, Lys, Leu, Met, Asn, Gln, Arg, Ser, Thr, or Val,
amino acid 297 to Asp, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Pro, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,
amino acid 298 to Ala, Asp, Glu, Phe, His, Ile, Lys, Met, Asn, Gln, Arg, Thr, Val, Trp, or Tyr,
amino acid 299 to Ala, Asp, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Gln, Arg, Ser, Val, Trp, or Tyr,
amino acid 300 to Ala, Asp, Glu, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Gln, Arg, Ser, Thr, Val, or Trp,
amino acid 301 to Asp, Glu, His, or Tyr,
amino acid 302 to Ile,
amino acid 303 to Asp, Gly, or Tyr,
amino acid 304 to Asp, His, Leu, Asn, or Thr,
amino acid 305 to Glu, Ile, Thr, or Tyr,
amino acid 311 to Ala, Asp, Asn, Thr, Val, or Tyr,
amino acid 313 to Phe,
amino acid 315 to Leu,
amino acid 317 to Glu or Gln,
amino acid 318 to His, Leu, Asn, Pro, Gln, Arg, Thr, Val, or Tyr,
amino acid 320 to Asp, Phe, Gly, His, Ile, Leu, Asn, Pro, Ser, Thr, Val, Trp, or Tyr,
amino acid 322 to Ala, Asp, Phe, Gly, His, Ile, Pro, Ser, Thr, Val, Trp, or Tyr,
amino acid 323 to Ile,

amino acid 324 to Asp, Phe, Gly, His, Ile, Leu, Met, Pro, Arg, Thr, Val, Trp, or Tyr,
amino acid 325 to Ala, Asp, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Pro, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,
amino acid 326 to Ala, Asp, Glu, Gly, Ile, Leu, Met, Asn, Pro, Gln, Ser, Thr, Val, Trp, or Tyr,
amino acid 327 to Ala, Asp, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Arg, Thr, Val, Trp, or Tyr,
amino acid 328 to Ala, Asp, Glu, Phe, Gly, His, Ile, Lys, Met, Asn, Pro, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,
amino acid 329 to Asp, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,
amino acid 330 to Cys, Glu, Phe, Gly, His, Ile, Lys, Leu, Met, Asn, Pro, Arg, Ser, Thr, Val, Trp, or Tyr,
amino acid 331 to Asp, Phe, His, Ile, Leu, Met, Gln, Arg, Thr, Val, Trp, or Tyr,
amino acid 332 to Ala, Asp, Glu, Phe, Gly, His, Lys, Leu, Met, Asn, Pro, Gln, Arg, Ser, Thr, Val, Trp, or Tyr,
amino acid 333 to Ala, Asp, Glu, Phe, Gly, His, Ile, Leu, Met, Pro, Ser, Thr, Val, or Tyr,
amino acid 334 to Ala, Glu, Phe, Ile, Leu, Pro, or Thr,
amino acid 335 to Asp, Phe, Gly, His, Ile, Leu, Met, Asn, Pro, Arg, Ser, Val, Trp, or Tyr,
amino acid 336 to Glu, Lys, or Tyr,
amino acid 337 to Glu, His, or Asn,
amino acid 339 to Asp, Phe, Gly, Ile, Lys, Met, Asn, Gln, Arg, Ser, or Thr,

amino acid 376 to Ala, or Val,
amino acid 377 to Gly, or Lys,
amino acid 378 to Asp,
amino acid 379 to Asn,
amino acid 380 to Ala, Asn, or Ser,
amino acid 382 to Ala, or Ile,
amino acid 385 to Glu,
amino acid 392 to Thr,
amino acid 396 to Leu,
amino acid 421 to Lys,
amino acid 427 to Asn,
amino acid 428 to Phe, or Leu,
amino acid 429 to Met,
amino acid 434 to Trp,
amino acid 436 to Ile, or
amino acid 440 to Gly, His, Ile, Leu, or Tyr

based on the EU numbering in the Fc region. The number of amino acids to be modified is not limited. Only one amino acid may be modified, or two or more amino acids may be modified. Examples of combinations of amino acid modifications at two or more positions include combinations as described in Table 3 (Tables 3-1 to 3-3). Also, WO2007/047291 discloses specific examples of the anti-GPC3 antibody comprising the FcγR-binding modified Fc region having higher binding activity against Fcγ receptors than that of the native human IgG Fc region against Fcγ receptors.

[0092]

[Table 3-1]

Combination of amino acids	Combination of amino acids
K370E/P396L/D270E	S239Q/I332Q
Q419H/P396L/D270E	S267D/I332E
V240A/P396L/D270E	S267E/I332E
R255L/P396L/D270E	S267L/A327S
R255L/P396L/D270E	S267Q/A327S
R255L/P396L/D270E/R292G	S298A/I332E
R255L/P396L/D270E	S304T/I332E
R255L/P396L/D270E/Y300L	S324G/I332D
F243L/D270E/K392N/P396L	S324G/I332E
F243L/R255L/D270E/P396L	S324I/I332D
F243L/R292P/Y300L/V305I/P396L	S324I/I332E
F243L/R292P/Y300L/P396L	T260H/I332E
F243L/R292P/Y300L	T335D/I332E
F243L/R292P/P396L	V240I/V266I
F243L/R292P/V305I	V264I/I332E
F243L/R292P	D265F/N297E/I332E
S298A/E333A/K334A	D265Y/N297D/I332E
E380A/T307A	F243L/V262I/V264W
K326M/E333S	N297D/A330Y/I332E
K326A/E333A	N297D/T299E/I332E
S317A/K353A	N297D/T299F/I332E
A327D/I332E	N297D/T299H/I332E
A330L/I332E	N297D/T299I/I332E
A330Y/I332E	N297D/T299L/I332E
E258H/I332E	N297D/T299V/I332E
E272H/I332E	P230A/E233D/I332E
E272I/N276D	P244H/P245A/P247V
E272R/I332E	S239D/A330L/I332E
E283H/I332E	S239D/A330Y/I332E
E293R/I332E	S239D/H268E/A330Y
F241L/V262I	S239D/I332E/A327A
F241W/F243W	S239D/I332E/A330I

[0093]

[Table 3-2]

F243L/V264I	S239D/N297D/I332E
H268D/A330Y	S239D/S298A/I332E
H268E/A330Y	S239D/V264I/I332E
K246H/I332E	S239E/N297D/I332E
L234D/I332E	S239E/V264I/I332E
L234E/I332E	S239N/A330L/I332E
L234G/I332E	S239N/A330Y/I332E
L234I/I332E	S239N/S298A/I332E
L234I/L235D	S239Q/V264I/I332E
L234Y/I332E	V264E/N297D/I332E
L235D/I332E	V264I/A330L/I332E
L235E/I332E	V264I/A330Y/I332E
L235I/I332E	V264I/S298A/I332E
L235S/I332E	Y296D/N297D/I332E
L328A/I332D	Y296E/N297D/I332E
L328D/I332D	Y296H/N297D/I332E
L328D/I332E	Y296N/N297D/I332E
L328E/I332D	Y296Q/N297D/I332E
L328E/I332E	Y296T/N297D/I332E
L328F/I332D	D265Y/N297D/T299L/I332E
L328F/I332E	F241E/F243Q/V262T/V264E
L328H/I332E	F241E/F243R/V262E/V264R
L328I/I332D	F241E/F243Y/V262T/V264R
L328I/I332E	F241L/F243L/V262I/V264I
L328M/I332D	F241R/F243Q/V262T/V264R
L328M/I332E	F241S/F243H/V262T/V264T
L328N/I332D	F241W/F243W/V262A/V264A
L328N/I332E	F241Y/F243Y/V262T/V264T
L328Q/I332D	I332E/A330Y/H268E/A327A
L328Q/I332E	N297D/I332E/S239D/A330L
L328T/I332D	N297D/S298A/A330Y/I332E
L328T/I332E	S239D/A330Y/I332E/K326E
L328V/I332D	S239D/A330Y/I332E/K326T
L328V/I332E	S239D/A330Y/I332E/L234I
L328Y/I332D	S239D/A330Y/I332E/L235D

[0094]

[Table 3-3]

L328Y/I332E	S239D/A330Y/I332E/V240I
N297D/I332E	S239D/A330Y/I332E/V264T
N297E/I332E	S239D/A330Y/I332E/V266I
N297S/I332E	S239D/D265F/N297D/I332E
P227G/I332E	S239D/D265H/N297D/I332E
P230A/E233D	S239D/D265I/N297D/I332E
Q295E/I332E	S239D/D265L/N297D/I332E
R255Y/I332E	S239D/D265T/N297D/I332E
S239D/I332D	S239D/D265V/N297D/I332E
S239D/I332E	S239D/D265Y/N297D/I332E
S239D/I332N	S239D/I332E/A330Y/A327A
S239D/I332Q	S239D/I332E/H268E/A327A
S239E/D265G	S239D/I332E/H268E/A330Y
S239E/D265N	S239D/N297D/I332E/A330Y
S239E/D265Q	S239D/N297D/I332E/K326E
S239E/I332D	S239D/N297D/I332E/L235D
S239E/I332E	S239D/V264I/A330L/I332E
S239E/I332N	S239D/V264I/S298A/I332E
S239E/I332Q	S239E/V264I/A330Y/I332E
S239N/I332D	F241E/F243Q/V262T/V264E/I332E
S239N/I332E	F241E/F243R/V262E/V264R/I332E
S239N/I332N	F241E/F243Y/V262T/V264R/I332E
S239N/I332Q	F241R/F243Q/V262T/V264R/I332E
S239Q/I332D	S239D/I332E/H268E/A330Y/A327A
S239Q/I332E	S239E/V264I/S298A/A330Y/I332E
S239Q/I332N	F241Y/F243Y/V262T/V264T/N297D/I332E
S267E/L328F	G236D/S267E
S239D/S267E	

[0095]

The Fcγ receptor-binding domain contained in the anti-GPC3 antibody of the present invention can be

assayed for its binding activity against the Fcγ receptor appropriately using pH conditions selected from acidic to neutral regions of pH. The acidic to neutral regions of pH as the conditions under which the Fcγ receptor-binding domain contained in the antigen-binding molecule of the present invention is assayed for its binding activity against the Fcγ receptor usually mean pH 5.8 to pH 8.0. The pH range is preferably indicated by arbitrary pH values from pH 6.0 to pH 7.4 and is preferably selected from pH 6.0, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 7.0, 7.1, 7.2, 7.3, and 7.4. Particularly, a pH range of 6.15 to 7.4, which is close to the pH of cancer tissues, is preferred (Vaupel et al., Cancer Res. (1989) 49, 6449-6665). The binding affinity of the Fc region for the human Fcγ receptor can be evaluated under assay conditions involving an arbitrary temperature of 10°C to 50°C. Preferably, a temperature of 15°C to 40°C is used for determining the binding affinity of the Fc region for the human Fcγ receptor. More preferably, an arbitrary temperature of 20°C to 35°C, for example, any one temperature of 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, and 35°C, is also used for determining the binding affinity of the Fc region for the Fcγ receptor. The temperature 25°C is one non-limiting example in an aspect of the present invention.

[0096]

The phrase "FcγR-binding modified Fc region having higher binding activity against Fcγ receptors than that of the native Fc region against Fcγ receptors" described herein means that the FcγR-binding modified Fc region has higher binding activity against any of the human Fcγ receptors FcγRI, FcγRIIa, FcγRIIb, FcγRIIIa, and /or FcγRIIIb than that of the native Fc region against the human Fcγ receptor. The phrase means that, for example, on the basis of the analysis method described above, the anti-GPC3 antibody comprising the FcγR-binding modified Fc region exhibits 105% or more, preferably 110% or more, 115% or more, 120% or more, or 125% or more, particularly preferably 130% or more, 135% or more, 140% or more, 145% or more, 150% or more, 155% or more, 160% or more, 165% or more, 170% or more, 175% or more, 180% or more, 185% or more, 190% or more, 195% or more, 2 times or more, 2.5 times or more, 3 times or more, 3.5 times or more, 4 times or more, 4.5 times or more, 5 times or more, 7.5 times or more, 10 times or more, 20 times or more, 30 times or more, 40 times or more, 50 times or more, 60 times or more, 70 times or more, 80 times or more, 90 times or more, 100 times or more binding activity compared with the binding activity of an anti-GPC3 antibody comprising the native Fc region of human IgG serving as a control. The native Fc region used may be the starting Fc region or may be the native Fc region of

an antibody of the same subclass as the anti-GPC antibody concerned.

[0097]

In the present invention, a native human IgG Fc region having a fucose-containing sugar chain as a sugar chain bound to amino acid 297 (EU numbering) is preferably used as the native Fc region of human IgG serving as a control. Whether or not the sugar chain bound to amino acid 297 (EU numbering) is a fucose-containing sugar chain can be confirmed using an approach known in the art. Whether or not the sugar chain bound to the native human IgG Fc region is a fucose-containing sugar chain can be determined by, for example, a method as shown below. The native human IgG to be tested liberates a sugar chain through reaction with N-Glycosidase F (Roche Diagnostics K.K.) (Weitzhandler et al., J. Pharma. Sciences (1994) 83, 12, 1670-1675). Next, proteins are removed through reaction with ethanol, and the resulting reaction solution (Schenk et al., J. Clin. Investigation (2001) 108 (11) 1687-1695) is evaporated to dryness and then fluorescently labeled with 2-aminobenzamide (Bigge et al., Anal. Biochem. (1995) 230 (2) 229-238). After removal of the reagent by solid-phase extraction using a cellulose cartridge, the 2-AB-fluorescently labeled sugar chain is analyzed by normal-phase chromatography. The detected peak in the chromatogram can be observed to thereby determine whether

or not the sugar chain bound to the native Fc region of human IgG is a fucose-containing sugar chain.

[0098]

An anti-GPC3 antibody having an IgG monoclonal antibody Fc region can be appropriately used as the anti-GPC3 antibody comprising the native Fc region of an antibody of the same subclass serving as a control. Structural examples of the Fc region include Fc regions contained in constant regions represented by SEQ ID NOs: 74 (having A added to the N terminus of the sequence of database registration No. AAC82527.1), 75 (having A added to the N terminus of the sequence of database registration No. AAB59393.1), 76 (database registration No. CAA27268.1), and 77 (having A added to the N terminus of the sequence of database registration No. AAB59394.1). In the case of using a certain isotype of anti-GPC3 antibody as a test substance, the anti-GPC3 antibody comprising the Fc region to be tested is studied for its effect of binding activity against Fcγ receptors by use of an anti-GPC3 antibody of the certain isotype as a control. The anti-GPC3 antibody comprising the Fc region thus confirmed to have higher binding activity against Fcγ receptors is appropriately selected.

[0099]

Fc region having higher binding activity against active Fcγ receptor than its binding activity against inhibitory Fcγ receptor

As described above, preferred examples of the active Fcγ receptors include FcγRI (CD64) including FcγRIa, FcγRIb, and FcγRIc, FcγRIIa, and FcγRIII (CD16) including isoforms FcγRIIIa (including allotypes V158 and F158) and FcγRIIIb (including allotypes FcγRIIIb-NA1 and FcγRIIIb-NA2). Preferred examples of the inhibitory Fcγ receptors include FcγRIIb (including FcγRIIb-1 and FcγRIIb-2).

[0100]

In a non-limiting aspect, alternative examples of the anti-GPC3 antibody of the present invention include an anti-GPC3 antibody comprising an Fc region having higher binding activity against active Fcγ receptors than its binding activity against inhibitory Fcγ receptors. In this case, the phrase "having higher binding activity against active Fcγ receptors than its binding activity against inhibitory Fcγ receptors" means that the Fc region has higher binding activity against any of the human Fcγ receptors FcγRIa, FcγRIIa, FcγRIIIa, and/or FcγRIIIb than its binding activity against FcγRIIb. The phrase means that, for example, on the basis of the analysis method described above, the antigen-binding molecule comprising the Fc region exhibits 105% or more, preferably 110% or more, 120% or more, 130% or more, or 140% or more, particularly preferably 150% or more, 160% or more, 170% or more, 180% or more, 190% or more, 200% or more, 250% or more, 300% or more, 350% or more, 400% or more, 450% or more, 500% or more, 750% or more, 10

times or more, 20 times or more, 30 times or more, 40 times or more, 50 times, 60 times, 70 times, 80 times, 90 times, or 100 times or more binding activity against any of the human Fcγ receptors FcγRIa, FcγRIIa, FcγRIIIa, and/or FcγRIIIb compared with its binding activity against FcγRIIb. The IgG antibody comprising such an Fc region is known to have enhancement in the ADCC activity. Thus, the anti-GPC3 antibody comprising the Fc region is useful as the GPC3-targeting drug of the present invention.

[0101]

In a non-limiting aspect of the present invention, examples of the Fc region having higher binding activity against active Fcγ receptors than its binding activity against inhibitory Fcγ receptors (having selective binding activity against active Fcγ receptors) preferably include Fc regions in which at least one or more amino acids selected from the group consisting of position 221, position 222, position 223, position 224, position 225, position 227, position 228, position 230, position 231, position 232, position 233, position 234, position 235, position 236, position 237, position 238, position 239, position 240, position 241, position 243, position 244, position 245, position 246, position 247, position 249, position 250, position 251, position 254, position 255, position 256, position 258, position 260, position 262, position 263, position 264, position 265, position 266,

position 267, position 268, position 269, position 270, position 271, position 272, position 273, position 274, position 275, position 276, position 278, position 279, position 280, position 281, position 282, position 283, position 284, position 285, position 286, position 288, position 290, position 291, position 292, position 293, position 294, position 295, position 296, position 297, position 298, position 299, position 300, position 301, position 302, position 303, position 304, position 305, position 311, position 313, position 315, position 317, position 318, position 320, position 322, position 323, position 324, position 325, position 326, position 327, position 328, position 329, position 330, position 331, position 332, position 333, position 334, position 335, position 336, position 337, position 339, position 376, position 377, position 378, position 379, position 380, position 382, position 385, position 392, position 396, position 421, position 427, position 428, position 429, position 434, position 436 and position 440
(EU numbering)
are modified to amino acids different from those in the native Fc region.

[0102]

In a non-limiting aspect of the present invention, further examples of the Fc region having higher binding activity against active Fcγ receptors than its binding activity against inhibitory Fcγ receptors (having

selective binding activity against active Fcγ receptors) preferably include Fc regions in which a plurality of amino acids described in Tables 3-1 to 3-3 are modified to amino acids different from those in the native Fc region.

[0103]

Fc region having modified sugar chain

The Fc region contained in the anti-GPC3 antibody provided by the present invention can also include an Fc region modified such that a higher proportion of fucose-deficient sugar chains is bound to the Fc region or a higher proportion of bisecting N-acetylglucosamine is added to the Fc region in the composition of sugar chains bound to the Fc region. The removal of a fucose residue from N-acetylglucosamine at the reducing end of a N-glycoside-linked complex sugar chain bound to an antibody Fc region is known to enhance its affinity for FcγRIIIa (Sato et al., Expert Opin. Biol. Ther. (2006) 6 (11), 1161-1173). An IgG1 antibody comprising such an Fc region is known to have enhancement in the ADCC activity. Thus, the antigen-binding molecule comprising the Fc region is also useful as the antigen-binding molecule contained in the pharmaceutical composition of the present invention. Examples of an antibody that lacks a fucose residue in N-acetylglucosamine at the reducing end of a N-glycoside-linked complex sugar chain bound to the antibody Fc region include the following antibodies:

glycosylated antibodies (e.g., International Publication No. WO1999/054342); and
antibodies deficient in fucose added to the sugar chain (e.g., International Publication Nos. WO2000/061739, WO2002/031140, and WO2006/067913).
Also, WO2006/046751 and WO2009/ 041062 disclose specific examples of the anti-GPC3 antibody comprising the Fc region modified such that a higher proportion of fucose-deficient sugar chains is bound to the Fc region or a higher proportion of bisecting N-acetylglucosamine is added to the Fc region in the composition of sugar chains bound to the Fc region.

[0104]

More specifically, in an alternative non-limiting aspect of the antibody that lacks a fucose residue in N-acetylglucosamine at the reducing end of a N-glycoside-linked complex sugar chain bound to the antibody Fc region, the antibody deficient in fucose added to the sugar chain (e.g., International Publication Nos. WO2000/061739, WO2002/031140, and WO2006/067913) may be prepared. For this purpose, host cells less able to add fucose to sugar chains are prepared as a result of altering the activity of forming the sugar chain structures of polypeptides that undergo sugar chain modification. The host cells are allowed to express the desired antibody gene, and the antibody deficient in fucose in its sugar chain can be recovered from the

culture solution of the host cells. Non-limiting preferred examples of the activity of forming the sugar chain structures of polypeptides can include the activity of an enzyme or a transporter selected from the group consisting of fucosyltransferase (EC 2.4.1.152), fucose transporter (SLC35C1), GDP-mannose 4,6-dehydratase (GMD) (EC 4.2.1.47), GDP-keto-6-deoxymannose 3,5-epimerase/4-reductase (Fx) (EC 1.1.1.271), and GDP-β-L-fucose pyrophosphorylase (GFPP) (EC 2.7.7.30). These enzymes or transporters are not necessarily limited by their structures as long as the enzymes or the transporters can exert their activity. These proteins capable of exerting such activity are referred to as functional proteins herein. In a non-limiting aspect, examples of methods for altering the activity include the deletion of the activity. Host cells that lack the activity can be prepared by an appropriately adopted method known in the art such as a method which involves disrupting the genes of these functional proteins to render the genes unfunctional (e.g., International Publication Nos. WO2000/061739, WO2002/031140, and WO2006/067913). Such host cells that lack the activity may be prepared by, for example, a method which involves disrupting the endogenous genes of these functional proteins in cells such as CHO cells, BHK cells, NS0 cells, SP2/0 cells, YO myeloma cells, P3X63 mouse myeloma cells, PER cells,

PER.C6 cells, HEK293 cells, or hybridoma cells to render the genes unfunctional.

[0105]

Antibodies containing sugar chains having bisecting GlcNAc (e.g., International Publication No. WO2002/079255) are known in the art. In a non-limiting aspect, host cells expressing genes encoding functional proteins having β-1,4-mannosyl-glycoprotein 4-β-N-acetylglucosaminyltransferase (GnTIII) (EC 2.4.1.144) activity or β-1,4-galactosyltransferase (GalT) (EC 2.4.1.38) activity are prepared in order to prepare such an antibody containing sugar chains having bisecting GlcNAc. In another non-limiting preferred aspect, host cells coexpressing a gene encoding a functional protein having human mannosidase II (ManII) (3.2.1.114) activity, a gene encoding a functional protein having β-1,2-acetylglucosaminyltransferase I (GnTI) (EC 2.4.1.94) activity, a gene encoding a functional protein having β-1,2-acetylglucosaminyltransferase II (GnTII) (EC 2.4.1.143) activity, a gene encoding a functional protein having mannosidase I (ManI) (EC 3.2.1.113) activity, and an α-1,6-fucosyltransferase (EC 2.4.1.68) gene, in addition to the functional proteins described above, are prepared (International Publication Nos. WO2004/065540).

[0106]

The host cells less able to add fucose to sugar chains and the host cells having the activity of forming

sugar chains having bisecting GlcNAc structures as described above can be transformed with antibody gene-containing expression vectors to respectively prepare the antibody that lacks a fucose residue in N-acetylglucosamine at the reducing end of a N-glycoside-linked complex sugar chain bound to the antibody Fc region and the antibody containing sugar chains having bisecting GlcNAc. The methods for producing these antibodies are also applicable to a method for producing the antigen-binding molecule comprising the Fc region modified such that a higher proportion of fucose-deficient sugar chains is bound to the Fc region or a higher proportion of bisecting N-acetylglucosamine is added to the Fc region in the composition of sugar chains bound to the Fc region of the present invention. The composition of sugar chains bound to the Fc region contained in the antigen-binding molecule of the present invention prepared by such a production method can be confirmed by the method described in the paragraph "Fcγ receptor (FcγR)-binding modified Fc region".

[0107]

Anti-GPC3 antibody having altered isoelectric point

In a non-limiting aspect, further examples of the anti-GPC3 antibody that may be used in the present invention include an anti-GPC3 antibody having an amino acid residue modified to alter its isoelectric point (pI). Preferred examples of the "alteration of the electric

charge of an amino acid residue" in the anti-GPC3 antibody provided by the present invention are as follows: alteration to increase the pI value can be performed by, for example, at least one substitution selected from the substitution of Q by K at position 43, the substitution of D by N at position 52, and the substitution of Q by R at position 105 based on the Kabat numbering in the anti-GPC3 antibody heavy chain variable region represented by SEQ ID NO: 50, which is consequently modified to, for example, the amino acid sequence represented by SEQ ID NO: 67. Also, this alteration can be performed by, for example, at least one substitution selected from the substitution of E by Q at position 17, the substitution of Q by R at position 27, and the substitution of Q by R at position 105 based on the Kabat numbering in the anti-GPC3 antibody light chain variable region represented by SEQ ID NO: 51 or 66, which is consequently modified to, for example, the amino acid sequence represented by SEQ ID NO: 68. On the other hand, alteration to decrease the pI value can be performed by at least one substitution selected from the substitution of K by T at position 19, the substitution of Q by E at position 43, the substitution of G by E at position 61, the substitution of K by S at position 62, the substitution of K by Q at position 64, and the substitution of G by D at position 65 based on the Kabat numbering in the anti-GPC3 antibody heavy chain variable

region represented by SEQ ID NO: 50, which is consequently modified to, for example, the amino acid sequence represented by SEQ ID NO: 69 or 71. Also, this alteration can be performed by, for example, at least one substitution selected from the substitution of R by Q at position 24, the substitution of Q by E at position 27, the substitution of K by T at position 74, the substitution of R by S at position 77, and the substitution of K by E at position 107 based on the Kabat numbering in the anti-GPC3 antibody light chain variable region represented by SEQ ID NO: 51 or 66, which is consequently modified to, for example, the amino acid sequence represented by SEQ ID NO: 70, 72, or 73. Further examples of the alteration to decrease the pI value include the substitution of at least one amino acid selected from amino acids 268, 274, 355, 356, 358, and 419 based on the EU numbering in the heavy chain constant region represented by SEQ ID NO: 74. Preferred examples of these substitutions can include at least one substitution selected from the substitution of H by Q at position 268, the substitution of K by Q at position 274, the substitution of R by Q at position 355, the substitution of D by E at position 356, the substitution of L by M at position 358, and the substitution of Q by E at position 419 based on the EU numbering in the heavy chain constant region represented by SEQ ID NO: 31. As a result of these substitutions, a chimera having human

antibody IgG1 and IgG4 constant regions is constructed. Specifically, these substitutions can yield an antibody having the desired pI without influencing the immunogenicity of the modified antibody.

[0108]

Modification to reduce heterogeneity

An IgG constant region deficient in Gly at position 446 and Lys at position 447 based on the EU numbering in the IgG constant region represented by SEQ ID NO: 74, 75, 76, or 77 may also be used as the constant region contained in the anti-GPC3 antibody of the present invention. Deficiency in both of these amino acids can reduce heterogeneity derived from the end of the heavy chain constant region of the antibody.

[0109]

Antibody modification

The posttranslational modification of a polypeptide refers to chemical modification given to the polypeptide translated during polypeptide biosynthesis. Since the primary structure of an antibody is composed of a polypeptide, the anti-GPC3 antibody of the present invention also includes a modified form that has received the posttranslational modification of the polypeptide constituting the primary structure of the anti-GPC3 antibody. The posttranslational modification of a polypeptide can be broadly classified into the addition of a functional group, the addition of a polypeptide or a

peptide (ISGylation, SUMOylation, or ubiquitination), the conversion of the chemical properties of an amino acid (silylation, deamination, or deamidation), and structural conversion (disulfidation or protease degradation). In a non-limiting aspect, examples of the posttranslational modification according to the present invention include the addition of a peptide or a functional group to an amino acid residue as a unit constituting the polypeptide. Examples of such modification can specifically include phosphorylation (serine, threonine, tyrosine, aspartic acid, etc.), glucosylation (serine, threonine, aspartic acid, etc.), acylation (lysine), acetylation (lysine), hydroxylation (lysine and proline), prenylation (cysteine), palmitoylation (cysteine), alkylation (lysine and arginine), polyglutamylation (glutamic acid), carboxylation (glutamic acid), polyglycylation (glutamic acid), citrullination (arginine), and succinimide formation (aspartic acid). For example, an anti-GPC3 antibody that has received the modification of N-terminal glutamine to pyroglutamic acid by pyroglutamylation is also included in the anti-GPC3 antibody of the present invention, as a matter of course. Also, for example, a posttranslationally modified anti-GPC3 antibody comprising heavy and light chains or heavy chains linked via a "disulfide bond", which means a covalent bond formed between two sulfur atoms is included in the anti-GPC3 antibody of the present invention. A thiol group

contained in an amino acid cysteine can form a disulfide bond or crosslink with a second thiol group. In general IgG molecules, CH1 and CL regions are linked via a disulfide bond, and two polypeptides constituting heavy chains are linked via a disulfide bond between cysteine residues at positions 226 and 229 based on the EU numbering. A posttranslationally modified anti-GPC3 antibody having such a linkage via a disulfide bond is also included in the anti-GPC3 antibody of the present invention.

[0110]

GPC3-targeting drug therapy

The term "GPC3-targeting drug therapy" refers to the administration of a GPC3-targeting drug to a patient.

[0111]

The phrase "efficacy of GPC3-targeting drug therapy for cancer" or "GPC3-targeting drug therapy has efficacy for cancer" means that the GPC3-targeting drug therapy produces desired or beneficial effects on a patient diagnosed with cancer. The desired or beneficial effects can include: (1) the inhibition of the further growth or diffusion of cancer cells; (2) the killing of cancer cells; (3) the inhibition of cancer recurrence; (4) the alleviation, reduction, mitigation, or inhibition of cancer-related symptoms (pain, etc.) or reduction in the frequency of the symptoms; and (5) improvement in the survival rate of the patient. The inhibition of cancer

recurrence includes the inhibition of the growth of cancer already treated by radiation, chemotherapy, surgical operation, or other techniques, at the primary site of the cancer and its neighboring tissues, and the absence of the growth of cancer at a new distal site. The desired or beneficial effects may be subjectively perceived by the patient or may be objectively found. In the case of, for example, a human patient, the human is able to recognize improvement in energy or vitality or reduction in pain as improvement or a therapy-responsive sign perceived by the patient. Alternatively, a clinician is able to notice decrease in tumor size or the amount of tumor tissues on the basis of findings gained by physical examination, experimental parameters, tumor markers, or X-ray photography. Some experimental signs that can be observed by the clinician in response to treatment include normalized test results of, for example, leukocyte counts, erythrocyte counts, platelet counts, erythrocyte sedimentation rates, and levels of various enzymes. The clinician is further able to observe decrease in detectable tumor marker level. Alternatively, other tests, such as sonography, nuclear magnetic resonance test, and positron emission test, may be used for evaluating objective improvement.

[0112]

Any cancer having high expression of targeted GPC3 corresponds to the cancer to be treated by the GPC3-

targeting drug therapy of the present invention. One example of such cancer include cancer selected from breast cancer, uterine cervix cancer, colon cancer, uterine body cancer, head and neck cancer, liver cancer, lung cancer, malignant carcinoid, malignant glioma, malignant lymphoma, malignant melanoma, ovary cancer, pancreatic cancer, prostatic cancer, renal cancer, skin cancer, gastric cancer, testicle cancer, thyroid cancer, urothelial cancer, and the like.

[0113]

Method for determining efficacy of GPC3-targeting drug therapy or method for determining continuation of GPC3-targeting drug therapy

In a non-limiting aspect, the present invention provides a method comprising measuring the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from a patient before the start of GPC3-targeting drug therapy and/or a patient treated with the GPC3-targeting drug therapy, wherein when the number of an immunocyte and/or the expression level is a predetermined value, the efficacy of the GPC3-targeting drug therapy is determined or the continuation of the GPC3-targeting drug therapy is determined. The "patient before the start of GPC3-targeting drug therapy" refers to a patient diagnosed with cancer, having no history of administration of the GPC3-targeting drug. The patient

may be a patient for which the efficacy of the GPC3-targeting drug therapy has been determined from the expression level of GPC3 in the tissues. Further, the "patient treated with GPC3-targeting drug therapy" refers to a patient having a history of administration of the GPC3-targeting drug. The administration route of the GPC3-targeting drug can be appropriately selected from administration routes suitable for the properties, etc., of the GPC3-targeting drug to be administered. Examples of the administration route include parenteral administration. Further examples of the parenteral administration include injection, transnasal administration, transpulmonary administration, and percutaneous administration. Further examples of the injection include systemic or local administration based on intravenous injection, intramuscular injection, intraperitoneal injection, and subcutaneous injection.

[0114]

In a non-limiting aspect, the method of the present invention comprises measuring the number of an immunocyte in a biological sample isolated from the patient, wherein when the number of an immunocyte is a predetermined value, the efficacy of the GPC3-targeting drug therapy for cancer in the patient is predicted, expected, or determined or the continuation of the therapy is determined. Examples of the immunocyte for the measurement in the present invention include, but not

limited to, leukocytes, monocytes, neutrophils, and lymphocytes. Examples of the lymphocytes include CD19+ B cells, CD45+ lymphocytes, CD3+ T cells, CD4+ T cells, CD8+ T cells, CD4+/CD8+ T cells, CD16+ NK cells, NKp46+ NK cells, strongly CD56-positive NK cells, CD56-/CD16+ NK cells, weakly or moderately CD56-positive and CD16-negative NK cells, and weakly or moderately CD56-positive and strongly CD16-positive NK cells. The number of any one type of these cells may be measured and used as an index for predicting, expecting, or determining the efficacy of the GPC3-targeting drug therapy for cancer. Alternatively, the numbers of two or more types of these cells in combination may be used as an index.

[0115]

The predetermined value can be regarded as a predetermined value at which the effect of the GPC3-targeting drug therapy can be expected, for example, provided that this value falls within a range higher than the average number of an immunocyte in a patient group for which the effect of the GPC3-targeting drug therapy on cancer cannot be confirmed among a plurality of cancer patients treated with the GPC3-targeting drug therapy. For example, the predetermined value can also be determined on the basis of the average number of an immunocyte in a patient group showing a tendency toward significantly prolonged PFS or significantly prolonged OS among a plurality of cancer patients treated with the

GPC3-targeting drug therapy. For example, a predetermined value for selecting with a high probability a patient showing a tendency toward significantly prolonged PFS or significantly prolonged OS as a result of GPC3-targeting drug therapy can be determined by measuring the numbers of immunocytes in a plurality of cancer patients and setting the predetermined value to a value higher than the median value thereof. In this context, a plurality of cancer patients may be any number of cancer patients as long as the predetermined value for the number of an immunocyte serving as a criterion for determining the efficacy of GPC3-targeting drug therapy or the continuation of the therapy can be calculated as a significant value. The number of cancer patients is preferably 100 or more, more preferably 150 or more. Specifically, the predetermined value can be determined from a value higher than a particular value such as 2500 cells/μL, 3000 cells/μL, 3500 cells/μL, 4000 cells/μL, 4350 cells/μL, 4500 cells/μL, 4750 cells/μL, 5000 cells/μL, 5250 cells/μL, 5500 cells/μL, 5750 cells/μL, 6000 cells/μL, 6500 cells/μL, 7000 cells/μL, 7500 cells/μL, 8000 cells/μL, 8500 cells/μL, or 9000 cells/μL, for example, in terms of the number of leukocytes. The particular value can be appropriately selected from a numerical range from, for example, 2500 cells/μL to 9000 cells/μL. The numerical range is preferably, for example, from 3000 cells/μL to 8000 cells/μL. The numerical range

is more preferably, for example, from 3500 cells/μL to 7000 cells/μL, further preferably, for example, from 4000 cells/μL to 6000 cells/μL, though the numerical range is not limited to these values. A value higher than the particular value selected from the numerical range can be used as the predetermined value.

[0116]

The predetermined value can be determined from a value higher than a particular value such as 50 cells/μL, 100 cells/μL, 200 cells/μL, 300 cells/μL, 350 cells/μL, 400 cells/μL, 450 cells/μL, 500 cells/μL, 550 cells/μL, 600 cells/μL, 650 cells/μL, 700 cells/μL, 800 cells/μL, 900 cells/μL, 1000 cells/μL, 1100 cells/μL, in terms of the number of monocytes. The particular value can be appropriately selected from a numerical range from, for example, 50 cells/μL to 1100 cells/μL. The numerical range is preferably, for example, from 100 cells/μL to 1000 cells/μL. The numerical range is more preferably, for example, from 200 cells/μL to 900 cells/μL, further preferably, for example, from 400 cells/μL to 800 cells/μL, though the numerical range is not limited to these values. A value higher than the particular value selected from the numerical range can be used as the predetermined value.

[0117]

The predetermined value can be determined from a value higher than a particular value such as 500 cells/μL,

1000 cells/μL, 1500 cells/μL, 2000 cells/μL, 2500 cells/μL, 3000 cells/μL, 3250 cells/μL, 3500 cells/μL, 3750 cells/μL, 4000 cells/μL, 4250 cells/μL, 4500 cells/μL, 5000 cells/μL, 5500 cells/μL, 6000 cells/μL, 6500 cells/μL, 7000 cells/μL, in terms of the number of neutrophils. The particular value can be appropriately selected from a numerical range from, for example, 500 cells/μL to 7000 cells/μL. The numerical range is preferably, for example, from 1000 cells/μL to 6000 cells/μL. The numerical range is more preferably, for example, from 1500 cells/μL to 5000 cells/μL, further preferably, for example, from 3000 cells/μL to 4000 cells/μL, though the numerical range is not limited to these values. A value higher than the particular value selected from the numerical range can be used as the predetermined value.

[0118]

The predetermined value can be determined from a value higher than a particular value such as 400 cells/μL, 500 cells/μL, 600 cells/μL, 700 cells/μL, 800 cells/μL, 900 cells/μL, 1000 cells/μL, 1100 cells/μL, 1200 cells/μL, 1250 cells/μL, 1300 cells/μL, 1400 cells/μL, 1500 cells/μL, 1600 cells/μL, 1700 cells/μL, 1800 cells/μL, 1900 cells/μL, 2000 cells/μL, 2100 cells/μL, 2200 cells/μL, 2300 cells/μL, 2400 cells/μL, 2500 cells/μL, 3000 cells/μL, 3500 cells/μL, 4000 cells/μL, in terms of the number of lymphocytes. The particular value can be

appropriately selected from a numerical range from, for example, 400 cells/μL to 4000 cells/μL. The numerical range is preferably, for example, from 450 cells/μL to 3000 cells/μL. The numerical range is more preferably, for example, from 500 cells/μL to 2500 cells/μL, further preferably, for example, from 1000 cells/μL to 2000 cells/μL, though the numerical range is not limited to these values. A value higher than the particular value selected from the numerical range can be used as the predetermined value.

[0119]

The predetermined value can be determined from a value higher than a particular value such as 400 cells/μL, 500 cells/μL, 600 cells/μL, 700 cells/μL, 800 cells/μL, 900 cells/μL, 950 cells/μL, 1000 cells/μL, 1050 cells/μL, 1100 cells/μL, 1200 cells/μL, 1300 cells/μL, 1400 cells/μL, 1500 cells/μL, 1600 cells/μL, 1700 cells/μL, 1800 cells/μL, 1900 cells/μL, 2000 cells/μL, 2100 cells/μL, 2200 cells/μL, 2300 cells/μL, 2400 cells/μL, 2500 cells/μL, 2600 cells/μL, 2700 cells/μL, 2800 cells/μL, 2900 cells/μL, 3000 cells/μL, 3500 cells/μL, or 4000 cells/μL in terms of the number of CD45+ lymphocytes among lymphocytes. The particular value can be appropriately selected from a numerical range from, for example, 400 cells/μL to 4000 cells/μL. The numerical range is preferably, for example, from 450 cells/μL to 3500 cells/μL. The numerical range is more preferably,

for example, from 500 cells/μL to 3000 cells/μL, further preferably, for example, from 1000 cells/μL to 1500 cells/μL, though the numerical range is not limited to these values. A value higher than the particular value selected from the numerical range can be used as the predetermined value.

[0120]

The predetermined value can be determined from a value higher than a particular value such as 250 cells/μL, 300 cells/μL, 400 cells/μL, 500 cells/μL, 600 cells/μL, 700 cells/μL, 800 cells/μL, 900 cells/μL, 1000 cells/μL, 1100 cells/μL, 1200 cells/μL, 1250 cells/μL, 1300 cells/μL, 1400 cells/μL, 1500 cells/μL, 1600 cells/μL, 1700 cells/μL, 1800 cells/μL, 1900 cells/μL, 2000 cells/μL, 2100 cells/μL, 2200 cells/μL, 2300 cells/μL, 2400 cells/μL, 2500 cells/μL, 3000 cells/μL, in terms of the number of CD3+ T cell. The particular value can be appropriately selected from a numerical range from, for example, 250 cells/μL to 3000 cells/μL. The numerical range is preferably, for example, from 300 cells/μL to 2500 cells/μL. The numerical range is more preferably, for example, from 350 cells/μL to 2000 cells/μL, further preferably, for example, from 400 cells/μL to 1000 cells/μL, though the numerical range is not limited to these values. A value higher than the particular value selected from the numerical range can be used as the predetermined value.

[0121]

The predetermined value can be determined from a value higher than a particular value such as 150 cells/μL, 200 cells/μL, 250 cells/μL, 300 cells/μL, 350 cells/μL, 400 cells/μL, 450 cells/μL, 500 cells/μL, 550 cells/μL, 600 cells/μL, 650 cells/μL, 700 cells/μL, 750 cells/μL, 800 cells/μL, 850 cells/μL, 900 cells/μL, 950 cells/μL, 1000 cells/μL, 1100 cells/μL, 1200 cells/μL, 1300 cells/μL, 1400 cells/μL, 1500 cells/μL, 1600 cells/μL, 1700 cells/μL, in terms of the number of CD4+ T cell. The particular value can be appropriately selected from a numerical range from, for example, 150 cells/μL to 1700 cells/μL. The numerical range is preferably, for example, from 200 cells/μL to 1500 cells/μL. The numerical range is more preferably, for example, from 250 cells/μL to 700 cells/μL, further preferably, for example, from 300 cells/μL to 600 cells/μL, though the numerical range is not limited to these values. A value higher than the particular value selected from the numerical range can be used as the predetermined value.

[0122]

The predetermined value can be determined from a value higher than a particular value such as 50 cells/μL, 75 cells/μL, 100 cells/μL, 125 cells/μL, 150 cells/μL, 175 cells/μL, 200 cells/μL, 225 cells/μL, 250 cells/μL, 275 cells/μL, 300 cells/μL, 325 cells/μL, 350 cells/μL, 400 cells/μL, 500 cells/μL, in terms of the number of

CD8+ T cell. The particular value can be appropriately selected from a numerical range from, for example, 50 cells/μL to 500 cells/μL. The numerical range is preferably, for example, from 50 cells/μL to 300 cells/μL. The numerical range is more preferably, for example, from 75 cells/μL to 275 cells/μL, further preferably, for example, from 100 cells/μL to 250 cells/μL, though the numerical range is not limited to these values. A value higher than the particular value selected from the numerical range can be used as the predetermined value.

[0123]

The predetermined value can be determined from a value higher than a particular value such as 25 cells/μL, 50 cells/μL, 150 cells/μL, 175 cells/μL, 200 cells/μL, 225 cells/μL, 250 cells/μL, 300 cells/μL, 350 cells/μL, 400 cells/μL, 450 cells/μL, 500 cells/μL, 550 cells/μL, 600 cells/μL, 700 cells/μL, 800 cells/μL, in terms of the number of CD16+ NK cell. The particular value can be appropriately selected from a numerical range from, for example, 25 cells/μL to 800 cells/μL. The numerical range is preferably, for example, from 50 cells/μL to 700 cells/μL. The numerical range is more preferably, for example, from 100 cells/μL to 600 cells/μL, further preferably, for example, from 150 cells/μL to 300 cells/μL, though the numerical range is not limited to these values. A value higher than the particular value

selected from the numerical range can be used as the predetermined value.

[0124]

The predetermined value can be determined from a value higher than a particular value such as 20 cells/μL, 30 cells/μL, 40 cells/μL, 50 cells/μL, 60 cells/μL, 70 cells/μL, 80 cells/μL, 90 cells/μL, 100 cells/μL, 110 cells/μL, 120 cells/μL, 130 cells/μL, 140 cells/μL, 150 cells/μL, 200 cells/μL, 250 cells/μL, 300 cells/μL, 350 cells/μL, 400 cells/μL, in terms of the number of NKp46+ NK cell. The particular value can be appropriately selected from a numerical range from, for example, 20 cells/μL to 400 cells/μL. The numerical range is preferably, for example, from 30 cells/μL to 300 cells/μL. The numerical range is more preferably, for example, from 50 cells/μL to 250 cells/μL, further preferably, for example, from 100 cells/μL to 200 cells/μL, though the numerical range is not limited to these values. A value higher than the particular value selected from the numerical range can be used as the predetermined value.

[0125]

The predetermined value can be determined from a value higher than a particular value such as 2 cells/μL, 3 cells/μL, 4 cells/μL, 5 cells/μL, 6 cells/μL, 7 cells/μL, 8 cells/μL, 9 cells/μL, 10 cells/μL, 11 cells/μL, 12 cells/μL, 13 cells/μL, 14 cells/μL, 15 cells/μL, 20 cells/μL, 25 cells/μL, 30 cells/μL, 40

cells/μL, in terms of the number of CD56-/CD16+ NK cell. The particular value can be appropriately selected from a numerical range from, for example, 2 cells/μL to 40 cells/μL. The numerical range is preferably, for example, from 2 cells/μL to 30 cells/μL. The numerical range is more preferably, for example, from 2 cells/μL to 20 cells/μL, further preferably, for example, from 3 cells/μL to 10 cells/μL, though the numerical range is not limited to these values. A value higher than the particular value selected from the numerical range can be used as the predetermined value.

[0126]

In a non-limiting aspect, the method of the present invention comprises measuring an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the patient, wherein when the expression level is a predetermined value, the efficacy of the GPC3-targeting drug therapy for cancer in the patient is predicted, expected, or determined or the continuation of the therapy is determined. Examples of the molecule expressed on the immunocyte for the measurement in the present invention include, but not limited to, CD16. The expression level of any one of such molecules may be measured and used as an index for predicting, expecting, or determining the efficacy of the GPC3-targeting drug therapy for cancer. Alternatively, the expression levels of two or more of these molecules

in combination may be used as an index. The predetermined value, for example, for CD16, can be regarded as a predetermined value at which the effect of the GPC3-targeting drug therapy can be expected, provided that this value falls within a range higher than the average expression level of CD16 on immunocytes in a patient group for which the effect of the GPC3-targeting drug therapy on cancer cannot be confirmed among a plurality of cancer patients treated with the GPC3-targeting drug therapy. For example, the predetermined value can also be determined on the basis of the average expression level of CD16 in a patient group showing a tendency toward significantly prolonged PFS or significantly prolonged OS among a plurality of cancer patients treated with the GPC3-targeting drug therapy. For example, a predetermined value for selecting with a high probability a patient showing a tendency toward significantly prolonged PFS or significantly prolonged OS as a result of GPC3-targeting drug therapy can be determined by measuring the expression level of CD16 in a plurality of cancer patients and setting the predetermined value to a value higher than the median value thereof. In this context, a plurality of cancer patients may be any number of cancer patients as long as the predetermined value for the expression level of CD16 serving as a criterion for determining the efficacy of GPC3-targeting drug therapy or the continuation of the

therapy can be calculated as a significant value. The number of cancer patients is preferably 100 or more, more preferably 150 or more. Specifically, the predetermined value can be determined from a value higher than a particular value such as 150000 mesf, 175000 mesf, 200000 mesf, 225000 mesf, 250000 mesf, 275000 mesf, 300000 mesf, 325000 mesf, 350000 mesf, 375000 mesf, 400000 mesf, 425000 mesf, 450000 mesf, 475000 mesf, 500000 mesf, 525000 mesf, 550000 mesf, 575000 mesf, 600000 mesf, 625000 mesf, 650000 mesf, 675000 mesf, 700000 mesf, 750000 mesf, or 800000 mesf, for example, in terms of the above-described flow cytometry measurement value of fluorescence intensity of CD16 on NK cells. The particular value can be appropriately selected from a numerical range from, for example, 150000 mesf to 800000 mesf. The numerical range is preferably, for example, from 200000 mesf to 700000 mesf. The numerical range is more preferably, for example, from 300000 mesf to 650000 mesf, further preferably, for example, from 350000 mesf to 600000 mesf, though the numerical range is not limited to these values. A value higher than the particular value selected from the numerical range can be used as the predetermined value.

[0127]

In a non-limiting aspect, the method of the present invention comprises measuring ADCC activity against GPC3-expressing cells using an immunocyte in a biological

sample isolated from the patient, wherein when the expression level of CD16 and/or CD107a on the immunocyte is a predetermined value, the efficacy of the GPC3-targeting drug therapy for cancer in the patient with high ADCC activity is predicted, expected, or determined or the continuation of the therapy is determined. In the present invention, the expression level of any one or both of CD16 and CD107a on the immunocyte may be measured and used as an index for predicting, expecting, or determining the efficacy of the GPC3-targeting drug therapy for cancer.

[0128]

For example, the expression level of CD16 or CD107a on immunocytes in the biological samples of a patient group for which the effect of the GPC3-targeting drug therapy on cancer cannot be confirmed among a plurality of cancer patients treated with the GPC3-targeting drug therapy is compared between in the presence and in the absence of the GPC3-targeting drug. In the case of CD16, the predetermined value can be regarded as a predetermined value at which the effect of the GPC3-targeting drug therapy can be expected, provided that this value falls within a range lower than the average difference from the expression level in the absence of the GPC3-targeting drug. In the case of CD107a, the predetermined value can be regarded as a predetermined value at which the effect of the GPC3-targeting drug

therapy can be expected, provided that this value falls within a range higher than the average difference from the expression level in the absence of the GPC3-targeting drug. For example, the expression level of CD16 or CD107a on immunocytes in the biological samples of a patient group showing a tendency toward significantly prolonged PFS or significantly prolonged OS among a plurality of cancer patients treated with the GPC3-targeting drug therapy is compared between in the presence and in the absence of the GPC3-targeting drug. The predetermined value can be determined on the basis of the average difference from the expression level in the absence of the GPC3-targeting drug. For example, the expression level of CD16 or CD107a on immunocytes in the biological samples of a plurality of cancer patients is compared between in the presence and in the absence of the GPC3-targeting drug. In the case of CD16, the predetermined value can be regarded as a predetermined value at which the effect of the GPC3-targeting drug therapy can be expected, provided that this value falls within a range lower than the median value of the difference from the expression level in the absence of the GPC3-targeting drug. In the case of CD107a, the predetermined value can be regarded as a predetermined value at which the effect of the GPC3-targeting drug therapy can be expected, provided that this value falls within a range higher than the median value of the

difference from the expression level in the absence of the GPC3-targeting drug. In this context, a plurality of cancer patients may be any number of cancer patients as long as the predetermined value for the expression level of CD16 or CD107a serving as a criterion for determining the efficacy of GPC3-targeting drug therapy or the continuation of the therapy can be calculated as a significant value. The number of cancer patients is preferably 100 or more, more preferably 150 or more.

[0129]

In the case of CD16, specific examples of the predetermined value include values lower than a particular value selected from a range from -10% to -95% when the CD16 expression level in the absence of the GPC3-targeting drug is subtracted from the expression level in the presence of the GPC3-targeting drug. The numerical range is preferably, for example, from -20% to -90%, more preferably, for example, from -50% to -90%, though the numerical range is not limited to these values.

[0130]

In the case of CD107a, specific examples of the predetermined value include values higher than a particular value selected from a range from 5% to 70% when the CD16 expression level in the absence of the GPC3-targeting drug is subtracted from the expression level in the presence of the GPC3-targeting drug. The numerical range is preferably, for example, from 10% to

60%, more preferably, for example, from 25% to 60%, though the numerical range is not limited to these values.

[0131]

The predetermined value of the number of an immunocyte and an expression level of a molecule expressed on the immunocyte can slightly vary depending on many factors, for example, the assay method used, the type of a sample for free GPC3 assay, storage conditions (e.g., temperature and duration) of the sample, and the ethnic identity of the patient. In the method for predicting, expecting, or determining the efficacy or determining the continuation of the therapy, the number of an immunocyte and an expression level of a molecule expressed on the immunocyte is measured in a biological sample, particularly peripheral blood isolated from the patient.

[0132]

The number of an immunocyte and an expression level of a molecule expressed on the immunocyte can be measured in a sample isolated before and/or after the start of the GPC3-targeting drug therapy and may be measured in a plurality of samples collected at predetermined time intervals. When the number of an immunocyte and an expression level of a molecule expressed on the immunocyte in any one of the plurality of samples collected at predetermined time intervals is the predetermined number of an immunocyte and/or the

expression level, the efficacy of the GPC3-targeting drug therapy for cancer in the patient is predicted, expected, or determined or the continuation of the therapy is determined. The predetermined time intervals are appropriately set. In a non-limiting aspect of the intervals, the samples can be collected at intervals of 1 day, 2 days, 3 days, 4 days, 5 days, 6 days, 7 days (i.e., 1 week), 8 days, 9 days, 10 days, 11 days, 12 days, 13 days, 14 days (i.e., 2 weeks), 15 days, 16 days, 17 days, 18 days, 19 days, 20 days, 21 days (i.e., 3 weeks), 22 days, 23 days, 24 days, 25 days, 26 days, 27 days, 28 days (i.e., 4 weeks), 29 days, 30 days, 1 month, 5 weeks, 6 weeks, 7 weeks, 8 weeks, 9 weeks, 10 weeks, 2 months, 3 months, 4 months, 5 months, or 6 months after the initial administration of the GPC3-targeting drug, or at arbitrary points in time between the start and completion of the therapy, for example, after 1, 2, 3, 4 or more treatment cycles. The dosing intervals, i.e., the treatment cycles, can be appropriately set. One non-limiting example thereof includes 1 day, 2 days, 3 days, 4 days, 5 days, 6 days, 7 days (i.e., 1 week), 8 days, 9 days, 10 days, 11 days, 12 days, 13 days, 14 days (i.e., 2 weeks), 15 days, 16 days, 17 days, 18 days, 19 days, 20 days, 21 days (i.e., 3 weeks), 22 days, 23 days, 24 days, 25 days, 26 days, 27 days, 28 days (i.e., 4 weeks), 29 days, 30 days, 1 month, 5 weeks, 6 weeks, 7 weeks, 8

weeks, 9 weeks, 10 weeks, 2 months, 3 months, 4 months, 5 months, or 6 months.

[0133]

As described above, when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte is a predetermined value, the efficacy of the GPC3-targeting drug therapy is determined. In this procedure, whether the patient has, in the Fcγ receptor type IIA and/or type IIIA genes, a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA and/or a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA may be taken into consideration. Specifically, when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte in the patient is a predetermined value and the patient has a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA and/or a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA, the efficacy of the GPC3-targeting drug therapy is determined.

[0134]

As described above, when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte is a predetermined value, the continuation of the GPC3-targeting drug therapy is determined. In

this procedure, whether the patient has, in the Fcγ receptor type IIA and/or type IIIA genes, a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA and/or a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA may be taken into consideration. Specifically, when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte in the patient is a predetermined value and the patient has a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA and/or a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA, the continuation of the GPC3-targeting drug therapy is determined.

[0135]

In this context, the phrase "having a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA" corresponds to the case where the patient has a nucleotide sequence of Val homozygote (V/V) or heterozygote (V/F) when a nucleotide sequence encoding amino acid residue 158 of FcγRIIIA is confirmed according to the method described in the above paragraph "Confirmation of Fcγ receptor gene polymorphism". Also, the phrase "having a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA" corresponds to the case

where the patient has a nucleotide sequence of His homozygote (H/H) or heterozygote (H/R) when a nucleotide sequence encoding amino acid residue 131 of FcγRIIA is confirmed in the same way as above.

[0136]

As described above, when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte is a predetermined value, the efficacy of the GPC3-targeting drug therapy is determined. In this procedure, the expression level of GPC3 in a tissue, particularly, a cancer tissue (including a liver cancer tissue), isolated from the patient may be further taken into consideration. Specifically, when the expression level of GPC3 in a tissue, particularly, a cancer tissue (including a liver cancer tissue), isolated from the patient is equal to or larger than a particular evaluation score and the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte in the patient is a predetermined value, the efficacy of the GPC3-targeting drug therapy is determined.

[0137]

As described above, when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte is a predetermined value, the continuation of the GPC3-targeting drug therapy is determined. In this procedure, the expression level of GPC3 in a tissue, particularly, a cancer tissue (including a liver cancer

tissue), isolated from the patient may be further taken into consideration. Specifically, when the expression level of GPC3 in a tissue, particularly, a cancer tissue (including a liver cancer tissue), isolated from the patient is equal to or larger than a particular evaluation score and the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte in the patient is a predetermined value, the continuation of the GPC3-targeting drug therapy is determined.

[0138]

In a non-limiting aspect, examples of the case where the expression level of GPC3 in a tissue, particularly, a cancer tissue (including a liver cancer tissue), isolated from the patient is equal to or larger than a particular evaluation score can include a case where the expression level of GPC3 is equal to or larger than a predetermined immunohistochemical staining score. In a non-limiting aspect, examples of the case where the expression level of GPC3 is equal to or larger than a predetermined immunohistochemical staining score can include high expression and low or moderate expression (IHC total score: 7 or higher and lower than 7, respectively) in a composite score 1 calculated as a result of staining according to the method as described in WO2009/116659 (staining method 1). In a non-limiting aspect, alternative examples of the case where the expression

level of GPC3 is equal to or larger than a predetermined immunohistochemical staining score can include GPC3-IHC scores (Composite score 2) of 1+, 2+, and 3+ calculated as a result of staining according to the staining method used for calculating Composite score 2 (staining method 2).

[0139]

Drug and preparation

In the present invention, the drug usually refers to an agent for the treatment or prevention of a disease or for examination or diagnosis. In the present invention, the phrase "GPC3-targeting drug which is to be administered to a cancer patient having a predetermined value of the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the cancer patient before the start of GPC3-targeting drug therapy" may be translated into a "method for treating cancer, comprising administering a GPC3-targeting drug to a cancer patient having a predetermined value of the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the cancer patient before the start of GPC3-targeting drug therapy" or may be translated into "use of a GPC3-targeting drug which is to be administered to a cancer patient having a predetermined value of the number of an immunocyte and/or an expression level of a

molecule expressed on the immunocyte in a biological sample isolated from the cancer patient before the start of GPC3-targeting drug therapy, for production of an agent for the treatment of cancer". In the present invention, the phrase "GPC3-targeting drug which is to be further administered to a cancer patient having a predetermined value of the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the cancer patient after the start of GPC3-targeting drug therapy" may be translated into a "method for treating cancer, comprising further administering a GPC3-targeting drug to a cancer patient having a predetermined value of the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the cancer patient after the start of GPC3-targeting drug therapy" or may be translated into "use of a GPC3-targeting drug which is to be further administered to a cancer patient having a predetermined value of the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the cancer patient after the start of GPC3-targeting drug therapy, for production of an agent for the treatment of cancer".

[0140]

The drug of the present invention can be formulated using a method generally known to those skilled in the

art. For example, the drug of the present invention can be parenterally used in the form of an injection in a sterile solution or suspension with water or any other pharmaceutically acceptable solution. For example, the active ingredient can be appropriately combined with pharmacologically acceptable carriers or media, specifically, sterile water or saline, a plant oil, an emulsifier, a suspending agent, a surfactant, a stabilizer, a flavor, an excipient, a vehicle, an antiseptic, a binder, and the like and mixed therewith in a unit dosage form required for generally accepted pharmaceutical practice to produce preparations. The amount of the active ingredient in these preparations is set to give an appropriate volume within a prescribed range.

[0141]

Sterile compositions for injection can be formulated according to usual pharmaceutical practice using a vehicle such as injectable distilled water. Examples of injectable aqueous solutions include saline and isotonic solutions containing glucose or other adjuvants (e.g., D-sorbitol, D-mannose, D-mannitol, and sodium chloride). An appropriate solubilizer, for example, an alcohol (ethanol, etc.), a polyalcohol (propylene glycol, polyethylene glycol, etc.), or a nonionic surfactant (Polysorbate 80(TM), HCO-50, etc.) may be used in combination therewith.

[0142]

Examples of oil solutions include sesame oil and soybean oil. Benzyl benzoate and/or benzyl alcohol may be used as a solubilizer in combination therewith. These injectable solutions may be mixed with a buffer (e.g., a phosphate buffer solution and a sodium acetate buffer solution), a soothing agent (e.g., procaine hydrochloride), a stabilizer (e.g., benzyl alcohol and phenol), and an antioxidant. The prepared injections are usually charged into appropriate ampules.

[0143]

The drug of the present invention is preferably administered by parenteral administration. For example, the drug is administered in a dosage form of an injection, a transnasal agent, a transpulmonary agent, or a percutaneous agent. The drug can be administered systemically or locally by, for example, intravenous injection, intramuscular injection, intraperitoneal injection, or subcutaneous injection.

[0144]

The administration method can be appropriately selected according to the age and symptoms of the patient. The single dose of a pharmaceutical preparation containing the drug can be set within the range of, for example, 0.0001 mg to 1000 mg per kg body weight. Alternatively, the dose can be set to, for example, 0.001 to 100000 mg per patient, though the dose of the present

invention is not necessarily limited to these numeric values. The dose and the administration method vary depending on the body weight, age, symptoms, etc. of the patient. Those skilled in the art can set an appropriate dose and administration method in consideration of these conditions. As a preferred example of the dose and the administration method of the present invention, the drug of the present invention can be administered to achieve a blood trough level equal to or higher than a predetermined level in the patient. Preferred examples of the blood trough level can include 150 μg/mL or higher, 160 μg/mL or higher, 170 μg/mL or higher, 180 μg/mL or higher, 190 μg/mL or higher, 200 μg/mL or higher, 210 μg/mL or higher, 220 μg/mL or higher, 230 μg/mL or higher, 240 μg/mL or higher, 250 μg/mL or higher, 260 μg/mL or higher, 270 μg/mL or higher, 280 μg/mL or higher, 290 μg/mL or higher, 300 μg/mL or higher, and 400 μg/mL or higher. More preferred examples thereof can include 200 μg/mL or higher.

[0145]

The preparation of the present invention comprises an instruction stating that the preparation is to be further administered to a cancer patient having a predetermined value of the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the cancer patient after the start of GPC3-targeting drug

therapy. In another non-limiting aspect, the preparation of the present invention comprises an instruction stating that the preparation is to be further administered to a cancer patient in which the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte in the biological sample isolated from the cancer patient after the start of GPC3-targeting drug therapy has been increased as a result of receiving the GPC3-targeting drug therapy.

[0146]

In a non-limiting aspect, the present invention provides the preparation comprising an instruction stating that the patient is selected on the basis of a method comprising measuring the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the patient treated with the GPC3-targeting drug therapy, wherein when the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte is a predetermined value, the efficacy of the GPC3-targeting drug therapy is determined or the continuation of the therapy is determined.

[0147]

In a non-limiting aspect, the present invention provides the preparation comprising an instruction stating that the patient is selected on the basis of a method comprising measuring the number of an immunocyte

and/or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the patient, wherein when the number of the immunocyte and/or the expression level are predetermined value, the efficacy of the GPC3-targeting drug therapy for cancer in the patient is predicted, expected, or determined or the continuation of the therapy is determined. In this context, examples of the predetermined value described in the instruction include the predetermined value described in the method for determining the efficacy of GPC3-targeting drug therapy or the method for determining the continuation of GPC3-targeting drug therapy.

[0148]

The predetermined value of the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte can slightly vary depending on many factors, for example, the assay method used, the type of a sample for measuring the number of an immunocyte and an expression level of a molecule expressed on the immunocyte, storage conditions (e.g., temperature and duration) of the sample, and the ethnic identity of the patient. In the method for predicting, expecting, or determining the efficacy or determining the continuation of the therapy, a value in a biological sample, particularly peripheral blood isolated from the patient is measured as the prededetermined value of the

number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte.

[0149]

The number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte can be measured in a sample isolated before and/or after the start of the GPC3-targeting drug therapy and may be measured in a plurality of samples collected at predetermined time intervals. When the number of an immunocyte and/or an expression level of a molecule expressed on the immunocyte in any one of the plurality of samples collected at predetermined time intervals is the predetermined value, the efficacy of the GPC3-targeting drug therapy for cancer in the patient is predicted, expected, or determined or the continuation of the therapy is determined. The predetermined time intervals at which the sample is collected after the start of the GPC3-targeting drug therapy are appropriately set. In a non-limiting aspect of the intervals, the samples can be collected at intervals of 1 day, 2 days, 3 days, 4 days, 5 days, 6 days, 7 days (i.e., 1 week), 8 days, 9 days, 10 days, 11 days, 12 days, 13 days, 14 days (i.e., 2 weeks), 15 days, 16 days, 17 days, 18 days, 19 days, 20 days, 21 days (i.e., 3 weeks), 22 days, 23 days, 24 days, 25 days, 26 days, 27 days, 28 days (i.e., 4 weeks), 29 days, 30 days, 1 month, 5 weeks, 6 weeks, 7 weeks, 8 weeks, 9 weeks, 10 weeks, 2 months, 3

months, 4 months, 5 months, or 6 months after the initial administration of the GPC3-targeting drug, or at arbitrary points in time between the start and completion of the therapy, for example, after 1, 2, 3, 4 or more treatment cycles. The dosing intervals, i.e., the treatment cycles, can be appropriately set. One non-limiting example thereof includes 1 day, 2 days, 3 days, 4 days, 5 days, 6 days, 7 days (i.e., 1 week), 8 days, 9 days, 10 days, 11 days, 12 days, 13 days, 14 days (i.e., 2 weeks), 15 days, 16 days, 17 days, 18 days, 19 days, 20 days, 21 days (i.e., 3 weeks), 22 days, 23 days, 24 days, 25 days, 26 days, 27 days, 28 days (i.e., 4 weeks), 29 days, 30 days, 1 month, 5 weeks, 6 weeks, 7 weeks, 8 weeks, 9 weeks, 10 weeks, 2 months, 3 months, 4 months, 5 months, or 6 months.

[0150]

As described above, the instruction states that when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte is a predetermined value, the GPC3-targeting drug therapy is effective. In this case, the instruction may state that whether the patient has, in the Fcγ receptor type IIA and/or type IIIA genes, a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA and/or a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA is also taken into consideration.

Specifically, the instruction may state that when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte in the patient is a predetermined value and the patient has a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA and/or a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA, the efficacy of the GPC3-targeting drug therapy is determined.

[0151]

As described above, the instruction states that when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte is a predetermined value, the continuation of the GPC3-targeting drug therapy is determined. In this case, the instruction may state that whether the patient has, in the Fcγ receptor type IIA and/or type IIIA genes, a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA and/or a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA is also taken into consideration. Specifically, the instruction may state that when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte in the patient is a predetermined value and the patient has a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA

and/or a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA, the continuation of the GPC3-targeting drug therapy is determined.

[0152]

In this context, the phrase "having a polymorphism that results in homozygous or heterozygous Val at amino acid residue 158 of FcγRIIIA" corresponds to the case where the patient has a nucleotide sequence of Val homozygote (V/V) or heterozygote (V/F) when a nucleotide sequence encoding amino acid residue 158 of FcγRIIIA is confirmed according to the method described in the above paragraph "Confirmation of Fcγ receptor gene polymorphism". Also, the phrase "having a polymorphism that results in homozygous or heterozygous His at amino acid residue 131 of FcγRIIA" corresponds to the case where the patient has a nucleotide sequence of His homozygote (H/H) or heterozygote (H/R) when a nucleotide sequence encoding amino acid residue 131 of FcγRIIA is confirmed in the same way as above.

[0153]

As described above, the instruction states that when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte is a predetermined value, the efficacy of the GPC3-targeting drug therapy is determined. In this case, the instruction may state that the expression level of GPC3

in a tissue, particularly, a cancer tissue (including a liver cancer tissue), isolated from the patient is further taken into consideration. Specifically, the instruction may state that when the expression level of GPC3 in a tissue, particularly, a cancer tissue (including a liver cancer tissue), isolated from the patient is equal to or larger than a particular evaluation score, particularly, a cancer tissue (including a liver cancer tissue), isolated from the patient is equal to or larger than a particular evaluation score and the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte in the patient is a predetermined value, the efficacy of the GPC3-targeting drug therapy is determined.

[0154]

As described above, the instruction states that when the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte is a predetermined value, the continuation of the GPC3-targeting drug therapy is determined. In this case, the instruction may state that the expression level of GPC3 in a tissue, particularly, a cancer tissue (including a liver cancer tissue), isolated from the patient is further taken into consideration. Specifically, the instruction may state that when the expression level of GPC3 in a tissue, particularly, a cancer tissue (including a liver cancer tissue), isolated from the

patient is equal to or larger than a particular evaluation score and the number of an immunocyte and/or the expression level of a molecule expressed on the immunocyte in the patient is a predetermined value, the continuation of the GPC3-targeting drug therapy is determined.

[0155]

In a non-limiting aspect, examples of the case where the expression level of GPC3 in a tissue, particularly, a cancer tissue (including a liver cancer tissue), isolated from the patient is equal to or larger than a particular evaluation score can include a case where the expression level of GPC3 is equal to or larger than a predetermined immunohistochemical staining score. In a non-limiting aspect, examples of the case where the expression level of GPC3 is equal to or larger than a predetermined immunohistochemical staining score can include high expression and low or moderate expression (IHC total score: 7 or higher and lower than 7, respectively) in a composite score 1 calculated as a result of staining according to the method as described in WO2009/116659 (staining method 1). In a non-limiting aspect, alternative examples of the case where the expression level of GPC3 is equal to or larger than a predetermined immunohistochemical staining score can include GPC3-IHC scores (Composite score 2) of 1+, 2+, and 3+ calculated as a result of staining according to the staining method

used for calculating Composite score 2 (staining method 2).

[0156]

Hereinafter, the present invention will be described specifically with reference to Examples. However, the present invention is not limited by these Examples.

[Example 1]

[0157]

GC33 (generic name: codrituzumab) used in the present Examples is a recombinant humanized IgG1 monoclonal antibody capable of binding to human GPC3 with high affinity (WO2006/006693). In order to confirm the effect of GC33 on patients who had advanced and/or recurrent hepatocellular cancer (HCC) and had experienced the progression of the condition after radical cure by systemic therapy with at least a single agent or patients with unresectable advanced and/or metastatic hepatocellular cancer for which medication had been discontinued due to adverse events, a phase-II multicenter randomized double-blind placebo-controlled clinical trial was carried out (NP-27884 test). In this test chiefly aimed at evaluating efficacy on the basis of a progression-free survival duration in the patients with advanced and/or metastatic HCC and secondarily aimed at evaluating efficacy with an overall survival duration, a disease control rate, and a progression-free duration as

indexes, evaluating safety and/or tolerability, confirming the pharmacokinetic profile of GC33, and searching for a biomarker, GC33 (1,600 mg) was administered by injection through an intravenous drip to each HCC patient once a week for the first two weeks and once two weeks thereafter.

[0158]

The HCC patients subjected to the administration had histologically confirmed advanced or metastatic HCC (except for fibrolamellar type) unsuitable for curative therapy (surgical resection, liver transplantation, etc.) and/or local therapy or exacerbated after treatment and had a past history of treatment based on systemic therapy with at least one agent. Eligible patients were at least 18 years old with the capability of providing a tumor sample for GPC3 assay and exhibited Eastern Cooperative Oncology Group Performance Status of 0 or 1 and Child-Pugh class A. The patients also had at least one lesion that was evaluable according to the response evaluation criteria in solid tumors (RECIST). Appropriate hematopoietic functions (absolute neutrophil count ≥ 1500/μl, platelet ≥ 50000/μl, hemoglobin ≥ 8.0 g/dl), hepatic functions (total bilirubin ≤ 2 mg/dl, aspartate aminotransferase and alanine aminotransferase ≤ 5 times the upper limit of the normal level), and renal functions (serum creatinine ≤ twice the upper limit of the normal level) were evaluated as other criteria. Registrable

female subjects were premenopausal female patients confirmed to be negative for a serum pregnancy test conducted within 10 days before the start of administration of the study drug, women without the possibility of pregnancy as a result of surgical contraception or after a lapse of 1 year or longer after menopause, and female patients other than the postmenopausal women (12-month or longer absence of menstruation) or the surgically contracepted women (resection of the ovary and/or the uterus), who consented to use two types of appropriate fertility control methods during clinical trial treatment and for at least 3 months or longer after the completion of administration of the study drug. Registrable male subjects were patients who consented to use fertility control based on the barrier method during clinical trial treatment and for at least 40 days after the completion of administration of the study drug. On the other hand, the registered subjects excluded patients who received major surgical operation within 2 weeks before the administration of the GPC3-targeting drug or did not get over severe disorder, patients confirmed to have brain or leptomeningeal metastasis, patients having a past history of malignant tumor within the last 5 years, patients having active infection requiring treatment except for hepatitis B or hepatitis C, patients having a past history of NCI-CTCAE v4.0 Grade 3 or higher hemorrhage within 4 weeks before

the start of administration of the study drug, patients having a past history of organ transplantation including liver transplantation, patients who were scheduled to receive or were receiving the administration of an anticancer agent other than the agent to be administered in this test, patients who received the administration of an anticancer agent within 2 weeks before trial registration, patients who did not completely get over adverse reactions associated with the preceding locoregional or systemic therapy of hepatocellular cancer, patients under interferon therapy, patients who had baseline QTc exceeding 470 ms or exhibited baseline resting bradycardia (less than 45 beads/min.), patients who received the administration of an anticoagulant or a thrombolytic agent for therapeutic purposes within 2 weeks before the start of administration of the study drug (except for the administration of the agent at a low dose for the purpose of removing clogs in a catheter or for preventive purposes), pregnant or nursing patients, HIV-positive patients or patients having an AIDS-related disease, patients having a past history of hypersensitivity for similar agents (monoclonal antibodies, protein-containing preparations, and Chinese hamster ovary-derived preparations), and patients having a serious comorbidity judged by a principal investigator or a sub-investigator as being possibly worsened due to the study drug.

[0159]

The protocol was carried out according to the guideline of the Good Clinical Practice (GCP) and approved by each participating ethical committee on clinical trials. All patients signed their names on written informed consent before registration. The patients received the continuous administration of GC33 unless the disease progressed or unacceptable toxicity appeared. Tumor was evaluated on the basis of a baseline and evaluated after 4 cycles, 7 cycles, and 10 cycles from the start of administration and then repetitively every four cycles until the disease progressed. Each cycle involved two weeks. The state of the disease was evaluated by principal investigators.

[0160]

These patients were randomized to a GC33 group (the fixed dose of 1600 mg was administered every other week after administration of two doses at a 1-week interval; n = 121 cases) or a placebo group (n = 60 cases) at a ratio of 2:1 and stratified to 3 cohorts on the basis of GPC3 expression levels (Composite score 2) (0, 1+, and 2+/3+) by IHC staining using GPC3-IHC kit (manufactured by Ventana Medical Systems, Inc.). Primary analysis was carried out at the time of occurrence of progression-free survival (PFS) events in 128 cases planned in the protocol.

[0161]

The expression of GPC3 proteins in HCC tumor tissues was evaluated by GPC3 immunohistochemical staining (GPC3-IHC), namely Composite score 2. The median measurement of GPC3-IHC was carried out by Ventana Medical Systems, Inc. (USA). Unstained slides of HCC tumor tissues prepared from tumor blocks formalin-fixed and paraffin-embedded after excision by needle biopsy in each hospital were subjected to immunohistochemical staining. The antibody used was a mouse GC33 antibody (manufactured by Ventana Medical Systems, Inc.).

[Example 2]

[0162]

Once the PFS events of 128 cases were obtained from among 121 GC33-administered cases and 60 placebo-administered cases as described above, the effects of administration of GC33 in GPC3-targeting treatment were evaluated on the basis of PFS. In addition, overall survival (OS) was evaluated as a secondary endpoint when reaching 92 events. As a result, the administration of GC33 was confirmed to be not effective for prolonging both PFS and OS (Figure 1), which was confirmed in the evaluation using each of the GPC-IHC scores (Comosite score 2)

[0163]

The GC33-administered group was further divided into two groups (a group exposed to GC33 at a lower level than a cutoff value: low-GC33-exposed group, and a group

exposed to GC33 at a higher level than a cutoff value: high-GC33-exposed group) using, as the cutoff value, the median value 230 μg/ml of putative blood trough levels of GC33 before administration of day 1 in the 3rd cycle (on the 4th week from the start of initial administration) based on population PK models obtained using the serum GC33 concentration values of this phase-II clinical trial. The progression-free survival duration or progression-free survival (PFS) or the overall survival duration or overall survival (OS) was compared as an index for clinical effects between these groups or between these groups and the placebo group by the Kaplan-Meier method. As a result, the effect of prolonging both PFS and OS was found in the high-GC33-exposed group compared with the placebo group or the low-GC33-exposed group (Figure 2).

[0164]

Immunocytes in peripheral blood, a polymorphism in the gene of Fc gamma receptor type IIA or IIIA expressed on immunocytes, and antibody-dependent cellular cytotoxicity activity (ADCC activity) in peripheral blood before the administration of GC33 were further assayed for the purpose of searching for a biomarker associated with the effect of GC33. PFS or OS was compared between groups by the Kaplan-Meier method in the same way as above. The log-rank test was conducted.

[Example 3]

[0165]

In order to study the relation of the effect of GC33 to the number of peripheral blood immunocytes measured as a GC33 effect-related biomarker by a usual method (method using an automatic blood cell counter) after blood collection from cases in each center, these cases were divided into high-value groups and low-value groups on the basis of the median values of the numbers of various types of immunocytes in the peripheral blood of the patients before the administration of GC33. PFS and OS were compared between a GC33-administered group and a placebo group. As a result, as shown in Table 4, the administration of GC33 was confirmed to prolong PFS in the groups with a large number of leukocytes, monocytes, or neutrophils compared with the placebo groups. By contrast, no such effect was confirmed in the groups with a small number of each immunocyte (smaller than the median value). Particularly, as for the neutrophils, significantly prolonged PFS was confirmed in the group with a large number of cells (Figure 3).

[0166]

Further study was limited to the high-GC33-exposed groups confirmed above to have prolonged PFS and OS compared with the placebo groups. Significantly prolonged PFS as well as prolonged OS was confirmed in all the groups with a large number of leukocytes, monocytes, or neutrophils (the number of leukocytes: ≥ 5,680 cells/μL, the number of monocytes: ≥ 503 cells/μL,

the number of neutrophils: ≥ 3,607 cells/μL). As for the number of lymphocytes, a tendency toward prolonged PFS as well as significantly prolonged OS was also confirmed only in the group with a large number of lymphocytes (≥ 1,246 cells/μL) (Table 4).

[0167]

[Table 4]

Table 4. Effect of GC33 on patients stratified depending on the number of immunocyte in peripheral blood

		Placebo vs. GC33				Placebo group vs. high-GC33-exposed group			
		PFS		OS		PFS		OS	
		Hazard ratio	*p* value (log-rank)	Hazard ratio	*p* value (log-rank)	Hazard ratio	*p* value (log-rank)	Hazard ratio	*p* value (log-rank)
The number of leukocyte	Low value	1.130	0.595	0.954	0.864	0.923	0.756	0.612	0.123
	High value	0.752	0.195	0.862	0.583	0.507	0.014	0.461	0.035
The number of monocyte	Low value	1.172	0.500	0.795	0.411	0.997	0.992	0.513	0.036
	High value	0.709	0.121	0.988	0.964	0.419	0.003	0.544	0.087
The number of neutrophil	Low value	1.229	0.369	1.004	0.988	1.082	0.754	0.682	0.222
	High value	0.607	0.030	0.796	0.390	0.311	0.000	0.361	0.008
The number of lymphocyte	Low value	0.944	0.802	1.063	0.826	0.738	0.240	0.666	0.196
	High value	0.938	0.773	0.759	0.307	0.658	0.128	0.404	0.017

[Example 4]

[0168]

In order to identify various types of immunocytes in more detail, median measurement was carried out in Covance Inc. by FACS using antibodies against the surface antigens of various types of immunocytes and collected peripheral blood. As shown in Table 5, an antibody

against each of lymphocyte markers CD19, CD45, CD3, CD4, and CD8 was mixed with collected whole blood. Lymphocyte subsets were assayed using Trucount tubes (manufactured by Becton, Dickinson and Company) and classified into low-value groups and high-value groups on the basis of the median values of the measurement values. As a result, significantly prolonged PFS was confirmed in the GC33-administered group with a large number of CD4-positive T cells (≥ 490 cells/μL) compared with the placebo group (Figure 4).

In addition, a tendency toward prolonged OS was confirmed in the group with a large number of CD45-positive cells (≥ 1,090 cells/μL); a tendency toward prolonged PFS and OS was confirmed in the group with a large number of CD3-positive T cells (≥ 752 cells/μL); and a tendency toward prolonged OS was confirmed in the group with a large number of CD4-positive T cells (≥ 490 cells/μL) (Table 5).

[0169]

Further study was limited to the high-GC33-exposed groups. Significantly prolonged PFS and OS were confirmed only in all the groups with a large number of CD3-positive or CD4-positive cells (CD3: ≥ 752 cells/μL, CD4: ≥ 490 cells/μL) or with a small number of CD8-positive cells (< 251 cells/μL) (Table 5). In the other fractions, the significant prolongation of some survival durations or some prolonging effect was observed, though

a certain strong tendency was not obtained in the high-value group or the low-value group.

[0170]

[Table 5]

Table 5. Effect of GC33 on patients stratified depending on peripheral blood immunocyte marker

		Placebo vs. GC33				Placebo group vs. high-GC33-exposed group			
		PFS		OS		PFS		OS	
		Hazard ratio	*p* value (log-rank)	Hazard ratio	*p* value (log-rank)	Hazard ratio	*p* value (log-rank)	Hazard ratio	*p* value (log-rank)
The number of CD19+ B cell	Low value	0.798	0.353	1.192	0.579	0.647	0.114	0.621	0.212
	High value	0.984	0.941	0.667	0.125	0.746	0.264	0.508	0.032
The number of CD45+ lymphocyte	Low value	1.072	0.771	1.520	0.139	0.737	0.279	0.783	0.486
	High value	0.780	0.289	0.537	0.040	0.653	0.121	0.430	0.021
The number of CD3+ T cell	Low value	1.103	0.674	1.161	0.578	0.844	0.526	0.715	0.291
	High value	0.760	0.239	0.642	0.155	0.616	0.076	0.462	0.046
The number of CD4+ T cell	Low value	1.273	0.307	1.465	0.173	1.058	0.836	1.045	0.891
	High value	0.635	0.050	0.476	0.013	0.461	0.004	0.235	0.0002
The number of CD8+ T cell	Low value	0.849	0.490	0.924	0.776	0.586	0.052	0.506	0.041
	High value	0.932	0.762	0.779	0.387	0.815	0.451	0.622	0.176

[0171]

Subsequently, more detailed analysis was carried out on NK cells. In the same way as above, median measurement was carried out in Covance Inc. using peripheral blood collected from patients. Classification based on FACS analysis using antibodies against CD3, CD16, and CD56 was carried out, also including the reactivity

of antibodies against NKp46 and CD8. Groups having cells negative for reactivity with CD3 were classified into a CD56bright NK cell fraction, a CD56-/CD16+ NK cell fraction, a CD56dim/CD16- NK cell fraction, and a CD56dim/CD16bright NK cell fraction on the basis of CD16 positivity, NKp46 positivity, and the reactivity of the antibodies against CD56 and CD16.

[0172]

The influence of GC33 administration on PFS and OS for each NK cell fraction is shown in Table 6. Of these NK cell fractions, a tendency toward significantly prolonged PFS and a prolonged OS by the administration of GC33 was confirmed only in the group with a high CD56-/CD16+ NK cell fraction (≥ 6.3 cells/μL) (Figure 5). The effect of prolonging survival durations was further prominent in the comparison between the high-GC33-exposed group and the placebo group. In the other fractions, the significant prolongation of some survival durations or some prolonging effect was observed, though a certain strong tendency was not obtained in the high-value group or the low-value group.

[0173]

In addition to fractionation based on each marker, the expression level of CD16 or NKp46 on NK cells was measured by FACS (FACSCanto II, manufactured by Becton, Dickinson and Company) in the same way as above. The cases were classified into high-expression groups and

low-expression group on the basis of the median values of the measurement results. PFS and OS were compared between a GC33-administered group or a high-GC33-exposed group and a placebo group. For each expression level (mean equivalent soluble fluorescent level (MESF)), an MESF calibration curve was prepared on the basis of the fluorescence intensity of calibration beads (Quantum MESF bead standard, manufactured by Bang Laboratories, Inc.), and the expression level (MESF) was calculated from the fluorescence intensity of an NK cell fraction. As a result, as shown in Table 6, a tendency toward significantly prolonged PFS and prolonged OS by the administration of GC33 was confirmed only in the group with a high expression level of CD16 (CD16 MESF) (≥ 372,254 mesf) (Figure 6). The effect of prolonging survival durations was further prominent in the comparison between the high-GC33-exposed group and the placebo group.

[0174]

[Table 6]

Table 6. Effect of GC33 on patients stratified depending on various surface markers for peripheral blood NK cell

		Placebo vs. GC33				Placebo group vs. high-GC33-exposed group			
		PFS		OS		PFS		OS	
		Hazard ratio	*p* value (log-rank)	Hazard ratio	*p* value (log-rank)	Hazard ratio	*p* value (log-rank)	Hazard ratio	*p* value (log-rank)
The number of CD16+ NK cell	Low value	0.977	0.919	1.043	0.884	0.697	0.183	0.466	0.043
	High value	0.743	0.244	0.727	0.309	0.618	0.101	0.595	0.148
The number of	Low	1.095	0.714	1.027	0.926	0.805	0.443	0.613	0.159

NKp46+ NK cell	value								
	High value	0.768	0.256	0.781	0.401	0.594	0.062	0.502	0.065
The number of CD56bright NK cell	Low value	0.913	0.706	1.206	0.527	0.709	0.207	0.686	0.286
	High value	0.901	0.658	0.653	0.150	0.641	0.126	0.462	0.041
The number of CD56-/CD16+ NK cell	Low value	1.259	0.344	1.173	0.594	0.991	0.975	0.666	0.269
	High value	0.571	0.022	0.615	0.110	0.405	0.002	0.425	0.020
The number of CD56dim/CD16- NK cell	Low value	0.935	0.780	0.932	0.811	0.684	0.166	0.499	0.053
	High value	0.896	0.641	0.860	0.603	0.722	0.248	0.643	0.211
The number of CD56dim/CD16bright NK cell	Low value	0.982	0.937	0.946	0.845	0.688	0.174	0.431	0.024
	High value	0.768	0.288	0.839	0.579	0.645	0.124	0.682	0.290
CD16MESF	Low value	1.130	0.612	1.152	0.631	0.908	0.724	0.758	0.421
	High value	0.668	0.101	0.665	0.170	0.473	0.010	0.348	0.005
NKp46 MESF	Low value	0.818	0.419	0.958	0.884	0.668	0.144	0.746	0.374
	High value	1.004	0.987	0.781	0.395	0.642	0.133	0.281	0.004

[Example 5]

[0175]

The induction of ADCC has been reported as a mechanism of action of GC33 (Ishiguro T. et al., Cancer Res. 2008; 68: 9832-9838). Thus, ADCC activity was measured in patients before the administration of GC33 and studied for its relation to the effect of GC33.

[0176]

The ADCC activity was studied as follows using peripheral blood collected from patients before the administration of GC33 or placebo: the collected

peripheral blood was frozen in liquid nitrogen and stored at -150°C. After thawing of the peripheral blood, an RPMI II medium (manufactured by HyClone Laboratories, Inc.) containing IL-2 (manufactured by PeproTech) was added thereto. GC33 (0.5 μg/mL) and target cells were added to 1 x 10^5 peripheral mononuclear cells cultured overnight, followed by culture at 37°C for 1 hour. Monensin was further added thereto, followed by culture for 2 hours. Then, the peripheral mononuclear cells were harvested, and a mixed solution of antibodies against CD45, CD3, CD16, CD56, and CD107 was added thereto. The expression level of CD16 or CD107a on NK cells was measured by FACS (FACSCanto II, manufactured by Becton, Dickinson and Company). Also, the expression level of CD107a or CD16 on NK cells cultured after the addition of only target cells was used as a negative control, and a difference from the negative control was used as an index for ADCC activity. The target cells used were GPC3-expressing human liver cancer cell line HepG2 cells (ATCC) for assay of ADCC activity, and human chronic myeloid leukemia cell line K562 cells (ATCC) for assay of antibody-independent NK activity. The preparation of any sample and median measurement in the assay were carried out in Covance Inc.

A group with an expression level of CD107a higher than the median value (34.15%) was defined as a high-ADCC activity group, while a group with an expression level

thereof lower than the median value was defined as a low-ADCC activity group. Also, a group with an expression level of CD16 lower than the median value (-64.33%) was defined as a high-ADCC activity group, while a group with an expression level thereof higher than the median value was defined as a low-ADCC activity group. PFS and OS were compared among a high-GC33-exposed group, a low-GC33-exposed group, and a placebo group of these groups. As a result, as shown in Table 7, significantly prolonged PFS and OS were confirmed only in the high-ADCC activity groups for both the indexes of CD107a and CD16 (Figures 7 and 8).

[0177]

On the other hand, change in the expression of CD107a or CD16 on the K562 cells (median value of the amount of change in CD107a expression: 9.74%, median value of the amount of change in CD16 expression: -15.76%) was measured as NK activity. Unlike ADCC, significantly prolonged PFS or OS only in either the low-value group or the high-value group of NK activity was not confirmed (Table 7).

[0178]

[Table 7]

Table 7. Effect of GC33 on patients stratified depending on NK activity or ADCC activity using peripheral blood before administration

		Placebo group vs. high-GC33-exposed group			
		PFS		OS	
ADCC activity		Hazard ratio	P value	Hazard ratio	P value
CD107a	Low	0.536	0.047	0.538	0.124

	High	0.513	0.038	0.303	0.003
CD16	Low	0.340	0.001	0.305	0.003
	High	0.813	0.521	0.575	0.182
NK activity		Hazard ratio	P value	Hazard ratio	P value
CD107a	Low	0.555	0.085	0.338	0.013
	High	0.601	0.127	0.406	0.048
CD16	Low	0.506	0.044	0.295	0.013
	High	0.573	0.117	0.390	0.026

[Example 6]

[0179]

A polymorphism of the gene of an Fc gamma receptor binding to an antibody Fc region is known to influence its binding to the antibody Fc region. Thus, the effect of GC33 was studied for its relation to a polymorphism in Fc gamma receptor type IIA and IIIA genes. The genomic gene was isolated from peripheral blood collected from each patient. A polymorphism in a nucleotide sequence corresponding to amino acid residue 131 of Fc gamma receptor type IIA or a nucleotide sequence corresponding to amino acid residue 158 of type IIIA was measured. Specifically, the genomic DNA isolated using MagNa Pure LC DNA Isolation kit 1 (manufactured by Roche Applied Science) from whole blood collected from each patient was used to perform genotyping by real-time PCR using TaqMan(R) probe designed to correspond to each SNP.

[0180]

PFS and OS were compared between a polymorphism that resulted in homozygous or heterozygous Val (V/V or V/F) at amino acid residue 158 of FcγRIIIA and a polymorphism

that resulted in homozygous Phe (F/F) at this residue in each of a high-GC33-exposed group, a low-GC33-exposed group, and a placebo group. As a result, as shown in Table 8, significantly prolonged PFS and OS were both confirmed in the high-GC33-exposed group having V/V or V/F compared with the placebo group. By contrast, no such effect was confirmed in the group having F/F.

[0181]

[Table 8]

Table 8. Effect of GC33 on patients stratified depending on polymorphism in Fc gamma receptor gene

Placebo group vs. high-GC33-exposed group				
FcγRIIIA-158	V/V or V/F		F/F	
	Hazard ratio	P value	Hazard ratio	P value
PFS	0.524	0.016	0.779	0.447
OS	0.442	0.039	0.628	0.288
FcγRIIA-131	H/H or H/R		R/R	
	Hazard ratio	P value	Hazard ratio	P value
PFS	0.565	0.011	0.948	0.925
OS	0.436	0.009	0.457	0.350

[0182]

Also, a gene polymorphism related to residue 131 of FcγRIIA was studied in the same way as above. PFS and OS were compared between a polymorphism that resulted in homozygous or heterozygous His (H/H or H/R) at amino acid residue 131 and a polymorphism that resulted in homozygous Arg (R/R) at this residue in each of a high-GC33-exposed group, a low-GC33-exposed group, and a

placebo group. As a result, as shown in Table 8, significantly prolonged PFS and OS were both confirmed in the high-GC33-exposed group having H/H or H/R compared with the placebo group. By contrast, no such effect was confirmed in the group having R/R.

[0183]

These results demonstrated that the immune state of a patient can be improved by measuring each of the number of an immunocyte in peripheral blood, ADCC activity, or a polymorphism in Fc gamma receptor gene, or the efficacy of GPC3-targeting therapy can be improved by the combination thereof.

[Example 7]

[0184]

With regard to the expression level of CD16 on NK cells (CD16 MESF), further analysis using Cox regression based on the proportional hazards model was performed. In the analysis, classification into CD16 MESF higher value groups and CD16 MESF lower value groups was performed based on the measurement results of Example 5 using different cut-off values, and the hazard ratio, 95% confidence interval (95% CI) and *p*-value of the log-rank test were calculated for each group. Here, the overall survival period was used as a variable response in the analysis and adjusted by clinically relevant background factors.

[0185]

279,736.9 mesf, which was 33% (33 percentile value) of the CD16 MESF value, 363,594 mesf, which was 50% (50 percentile value), or 439,468.3, which was 67% (33 percentile value), were the cut-off values. Classification into lower value groups and higher value groups was performed respectively using respective different cut-off values, and the hazard ratios, 95% confidence intervals and *p*-values of the GC33 high exposure group were compared to those of the placebo group. As a result, the hazard ratio decreased as the cut-off value of the CD16 MESF value increased in the CD16 MESF higher value group as shown in Table 9, which suggested that the clinical efficacy of GC33 and the expression level of CD16 were relevant (Table 9).

On the other hand, no significant relationship was observed between the change of the cut-off value of the MESF values for CD16 and the hazard ratio in the CD16 MESF lower value group.

[0186]

[Table 9]

Table 9. The relationship between cut-off value of MESF value for CD16 and hazard ratio

CD16 MESF Cut-off Value	CD16 MESF Higher Value Group					CD16 MESF Lower Value Group				
	N	Hazard ratio	95% CI Lower limit	95% CI Upper limit	*p*-Value	N	Hazard ratio	95% CI Lower limit	95% CI Upper limit	*p*-Value
33% Value	71	0.44	0.22	0.88	0.020	36	1.55	0.38	6.35	0.543
50%	54	0.33	0.14	0.77	0.011	53	1.46	0.55	4.11	0.459

Value										
67% Value	36	0.09	0.02	0.44	0.003	71	1.03	0.50	2.12	0.928

[0187]

All publications, patents, and patent applications cited herein are incorporated herein by reference in their entirety.

[Industrial Applicability]

[0188]

The present invention contributes to improvement in the efficacy of GPC3-targeting drug therapy and improvement in QOL of a patient to be treated, and is useful in the treatment of cancer including liver cancer.

Claims

1. A method for determining the efficacy of GPC3-targeting drug therapy for cancer in a patient or determining the continuation of GPC3-targeting drug therapy for a patient, comprising measuring the number of an immunocyte or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the patient before the start of GPC3-targeting drug therapy and/or the patient treated with the GPC3-targeting drug therapy, wherein when the number of an immunocyte or the expression level of a molecule expressed on the immunocyte is a predetermined value, the efficacy of the GPC3-targeting drug therapy is determined or the continuation of the GPC3-targeting drug therapy is determined.

2. The method according to claim 1, wherein the biological sample is peripheral blood isolated from the patient.

3. The method according to claim 1 or 2, wherein the immunocyte is at least one cell selected from a leukocyte, a monocyte, a neutrophil, and a lymphocyte.

4. The method according to claim 3, wherein the lymphocyte is at least one lymphocyte cell selected from

a CD45+ lymphocyte, a CD3+ T cell, a CD4+ T cell, and a CD8+ T cell.

5. The method according to claim 3, wherein the lymphocyte is at least one lymphocyte cell selected from a CD16+ NK cell, an NKp46+ NK cell, and a CD56-/CD16+ NK cell.

6. The method according to claim 1 or 2, wherein the molecule expressed on the immunocyte is CD16 or CD107a.

7. The method according to any of claims 1 to 7, wherein the patient has a polymorphism at least one allele having Val at amino acid residue 158 of FcγRIIIA and/or at least one allele having His at amino acid residue 131 of FcγRIIA.

8. The method according to any of claims 1 to 7, wherein the cancer is liver cancer.

9. The method according to any of claims 1 to 8, wherein the GPC3-targeting drug is administered to achieve a blood trough level of 200 μg/ml or higher in the cancer patient.

10. The method according to any of claims 1 to 9, wherein the GPC3-targeting drug comprises an anti-GPC3 antibody as an active ingredient.

11. The method according to claim 10, wherein the anti-GPC3 antibody has antibody-dependent cellular cytotoxicity (ADCC) activity and/or complement-dependent cytotoxicity (CDC) activity.

12. The method according to claim 10 or 11, wherein the anti-GPC3 antibody is an anti-GPC3 chimeric antibody or a humanized anti-GPC3 antibody comprising any of the following (1) to (5):
(1) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 4, 5, and 6, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 7, 8, and 9, respectively;
(2) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 12, 13, and 14, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 15, 16, and 17, respectively;
(3) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 20, 21, and 22, respectively, and light chain CDR1, light chain CDR2, and

light chain CDR3 represented by SEQ ID NOs: 23, 24, and 25, respectively;
(4) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 28, 29, and 30, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 31, 32, and 33, respectively; and
(5) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 36, 37, and 38, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 39, 40, and 41, respectively.

13. The method according to any of claims 10 to 12, wherein the anti-GPC3 antibody comprises any of the following (1) to (6):
(1) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region represented by SEQ ID NO: 51;
(2) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region selected from the group of light chain variable regions represented by SEQ ID NOs: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, and 66;

(3) a heavy chain variable region represented by SEQ ID NO: 67 and a light chain variable region represented by SEQ ID NO: 68;
(4) a heavy chain variable region represented by SEQ ID NO: 69 and a light chain variable region represented by SEQ ID NO: 70;
(5) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 72; and
(6) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 73.

14. The method according to claim 10, wherein the GPC3-targeting drug comprises an anti-GPC3 antibody conjugated with a cytotoxic substance.

15. A GPC3-targeting drug which is to be administered to a cancer patient in which the number of an immunocyte or an expression level of a molecule expressed on the immunocyte is a predetermined value.

16. The GPC3-targeting drug according to claim 15, wherein the number of an immunocyte or the expression level of a molecule expressed on the immunocyte is the number of an immunocyte or an expression level of a

molecule expressed on the immunocyte in a biological sample isolated from the cancer patient.

17. The drug according to claim 16, wherein the biological sample is peripheral blood isolated from the cancer patient.

18. The drug according to any of claims 15 to 17, wherein the immunocyte is at least one cell selected from a leukocyte, a monocyte, a neutrophil, and a lymphocyte.

19. The drug according to claim 18, wherein the lymphocyte is at least one lymphocyte cell selected from a CD45+ lymphocyte, a CD3+ T cell, a CD4+ T cell, and a CD8+ T cell.

20. The drug according to claim 18, wherein the lymphocyte is at least one lymphocyte cell selected from a CD16+ NK cell, an NKp46+ NK cell, and a CD56-/CD16+ NK cell.

21. The drug according to any of claims 15 to 17, wherein the molecule expressed on the immunocyte is CD16 or CD107a.

22. The drug according to any of claims 15 to 21, wherein the patient has at least one amino acid

polymorphism that results in Val at residue 158 of FcγRIIIA and/or at least one amino acid polymorphism that results in His at residue 131 of FcγRIIA.

23. The drug according to any of claims 15 to 22, wherein the cancer patient is a liver cancer patient.

24. The drug according to any of claims 15 to 23, wherein the GPC3-targeting drug is administered to achieve a blood trough level of 200 μg/ml or higher in the cancer patient.

25. The drug according to any of claims 15 to 24, wherein the GPC3-targeting drug comprises an anti-GPC3 antibody as an active ingredient.

26. The drug according to claim 25, wherein the anti-GPC3 antibody has antibody-dependent cellular cytotoxicity (ADCC) activity and/or complement-dependent cytotoxicity (CDC) activity.

27. The drug according to claim 25 or 26, wherein the anti-GPC3 antibody is an anti-GPC3 chimeric antibody or a humanized anti-GPC3 antibody comprising any of the following (1) to (5):
(1) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 4, 5, and 6, respectively,

and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 7, 8, and 9, respectively;
(2) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 12, 13, and 14, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 15, 16, and 17, respectively;
(3) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 20, 21, and 22, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 23, 24, and 25, respectively;
(4) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 28, 29, and 30, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 31, 32, and 33, respectively; and
(5) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 36, 37, and 38, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 39, 40, and 41, respectively.

28. The drug according to any of claims 25 to 27, wherein the anti-GPC3 antibody comprises any of the following (1) to (6):

(1) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region represented by SEQ ID NO: 51;
(2) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region selected from the group of light chain variable regions represented by SEQ ID NOs: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, and 66;
(3) a heavy chain variable region represented by SEQ ID NO: 67 and a light chain variable region represented by SEQ ID NO: 68;
(4) a heavy chain variable region represented by SEQ ID NO: 69 and a light chain variable region represented by SEQ ID NO: 70;
(5) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 72; and
(6) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 73.

29. The drug according to claim 25, wherein the GPC3-targeting drug comprises an anti-GPC3 antibody conjugated with a cytotoxic substance.

30. A preparation for GPC3-targeting treatment, comprising an instruction stating that the preparation is to be further administered to a cancer patient having a predetermined value of the number of an immunocyte or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the cancer patient before the start of GPC3-targeting drug therapy.

31. A preparation for GPC3-targeting treatment, comprising an instruction stating that the preparation is to be further administered to a cancer patient having a predetermined value of the number of an immunocyte or an expression level of a molecule expressed on the immunocyte in a biological sample isolated from the cancer patient after the start of GPC3-targeting drug therapy.

32. The preparation according to claim 30 or 31, wherein the biological sample is peripheral blood isolated from the cancer patient.

33. The preparation according to any of claims 30 to 32, wherein the immunocyte is at least one cell selected from a leukocyte, a monocyte, a neutrophil, and a lymphocyte.

34. The preparation according to claim 33, wherein the lymphocyte is at least one lymphocyte cell selected from a CD45+ lymphocyte, a CD3+ T cell, a CD4+ T cell, and a CD8+ T cell.

35. The preparation according to claim 33, wherein the lymphocyte is at least one lymphocyte cell selected from a CD16+ NK cell, an NKp46+ NK cell, and a CD56-/CD16+ NK cell.

36. The preparation according to any of claims 30 to 32, wherein the molecule expressed on the immunocyte is CD16 or CD107a.

37. The preparation according to any of claims 30 to 36, wherein the patient has at least one amino acid polymorphism that results in Val at residue 158 of FcγRIIIA and/or at least one amino acid polymorphism that results in His at residue 131 of FcγRIIA.

38. The preparation according to any of claims 30 to 37, wherein the cancer patient is a liver cancer patient.

39. The preparation according to any of claims 30 to 38, wherein the GPC3-targeting drug is administered to achieve a blood trough level of 200 μg/ml or higher in the cancer patient.

40. The preparation according to any of claims 30 to 39, wherein the GPC3-targeting drug comprises an anti-GPC3 antibody as an active ingredient.

41. The preparation according to claim 40, wherein the anti-GPC3 antibody has antibody-dependent cellular cytotoxicity (ADCC) activity and/or complement-dependent cytotoxicity (CDC) activity.

42. The preparation according to claim 40 or 41, wherein the anti-GPC3 antibody is an anti-GPC3 chimeric antibody or a humanized anti-GPC3 antibody comprising any of the following (1) to (5):
(1) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 4, 5, and 6, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 7, 8, and 9, respectively;
(2) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 12, 13, and 14, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 15, 16, and 17, respectively;
(3) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 20, 21, and 22, respectively, and light chain CDR1, light chain CDR2, and

light chain CDR3 represented by SEQ ID NOs: 23, 24, and 25, respectively;
(4) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 28, 29, and 30, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 31, 32, and 33, respectively; and
(5) heavy chain CDR1, heavy chain CDR2, and heavy chain CDR3 represented by SEQ ID NOs: 36, 37, and 38, respectively, and light chain CDR1, light chain CDR2, and light chain CDR3 represented by SEQ ID NOs: 39, 40, and 41, respectively.

43. The preparation according to any of claims 40 to 42, wherein the anti-GPC3 antibody comprises any of the following (1) to (6):
(1) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region represented by SEQ ID NO: 51;
(2) a heavy chain variable region selected from the group of heavy chain variable regions represented by SEQ ID NOs: 44, 45, 46, 47, 48, 49, and 50 and a light chain variable region selected from the group of light chain variable regions represented by SEQ ID NOs: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, and 66;

(3) a heavy chain variable region represented by SEQ ID NO: 67 and a light chain variable region represented by SEQ ID NO: 68;
(4) a heavy chain variable region represented by SEQ ID NO: 69 and a light chain variable region represented by SEQ ID NO: 70;
(5) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 72; and
(6) a heavy chain variable region represented by SEQ ID NO: 71 and a light chain variable region represented by SEQ ID NO: 73.

44. The preparation according to claim 40, wherein the GPC3-targeting drug comprises an anti-GPC3 antibody conjugated with a cytotoxic substance.

45. A method for treating cancer comprising administering a GPC3-targeting drug to a patient determined by the method according to any of claims 1 to 14.