[DESCRIPTION]

[Title of Invention]

IMMUNITY ENHANCING AGENT FOR CANCER BY ALLERGIN-1 ANTAGONIST

[Technical Field]

[0001] The present invention relates to an immunity enhancing agent for cancer, containing an Allergin-1 antagonist as an active ingredient. More specifically, the present invention relates to an agent for suppression of progress of, suppression of recurrence of and/or treatment of cancer, characterized by administration of an Allergin-1 antagonist alone or a combination thereof with an anti-cancer agent.

[Background Art]

[0002] Different from conventional therapies by surgery, radiotherapy or drug therapy by anti-cancer agents or molecular targeting agents, cancer immunotherapy is to suppress progress of cancer or treat cancer by acting on the immune surveillance intrinsic to cancer patients, thereby enhancing the immunity against cancer. As a result of recent researches on cancer immunity, it has been elucidated that the immunosuppressive environment surrounding a cancer site is involved in progress of cancer and cancer per se utilizes the system for avoiding the immune surveillance. As the molecules utilized for the avoidance system, so-called immune checkpoint molecules such as CTLA-4 and PD-1 or PD-L1, which is a ligand thereof, are known (PTL 1 and 2), and the inhibitors have

already exhibited significant clinical results.

[0003] However, it is also true that there are still cancer patients for whom sufficient therapeutic effects are not observed even with the immune checkpoint inhibitors. Thus, there is an urgent need for novel therapies for the cancer patients and functional understanding of target molecules crucial for establishment of the therapies.

[0004] Meanwhile, Allergin-1 involved in the present invention is a membrane-associated receptor having an ITIM domain in the intracellular region and an extracellular immunoglobulin-like structure and is strongly expressed on mast cells. It is known from analyses of the molecule using knockout mice that the molecule suppresses allergic reactions such as suppressing degranulation via IgE receptor signalling, thereby suppressing anaphylaxis, or suppressing asthma reaction induced by mite allergens (NPL 1, 2 and 3).

[0005] However, it is not sufficiently known that the molecule suppresses cancer immunity.

[Citation List]

[Patent Literatures]

[0006]

[PTL 1] WO 2006/121168

[PTL 2] Japanese Patent Application Publication No. 2006-340714

[Non Patent Literature]

[0007]

[NPL 1] Nature Immunology, 2010, Vol.11, No.7, p.601-608

[NPL 2] PLOS ONE, 2013, Vol.8, No.10, e76160

[NPL 3] Allergology & Immunology, 2011, Vol.18, No.4, p.506-514

[Summary of Invention]

[Technical Problem]

[0008] An object of the present invention is to provide an agent for suppression of progress of, suppression of recurrence of and/or treatment of cancer, containing a novel active ingredient capable of enhancing the immunity against cancer.

[Solution to Problem]

[0009] The inventors of the present invention carried out extensive studies and as a result, found out that an antagonist to Allergin-1 can solve the above problem, thereby completing the present invention.

[0010] Thus, the present invention is as follows:

[1] An immunity enhancing agent for cancer, containing an Allergin-1 antagonist as an active ingredient.

[2] The agent according to the preceding item [1], for use in suppression of progress of, suppression of recurrence of and/or treatment of cancer.

[3] An agent for suppression of progress of, suppression of recurrence of and/or treatment of cancer, containing an Allergin-1 antagonist as an active ingredient.

[4] The agent according to any one of the preceding items [1]

to [3], wherein the Allergin-1 antagonist suppresses immunosuppressive intracellular signalling of Allergin-1.

[5] The agent according to any one of the preceding items [1] to [4], wherein the Allergin-1 antagonist is an anti-Allergin-1 antibody, an Allergin-1 binding protein or an Allergin-1-fusion protein.

[6] The agent according to the preceding item [5], wherein the anti-Allergin-1 antibody is an anti-human Allergin-1 antibody.

[7] The agent according to the preceding item [5] or [6], wherein the anti-Allergin-1 antibody is a monoclonal antibody.

[8] The agent according to the preceding item [7], wherein the anti-Allergin-1 monoclonal antibody is of IgG_1 or IgG_4 isotype.

[9] The agent according to the preceding item [7] or [8], wherein the anti-Allergin-1 monoclonal antibody is an antibody fragment selected from the group consisting of Fab, Fab', Fv, scFv and $(Fab')_2$ fragments.

[10] The agent according to any one of the preceding items [7] to [9], wherein the anti-Allergin-1 monoclonal antibody is a humanized or human antibody.

[11] The agent according to the preceding item [7], wherein the anti-Allergin-1 monoclonal antibody is a humanized or human anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody.

[12] The agent according to any one of the preceding items [7] to [11], wherein the anti-Allergin-1 monoclonal antibody binds to human Allergin-1 with Kd value of 5×10^{-8} M or less.

[13] The agent according to any one of the preceding items [7]

to [11], wherein the anti-Allergin-1 monoclonal antibody binds to human Allergin-1 with Kd value of 1×10^{-8} M or less.

[14] The agent according to any one of the preceding items [7] to [11], wherein the anti-Allergin-1 monoclonal antibody binds to human Allergin-1 with Kd value of 5×10^{-9} M or less.

[15] The agent according to any one of the preceding items [7] to [11], wherein the anti-Allergin-1 monoclonal antibody binds to human Allergin-1 with Kd value of 1×10^{-9} M or less.

[16] The agent according to the preceding item [5] or [6], wherein the anti-Allergin-1 antibody is an Allergin-1 multispecific antibody recognizing two or more different epitopes present on one Allergin-1 molecule.

[17] The agent according to any one of the preceding items [2] to [16], wherein the cancer is solid cancer or hematologic cancer.

[18] The agent according to the preceding item [17], wherein the solid cancer is one or more cancers selected from malignant melanoma, non-small cell lung cancer, small cell lung cancer, head and neck cancer, renal cell cancer, clear cell renal cell cancer, breast cancer, ovarian cancer, ovarian clear cell adenocarcinoma, bone and soft tissue sarcoma, glioblastoma, gliosarcoma, nasopharyngeal cancer, uterine cancer, anal cancer, colorectal cancer, hepatocellular cancer, esophageal cancer, pancreatic cancer, stomach cancer, urothelial cancer, prostate cancer, fallopian tube cancer,

primary peritoneal cancer, pleural mesothelioma and myeloproliferative syndrome.

[19] The agent according to the preceding item [17], wherein the hematologic cancer is one or more cancers selected from multiple myeloma, non-Hodgkin lymphoma, Hodgkin lymphoma, acute myeloid leukaemia and chronic myeloid leukaemia.

[20] The agent according to any one of the preceding items [2] to [19], which is administered to a cancer patient with insufficient therapeutic efficacy by an anti-cancer drug.

[21] The agent according to the preceding item [20], wherein the anti-cancer drug is a tumor immunotherapeutic agent.

[22] The agent according to the preceding item [21], wherein the tumor immunotherapeutic agent is one or more drugs selected from an anti-PD-1 antibody, an anti-PD-L1 antibody, an anti-PD-L2 antibody, a PD-L1 fusion protein, a PD-L2 fusion protein, an anti-CTLA-4 antibody, an anti-LAG-3 antibody, an anti-Tim3 antibody, an anti-KIR antibody, an anti-BTLA antibody, an anti-TIGIT antibody, an anti-VISTA antibody, an anti-CD137 antibody, an anti-OX40 antibody, an anti-HVEM antibody, an anti-CD27 antibody, an anti-GITR antibody, an anti-CD28 antibody, an anti-CCR4 antibody and an anti-CD4 antibody.

[23] The agent according to the preceding item [22], wherein the anti-PD-1 antibody is Nivolumab, REGN-2810, Pembrolizumab, PDR-001, BGB-A317, STI-A1110 or AMP-514.

[24] The agent according to the preceding item [22], wherein

the anti-PD-L1 antibody is Atezolizumab, Avelumab, Durvalumab or BMS-936559.

[25] The agent according to the preceding item [22], wherein the anti-CTLA-4 antibody is Ipilimumab or Tremelimumab.

[26] The agent according to the preceding item [22], wherein the PD-L2 fusion protein is AMP-224.

[27] The agent according to any one of the preceding items [1] to [26], wherein one or more anti-cancer drugs are further administered.

[28] The agent according to the preceding item [27], wherein the Allergin-1 antagonist and the anti-cancer drug in different preparations are administered.

[29] The agent according to the preceding item [28], wherein the anti-cancer drug is administered prior to administration of the Allergin-1 antagonist.

[30] The agent according to the preceding item [28], wherein the Allergin-1 antagonist is administered prior to administration of the anti-cancer drug.

[31] The agent according to any one of the preceding items [27] to [30], wherein there is a period when the Allergin-1 antagonist and the anti-cancer drug are administered simultaneously.

[32] The agent according to the preceding item [27] or [28], wherein the Allergin-1 antagonist and the anti-cancer drug are administered simultaneously.

[33] The agent according to the preceding items [27] or [32],

wherein the Allergin-1 antagonist and the anti-cancer drug in one preparation is administered.

[34] The agent according to any one of the preceding items [27] to [33], wherein the anti-cancer drug is a tumor immunotherapeutic agent.

[35] The agent according to the preceding item [34], wherein the tumor immunotherapeutic agent is one or more selected from an anti-PD-1 antibody, an anti-PD-L1 antibody, an anti-PD-L2 antibody, a PD-L1 fusion protein, a PD-L2 fusion protein, an anti-CTLA-4 antibody, an anti-LAG-3 antibody, an anti-Tim3 antibody, an anti-KIR antibody, an anti-BTLA antibody, an anti-TIGIT antibody, an anti-VISTA antibody, an anti-CD137 antibody, an anti-OX40 antibody, an anti-HVEM antibody, an anti-CD27 antibody, an anti-GITR antibody, an anti-CD28 antibody, an anti-CCR4 antibody and an anti-CD4 antibody.

[36] The agent according to the preceding item [35], wherein the anti-PD-1 antibody is Nivolumab, REGN-2810, Pembrolizumab, PDR-001, BGB-A317, STI-A1110 or AMP-514.

[37] The agent according to the preceding item [35], wherein the anti-PD-L1 antibody is Atezolizumab, Avelumab, Durvalumab or BMS-936559.

[38] The agent according to the preceding item [35], wherein the anti-CTLA-4 antibody is Ipilimumab or Tremelimumab.

[39] The agent according to the preceding item [35], wherein the PD-L2 fusion protein is AMP-224.

[40] The agent according to the preceding item [35], wherein

the anti-CD4 antibody is IT1208.

[41] The agent according to any one of the preceding items [1] to [40], wherein the Allergin-1 antagonist enhances production of type I interferon (such as interferon-α and/or interferon-β).

[42] The agent according to any one of the preceding item [1] to [41], wherein the Allergin-1 antagonist stimulates proliferation of CD8 positive T cells.

[43] The agent according to any one of the preceding items [1] to [42], wherein the Allergin-1 antagonist activates CD8 positive T cells.

[44] An immunity enhancing agent for cancer, containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody as an active ingredient, wherein the cancer is/are one or more selected from malignant melanoma, non-small cell lung cancer, small cell lung cancer, head and neck cancer, renal cell cancer, clear cell renal cell cancer, breast cancer, ovarian cancer, ovarian clear cell adenocarcinoma, bone and soft tissue sarcoma, glioblastoma, gliosarcoma, nasopharyngeal cancer, uterine cancer, anal cancer, colorectal cancer, hepatocellular cancer, esophageal cancer, pancreatic cancer, stomach cancer, urothelial cancer, prostate cancer, fallopian tube cancer, primary peritoneal cancer, pleural mesothelioma and myeloproliferative syndrome.

[45] An immunity enhancing agent for cancer, containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or

IgG_4 antibody as an active ingredient, wherein the cancer is/are one or more selected from multiple myeloma, malignant lymphoma (such as non-Hodgkin lymphoma (such as follicular lymphoma and diffuse large B-cell lymphoma) and Hodgkin lymphoma) and leukaemia (such as acute myeloid leukaemia and chronic myeloid leukaemia).

[46] An agent for suppression of progress of, suppression of recurrence of and/or treatment of cancer, containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody as an active ingredient, wherein the cancer is/areone or more selected from malignant melanoma, non-small cell lung cancer, small cell lung cancer, head and neck cancer, renal cell cancer, clear cell renal cell cancer, breast cancer, ovarian cancer, ovarian clear cell adenocarcinoma, bone and soft tissue sarcoma, glioblastoma, gliosarcoma, nasopharyngeal cancer, uterine cancer, anal cancer, colorectal cancer, hepatocellular cancer, esophageal cancer, pancreatic cancer, stomach cancer, urothelial cancer, prostate cancer, fallopian tube cancer, primary peritoneal cancer, pleural mesothelioma and myeloproliferative syndrome.

[47] An agent for suppression of progress of, suppression of recurrence of and/or treatment of cancer, containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody as an active ingredient, wherein the cancer is/are one or more selected from multiple myeloma, malignant lymphoma (such as non-Hodgkin lymphoma (such as follicular lymphoma and

diffuse large B-cell lymphoma) and Hodgkin lymphoma) and leukaemia (such as acute myeloid leukaemia and chronic myeloid leukaemia).

[48] An agent for suppression of progress of, suppression of recurrence of and/or treatment of cancer, containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody as an active ingredient, wherein the agent is administered to a cancer patient with insufficient therapeutic efficacy by a tumor immunotherapeutic agent, and wherein the cancer is/are one or more selected from malignant melanoma, non-small cell lung cancer, small cell lung cancer, head and neck cancer, renal cell cancer, clear cell renal cell cancer, breast cancer, ovarian cancer, ovarian clear cell adenocarcinoma, bone and soft tissue sarcoma, glioblastoma, gliosarcoma, nasopharyngeal cancer, uterine cancer, anal cancer, colorectal cancer, hepatocellular cancer, esophageal cancer, pancreatic cancer, stomach cancer, urothelial cancer, prostate cancer, fallopian tube cancer, primary peritoneal cancer, pleural mesothelioma and myeloproliferative syndrome.

[49] An agent for suppression of progress of, suppression of recurrence of and/or treatment of cancer, containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody as an active ingredient, wherein the agent is administered to a cancer patient with insufficient therapeutic efficacy by a tumor immunotherapeutic agent, and wherein the cancer is/are one or more selected from multiple myeloma,

malignant lymphoma (such as non-Hodgkin lymphoma (such as follicular lymphoma and diffuse large B-cell lymphoma) and Hodgkin lymphoma) and leukaemia (such as acute myeloid leukaemia and chronic myeloid leukaemia).

[50] An agent for suppression of progress of, suppression of recurrence of and/or treatment of one or more cancers selected from malignant melanoma, non-small cell lung cancer, small cell lung cancer, head and neck cancer, renal cell cancer, clear cell renal cell cancer, breast cancer, ovarian cancer, ovarian clear cell adenocarcinoma, bone and soft tissue sarcoma, glioblastoma, gliosarcoma, nasopharyngeal cancer, uterine cancer, anal cancer, colorectal cancer, hepatocellular cancer, esophageal cancer, pancreatic cancer, stomach cancer, urothelial cancer, prostate cancer, fallopian tube cancer, primary peritoneal cancer, pleural mesothelioma and myeloproliferative syndrome, containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody as an active ingredient, wherein the agent is administered with one or more tumor immunotherapeutic agents selected from an anti-PD-1 antibody, an anti-PD-L1 antibody, an anti-PD-L2 antibody, a PD-L1 fusion protein, a PD-L2 fusion protein, an anti-CTLA-4 antibody, an anti-LAG-3 antibody, an anti-Tim3 antibody, an anti-KIR antibody, an anti-BTLA antibody, an anti-TIGIT antibody, an anti-VISTA antibody, an anti-CD137 antibody, an anti-OX40 antibody, an anti-HVEM antibody, an anti-CD27 antibody, an anti-GITR antibody, an anti-CD28 antibody, an

anti-CCR4 antibody and an anti-CD4 antibody.

[51] An agent for suppression of progress of, suppression of recurrence of and/or treatment of one or more cancers selected from multiple myeloma, malignant lymphoma (such as non-Hodgkin lymphoma (such as follicular lymphoma and diffuse large B-cell lymphoma) and Hodgkin lymphoma) and leukaemia (such as acute myeloid leukaemia and chronic myeloid leukaemia), containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody as an active ingredient, wherein the agent is administered with one or more tumor immunotherapeutic agents selected from an anti-PD-1 antibody, an anti-PD-L1 antibody, an anti-PD-L2 antibody, a PD-L1 fusion protein, a PD-L2 fusion protein, an anti-CTLA-4 antibody, an anti-LAG-3 antibody, an anti-Tim3 antibody, an anti-KIR antibody, an anti-BTLA antibody, an anti-TIGIT antibody, an anti-VISTA antibody, an anti-CD137 antibody, an anti-OX40 antibody, an anti-HVEM antibody, an anti-CD27 antibody, an anti-GITR antibody, an anti-CD28 antibody, an anti-CCR4 antibody and an anti-CD4 antibody.

[52] An agent for suppression of progress of, suppression of recurrence of and/or treatment of one or more cancers selected from malignant melanoma, non-small cell lung cancer, small cell lung cancer, head and neck cancer, renal cell cancer, clear cell renal cell cancer, breast cancer, ovarian cancer, ovarian clear cell adenocarcinoma, bone and soft tissue sarcoma, glioblastoma, gliosarcoma, nasopharyngeal cancer,

uterine cancer, anal cancer, colorectal cancer, hepatocellular cancer, esophageal cancer, pancreatic cancer, stomach cancer, urothelial cancer, prostate cancer, fallopian tube cancer, primary peritoneal cancer, pleural mesothelioma and myeloproliferative syndrome, containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody as an active ingredient, wherein the agent is administered with one or more anti-PD-1 antibodies selected from Nivolumab, REGN-2810, Pembrolizumab, PDR-001, BGB-A317, AMP-514, ANB011 and STI-A1110.

[53] An agent for suppression of progress of, suppression of recurrence of and/or treatment of one or more cancers selected from multiple myeloma, malignant lymphoma (such as non-Hodgkin lymphoma (such as follicular lymphoma and diffuse large B-cell lymphoma) and Hodgkin lymphoma) and leukaemia (such as acute myeloid leukaemia and chronic myeloid leukaemia), containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody as an active ingredient, wherein the agent is administered with one or more anti-PD-1 antibodies selected from Nivolumab, REGN-2810, Pembrolizumab, PDR-001, BGB-A317, AMP-514, ANB011 and STI-A1110.

[54] An agent for suppression of progress of, suppression of recurrence of and/or treatment of one or more cancers selected from malignant melanoma, non-small cell lung cancer, small cell lung cancer, head and neck cancer, renal cell cancer, clear cell renal cell cancer, breast cancer, ovarian cancer,

ovarian clear cell adenocarcinoma, bone and soft tissue sarcoma, glioblastoma, gliosarcoma, nasopharyngeal cancer, uterine cancer, anal cancer, colorectal cancer, hepatocellular cancer, esophageal cancer, pancreatic cancer, stomach cancer, urothelial cancer, prostate cancer, fallopian tube cancer, primary peritoneal cancer, pleural mesothelioma and myeloproliferative syndrome, containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody as an active ingredient, wherein the agent is administered with one or more anti-PD-L1 antibodies selected from Atezolizumab, Avelumab, Durvalumab and BMS-936559.

[55] An agent for suppression of progress of, suppression of recurrence of and/or treatment of one or more cancers selected from multiple myeloma, malignant lymphoma (such as non-Hodgkin lymphoma (such as follicular lymphoma and diffuse large B-cell lymphoma) and Hodgkin lymphoma) and leukaemia (such as acute myeloid leukaemia and chronic myeloid leukaemia), containing a human or humanized anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody as an active ingredient, wherein the agent is administered with one or more anti-PD-L1 antibodies selected from Atezolizumab, Avelumab, Durvalumab and BMS-936559.

[56] An Allergin-1 antagonist for enhancing the immunity against cancer.

[57] Use of an Allergin-1 antagonist in production of an immunity enhancing agent for cancer.

[58] A method for enhancing the immunity against cancer,

comprising administering an effective dosage of an Allergin-1 antagonist to a patient in need of cancer therapy.

[59] An Allergin-1 antagonist for suppression of progress of, suppression of recurrence of and/or treatment of cancer.

[60] Use of an Allergin-1 antagonist in production of an agent for suppression of progress of, suppression of recurrence of and/or treatment of cancer.

[61] A method for suppressing progress of, suppressing recurrence of and/or treating cancer, comprising administering an effective dosage of an Allergin-1 antagonist to a patient in need of cancer therapy.

[Advantageous Effects of Invention]

[0011] The Allergin-1 antagonist according to the present invention is capable of enhancing the immunity against cancer and may be used for suppression of progress of, suppression of recurrence of and/or treatment of cancer.

[Brief Description of Drawings]

[0012]

[Fig. 1]

Fig. 1 shows the structure of an Allergin-1 targeting vector and the results of Southern blotting of generated Allergin-1 knockout (hereinafter also referred to as Allergin-1KO or Alg1-KO) heterozygous and homozygous mice.

[Fig. 2]

Fig. 2 shows the transition (median and mean value) of the MC38 tumor volume in C57BL/6 mice (WT mice) and Allergin-1KO

mice carrying mouse colorectal cancer cell line MC38.

[Fig. 3]

Fig. 3 shows the transition (median and mean value) of the B16F10 tumor volume in C57BL/6 mice (WT mice) and Allergin-1KO mice carrying mouse melanoma cell line B16F10.

[Fig. 4]

Fig. 4 shows the transition (right panel) of the MC38 tumor volume after administration of an anti-mouse PD-1 antibody 4H2 (10 mg/kg) to Allergin-1KO mice carrying MC38. In the figure, "mIgG" means a control antibody.

[Fig. 5]

Fig. 5 shows the results of tumor-infiltrating lymphocytes analysis in C57BL/6 mice (WT mice) and Allergin-1KO mice carrying MC38.

[Fig. 6]

Fig. 6 shows the results of blood IFNα measurement after administration of a TLR9 agonist (CpG) to C57BL/6 mice (WT mice) and Allergin-1KO mice.

[Fig. 7]

Fig. 7 shows the transition of the MC38 tumor volume after administration of an anti-mouse PD-1 antibody 4H2 (3 mg/kg) to C57BL/6 mice (WT mice) and Allergin-1KO mice carrying MC38. In the figure, "mIgG" means a control antibody.

[Fig. 8]

Fig. 8 shows the transition of the MC38 tumor volume after administration of an anti-mouse PD-1 antibody 4H2 (1 mg/kg) to

C57BL/6 mice (WT mice) and Allergin-1KO mice carrying MC38.

[Fig. 9]

Fig. 9 shows the transition of the MC38 tumor volume after administration of an anti-mouse CD4 antibody GK1.5 (5 mg/kg) to C57BL/6 mice (WT mice) and Allergin-1KO mice carrying MC38. In the figure, "rat IgG_{2b}" means a control antibody.

[Fig. 10]

Fig. 10 shows the transition of the B16F10 tumor volume after administration of an anti-mouse CD4 antibody GK1.5 (5 mg/kg) to C57BL/6 mice (WT mice) and Allergin-1KO mice carrying B16F10.

[Fig. 11]

Fig. 11 shows the results of blood IFNα (in the Figure A) and IFNβ (in the Figure B) measurements after administration of a TLR7 agonist (polyuridine) to C57BL/6 mice (WT) and Allergin-1KO mice (KO).

[Fig. 12]

Fig. 12 shows the results of IFNβ measurement in culture supernatants produced after addition of a STING agonist (cGAMP) to intraperitoneal macrophages collected from C57BL/6 mice (WT) and Allergin-1KO mice.

[Fig. 13]

Fig. 13 shows the transition of the B16F10 tumor volume after administration of an anti-mouse PD-1 antibody 4H2 (10 mg/kg) to C57BL/6 mice (WT mice) and Allergin-1KO mice carrying

B16F10.

[Fig. 14]

Fig. 14 shows the transition of the mean tumor volume of MC38 (A) and B16F10 (B), respectively, in C57BL/6 mice (WT mice) and Allergin-1KO mice carrying MC38 and B16F10.

[Description of Embodiments]

[0013] Allergin-1 is also denoted as MILR1 and includes three splicing variants in humans which are "Allergin-1L", "Allergin-1S1" and "Allergin-1S2" which are membrane-associated proteins having amino acid sequences represented by GenBank accession Nos. NP_001078892.1, AB542951.1 and AB542952.1, respectively. The mouse homologue thereof is denoted as MCA32 having an amino acid sequence represented by GenBank accession No. AB542953.1.

[0014] In the present specification, the term "Allergin-1" is used to include, unless otherwise stated, human Allergin-1 and splicing variants thereof as well as mammalian homologues identified by now.

[0015] As used herein, the term "Allergin-1 antagonist" means a substance which suppresses, decreases or completely inhibits intrinsic physiological functions of Allergin-1. Examples of the "Allergin-1 antagonist" include a substance which suppresses, decreases or completely inhibits immunosuppressive intracellular signalling of Allergin-1 by antagonizing a natural ligand of Allergin-1. Specifically, examples thereof include an anti-Allergin-1 antibody, an

Allergin-1 fusion protein, an Allergin-1 binding protein, a peptide, a low molecular compound and the like. The Allergin-1 fusion protein means a protein molecule containing a whole or partial extracellular domain of Allergin-1, which suppresses, decreases or completely inhibits immunosuppressive intracellular signalling of Allergin-1 by antagonizing binding of, for example, a natural ligand of Allergin-1 to Allergin-1, and examples thereof include a whole or partial extracellular domain of Allergin-1 bound to an Fc region of an antibody. The Allergin-1 binding protein means a protein which binds to Allergin-1, antagonizes binding of, for example, a natural ligand of Allergin-1 to Allergin-1 and thus suppresses, decreases or completely inhibits immunosuppressive intracellular signalling of Allergin-1. Examples thereof include a natural ligand of Allergin-1, a whole or partial extracellular domain thereof, a fusion protein based on the foregoing, a scaffold protein and the like. Examples of the scaffold protein to Allergin-1 include Adnectin (WO 2001/64942), Affibody® (WO 95/19374, WO 2000/63243), Anticalin® (WO 99/16873), Avimer (Nature Biotechnology (2005), Vol.23, pp.1556-1561), DARPin (Nature Biotechnology (2004), Vol.22, pp.575-582), LRRP (Nature (2004), Vol.430, No.6996, pp.174-180), Affilin® (WO 2001/04144 and WO 2004/106368), Affitin (Journal of molecular biology (2008), Vol.383, No.5, pp.1058-1068), Fynomer (WO 2011/023685) and the like without limitation. Similarly to the Allergin-1 antagonist, an

antisense RNA or siRNA (small interfering RNA) of Allergin-1, which inhibits gene expression or protein synthesis of Allergin-1, is also useful for suppressing, decreasing or completely inhibiting intrinsic physiological functions of Allergin-1.

[0016] Whether the anti-Allergin-1 antibody or Allergin-1 binding protein among the Allergin-1 antagonist according to the present invention antagonizes a natural ligand of Allergin-1 may be examined, for example, by the following method.

[0017] An Allergin-1 fusion protein is first prepared and a cell line which binds to the fusion protein is sought. With the cell line for which specific binding to the Allergin-1 fusion protein is confirmed, whether or not a substance is the Allergin-1 antagonist can be found by using, as an index, the presence or absence of antagonism of the Allergin-1 antagonist against binding of the Allergin-1 fusion protein to the cells. For example, an Allergin-1 fusion protein binds to a cell line THP-1 derived from human acute monocytic leukaemia, and an Allergin-1 antagonist may be obtained by monitoring an inhibitory activity on binding of the Allergin-1 fusion protein to THP-1.

[0018] As used herein, the term "antibody" includes a full-length antibody, namely a full-length antibody consisting of two heavy chains and two light chains linked via disulphide bonds, as well as an antibody fragment thereof (such as a

single-stranded antibody (such as Fab, Fab', Fv and scFv) and $(Fab')_2$) and a multispecific antibody (such as a bispecific antibody and diabody).

[0019] As used herein, the term "monoclonal antibody" means an antibody consisting of a substantially uniform population having a single binding specificity toward a certain antigen. The monoclonal antibody used for the present invention may be prepared by the hybridoma method (for example, see Kohler and Milstein et al., Nature(1975), 256:495-97, Hongo et al., Hybridoma (1995), 14(3):253-260, Harlow et al., Antibodies: A Laboratory Manual, (Cold Spring Harbor Laboratory Press, second edition; 1988) and Hammerling et al., Monoclonal Antibodies and T-Cell Hybridomas, 563-681 (Elsevier, N.Y., 1981)), the recombinant DNA method (for example, see U.S. Patent No. 4816567), the phage display method (for example, see U.S. Patent Nos. 5223409, 5403484 and 5571698 by Ladner et al., U.S. Patent Nos. 5427908 and 5580717 by Dower et al., U.S. Patent Nos. 5969108 and 6172197 by McCafferty et al., and U.S. Patent Nos. 5885793, 6521404, 6544731, 6555313, 6582915 and 6593081 by Griffiths et al.).

[0020] As used herein, the term "multispecific antibody" means an antibody molecule having binding specificity toward two or more different antigen molecules or epitopes and typically includes a bispecific antibody. The epitopes in this context may be epitopes on two or more different antigen molecules or two or more different epitopes present on one

antigen molecule. Examples of embodiments of the bispecific antibody include a diabody, bispecific sc(Fv)$_2$, a bispecific minibody, bispecific F(ab')$_2$, a bispecific hybrid antibody, a covalent diabody (bispecific DART) (WO 2006/113665 or WO 2008/157379), bispecific (FvCys)$_2$ (J. Immunol., 1992, Vol.149, No.1, p.120-126), a bispecific F(ab'-zipper)$_2$ (J. Immunol., 1992, Vol.148, No.5, p.1547-1553), a bispecific (Fv-zipper)$_2$ (Biochemistry, 1992, Vol.31, No.6, p.1579-1584), a bispecific three-chain antibody (Proc. Natl. Acad. Sci. USA, 1993, Vol.90, No.14, p.6444-6448) and a bispecific mAb^2 (www.f-star.com/technology_mab.html) and the like.

[0021] As used herein, the term "antibody fragment" means a part of a full-length antibody containing at least an antigen binding portion and examples thereof include Fab, Fab', Fv, scFv, F(ab')$_2$ and the like. The antigen binding portion means a smallest unit of an antibody that can bind to an antigen and contains three complementarity-determining regions (CDRs) respectively in a heavy chain variable region and a light chain variable region and framework regions which arrange CDRs so that the combination of the CDRs can recognize a desired antigen.

[0022] As used herein, the term "chimeric antibody" means an antibody containing a variable region sequence and a constant region sequence respectively derived from different mammals. An example is one containing a variable region sequence derived from a mouse antibody and a constant region

sequence derived from a human antibody. The chimeric antibody may be prepared by linking a gene encoding an antibody variable region isolated according to a well-known method from an antibody-producing hybridoma isolated according to the hybridoma method, recombinant DNA method or the phage display method described above to a gene encoding an antibody constant region gene derived from humans by a well-known method (for example, see U.S. Patent No. 4816567 by Cabilly et al.).

[0023] As used herein, the term "humanized antibody" means an antibody containing CDR sequences derived from a germline of a mammal other than humans such as mice, grafted on human framework sequences. The humanized antibody may also be prepared by linking genes encoding antibody CDR regions isolated according to a well-known method from an antibody-producing hybridoma according to the above method to genes encoding antibody framework regions derived from humans by a well-known method (for example, see U.S. Patent Nos. 5225539 and 5530101 by Winter and U.S. Patent Nos. 5585089 and 6180370 by Queen).

[0024] As used herein, the term "human antibody" means an antibody containing a variable region formed with framework regions, CDR regions and a constant region, both of which are derived from a human germline immunoglobulin sequence. The human antibody used in the present invention may be prepared by a method in which mice transformed to produce a human antibody is used, such as Humab mice (for example, see U.S.

Patent Nos. 5545806, 5569825, 5625126, 5633425, 5789650, 5877397, 5661016, 5814318, 5874299 and 5770429 by Lonberg and Kay et al.), KM mice (for example, see WO 2002/43478 by Ishida et al.), Xeno mice (for example, see U.S. Patent Nos. 5939598, 6075181, 6114598, 6150584 and 6162963) and Tc mice (for example, see Tomizuka et al., Proc. Natl. Acad. Sci. USA (2000):722-727). The human antibody may also be prepared by using SCID mice (for example, see U.S. Patent Nos. 5476996 and 5698767 by Wilson et al.) in which human immune cells were reconstructed so as to trigger human antibody reaction by immunisation. The human antibody used in the present invention may also be prepared by the phage display method described above.

[0025] As used herein, the term "isotype" is used to denote an antibody class (such as IgM or IgG) encoded by a heavy chain constant region gene. The anti-Allergin-1 antibody according to the present invention is preferably IgG_1 or IgG_4. IgG_1 is preferably modified such that an arbitrary amino acid in the heavy chain constant region is substituted, deleted or inserted so that the antibody has eliminated or reduced binding to the Fc receptor. IgG_4 is preferably modified such that an arbitrary amino acid in the heavy chain constant region is substituted, deleted or inserted so that swapping is suppressed.

[0026] As used herein, the term "fusion protein" means a polypeptide having two protein moieties having different

properties which are covalently linked. For example, when a membrane-associated protein is used for a fusion protein, a portion mainly containing an extracellular part of the membrane-associated protein may be bound to the Fc region of an antibody to obtain the fusion protein in order to promote solubilisation of the protein.

[0027] The anti-Allergin-1 antibody which may be selected as the Allergin-1 antagonist of the present invention is an antibody which binds to human Allergin-1 with a dissociation constant (Kd value) of 5×10^{-8} M or less, more preferably binds to human Allergin-1 with Kd value of 1×10^{-8} M or less, still more preferably binds to human Allergin-1 with Kd value of 5×10^{-9} M or less and particularly preferably binds to human Allergin-1 with Kd value of 1×10^{-9} M or less.

[0028] In another embodiment, the anti-Allergin-1 antibody is preferably an anti-human Allergin-1 multispecific antibody which recognizes two or more different epitopes present on one antigen molecule.

[0029] In still another embodiment, the anti-Allergin-1 antibody is preferably an anti-human Allergin-1 monoclonal antibody and still more preferably an anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody.

[0030] As used herein, the term "cancer therapy" or the like encompasses, for example, a therapy which (i) reduces proliferation of cancer cells, (ii) attenuates a symptom

resulting from cancer, (iii) improves the quality of life of a cancer patient, (iv) reduces the dose of another anti-cancer drug or cancer therapy adjuvant which has already been administered and/or (v) is to extend the survival of a cancer patient. The term "suppression of progress of cancer" means to delay the progress of cancer, stabilise a symptom associated with cancer and reverses the progress of a symptom. The term "suppression of recurrence" means to prophylactically prevent recurrence of cancer in a patient whose cancer lesion has been completely or substantially eliminated or removed by cancer therapy or cancer excision.

[0031] The cancer which may be subjected to suppression of progress, suppression of recurrence and/or treatment with the Allergin-1 antagonist includes any solid cancer and hematologic cancer. Examples of the solid cancer for which the Allergin-1 antagonist may be particularly effective include malignant melanoma (such as malignant melanoma in the skin, oral mucosa epithelial and intraorbital), non-small cell lung cancer (such as squamous non-small cell lung cancer and non-squamous non-small cell lung cancer), small cell lung cancer, head and neck cancer, renal cell cancer, clear cell renal cell cancer, breast cancer, ovarian cancer, ovarian clear cell adenocarcinoma, bone and soft tissue sarcoma (such as Ewing sarcoma, childhood rhabdomyosarcoma and uterine leiomyosarcoma), glioblastoma, gliosarcoma, nasopharyngeal cancer, uterine cancer (such as cervical cancer and

endometrial cancer), anal cancer (such as anal canal cancer), colorectal cancer, hepatocellular cancer, esophageal cancer, pancreatic cancer, stomach cancer, urothelial cancer (such as bladder cancer, upper urinary tract cancer, ureteral cancer, renal pelvic cancer and urethral cancer), prostate cancer, fallopian tube cancer, primary peritoneal cancer, pleural mesothelioma and myeloproliferative syndrome. Examples of the hematologic cancer for which the Allergin-1 antagonist may be particularly effective include multiple myeloma, malignant lymphoma (such as non-Hodgkin lymphoma (such as follicular lymphoma and diffuse large B-cell lymphoma) and Hodgkin lymphoma) and leukaemia (such as acute myeloid leukaemia and chronic myeloid leukaemia).

[0032] Other than the above, the effect may also be expected in gallbladder cancer, bile duct cancer, biliary cancer, skin cancer (such as Merkel cell cancer), rectal cancer, colon cancer, testicular cancer (germ-cell cancer), vaginal cancer, vulvar cancer, penile cancer, small intestinal cancer, endocrine cancer, thyroid cancer, parathyroid cancer, adrenal cancer, brain tumor, spinal tumor, Kaposi sarcoma, squamous cell cancer, chronic or acute lymphocytic leukaemia, adult T-cell leukaemia, central nerve system primary malignant lymphoma, myelodysplastic syndrome, cancer in child and cancer of unknown primary.

[0033] The benefit of the Allergin-1 antagonist according to the present invention may be particularly recognized when

it is prescribed to a cancer patient with insufficient therapeutic efficacy by an existing anti-cancer drug (antineoplastic drug). Among others, the benefit of the Allergin-1 antagonist may be particularly recognized when it is prescribed to a cancer patient with insufficient therapeutic efficacy by a tumor immunotherapeutic agent. Examples of the "cancer patient with insufficient therapeutic efficacy by an anti-cancer drug" include patients identified as "progress (PD)" by the tumor reduction effect evaluation RECIST even after a therapy with an existing anti-cancer drug. Examples of the existing anti-cancer drug include an alkylating agent, a platinum preparation, an antimetabolite (such as an antifolate, a pyridine antimetabolite, a purine antimetabolite, a ribonucleotide reductase inhibitor and a nucleotide analogue), a topoisomerase inhibitor, a microtubule polymerization inhibitor, a microtubule depolymerization inhibitor, an antibiotic antineoplastic agent, a cytokine preparation, an antihormone, a molecular targeting drug, a tumor immunotherapeutic agent and the like.

[0034] Examples of the alkylating agent include dacarbazine, nimustine, temozolomide, fotemustine, cyclophosphamide, ifosfamide and the like. Examples of the platinum preparation include cisplatin, carboplatin, oxaliplatin and the like. Examples of the antifolate include pemetrexed, leucovorin, methotrexate and the like. Examples of the pyridine antimetabolite include TS-1®, 5-fluorouracil, UFT,

carmofur, doxifluridine, capecitabine and the like. Examples of the nucleotide analogue include gemcitabine and the like. Examples of the topoisomerase inhibitor include irinotecan, etoposide and the like. Examples of the microtubule polymerization inhibitor include vincristine, vinblastine, vinorelbine and the like. Examples of the microtubule depolymerization inhibitor include docetaxel, paclitaxel and the like. Examples of the antibiotic antineoplastic agent include bleomycin, mitomycin C, epirubicin and the like. Examples of the cytokine preparation include IFN-α 2a, IFN-α 2b, PEG-IFN-α 2b, natural IFN-β, interleukin-2 and the like. Examples of the antihormone include tamoxifen, fulvestrant, goserelin, leuprorelin, anastrozole, letrozole, exemestane and the like. Examples of the molecular targeting drug include imatinib, sorafenib, sunitinib, bevacizumab, gefitinib, erlotinib, crizotinib, temsirolimus, everolimus, axitinib, pazopanib, regorafenib, cetuximab, rituximab, ibrutinib, ofatumumab, panitumumab and the like.

[0035] As used herein, the term "tumor immunotherapy" or the like is a therapy for enhancing the immune reaction for cancer, namely for enhancing the immunity for cancer, thereby suppressing proliferation of cancer or reducing or eliminating cancer. The term "tumor immunotherapeutic agent" means an agent capable of enhancing the immune reaction. Examples of the therapeutic agent include an anti-PD-1 antibody (such as a human anti-human PD-1 monoclonal (neutralizing) antibody (such

as Nivolumab and REGN-2810) and a humanized anti-human PD-1 monoclonal (neutralizing) antibody (such as Pembrolizumab, PDR-001, BGB-A317 and AMP-514 (also known as MEDI0680)), ANB011 (also known as TSR-042) and STI-A1110), an anti-PD-L1 antibody (such as Atezolizumab (also known as RG7446 or MPDL3280A), Avelumab (also known as PF-06834635 or MSB0010718C), Durvalumab (also known as MEDI4736), BMS-936559, STI-1010, STI-1011 and STI-1014), a PD-1 antagonist (such as AUNP-12), an anti-PD-L2 antibody, a PD-L1 fusion protein, a PD-L2 fusion protein (such as AMP-224), an anti-CTLA-4 antibody (such as Ipilimumab and Tremelimumab), an anti-LAG-3 antibody (such as BMS-986016 and LAG525), an anti-Tim3 antibody (such as MBG453), an anti-KIR antibody (such as Lirilumab), an anti-BTLA antibody, an anti-TIGIT antibody, an anti-VISTA antibody, an anti-CD137 antibody (such as Urelumab), an anti-OX40 antibody (such as MEDI6469), an anti-HVEM antibody, an anti-CD27 antibody (such as Varlilumab), an anti-GITR antibody (such as MK-4166 and TRX-518), an anti-CD28 antibody, anti-CCR4 antibody (such as Mogamulizumab), anti-CD4 antibody (such as MTRX-1011A, TRX-1, Ibalizumab, huB-F5, Zanolimumab, 4162W94, Clenoliximab, Keliximab, AD-519, PRO-542, Cedelizumab, TNX-355, Dacetuzumab, Tregalizumab, Priliximab, MDX-CD4, CAMPATH-9 and IT1208), a TLR agonist, a STING agonist (such as MIW815) and the like. The tumor immunotherapeutic agent as used herein does not encompass the Allergin-1 antagonist according to the present invention.

[0036] Nivolumab may be produced according to the method disclosed in WO 2006/121168, Pembrolizumab may be produced according to the method disclosed in WO 2008/156712, BMS-936559 may be produced according to the method disclosed in WO 2007/005874 and Ipilimumab may be produced according to the method disclosed in WO 2001/014424.

[0037] The Allergin-1 antagonist according to the present invention is usually administered systemically or locally in a parenteral form. The dosage may vary according to the age, body weight, symptoms, therapeutic efficacy, manner of administration, treatment period and the like. However, the Allergin-1 antagonist may be usually administered in the range of 0.1 μg/kg to 300 mg/kg and particularly preferably in the range of 0.1 mg/kg to 10 mg/kg per dose per adult one to a few times a day by parenteral administration or by intravenous continuous administration over the period of 1 hour to 24 hours per day. As described above, the dosage may vary according to various conditions. Thus, a sufficient dosage may be less than the above or a higher dosage than the above range may be required.

[0038] The Allergin-1 antagonist according to the present invention may be combined with one or more other agents (mainly an anti-cancer drug) used for treatment of cancer described above in order to (1) suppress the progress of, suppress the recurrence of and/or enhance the therapeutic efficacy on cancer, (2) reduce the dosage of the other

agent(s) used in combination and/or (3) alleviate the side effect of the other agent(s) used in combination. When the Allergin-1 antagonist and the other agent(s) are separately administered, the Allergin-1 antagonist may be administered prior to administration of the other agent(s), the other agent(s) may be administered prior to administration of the Allergin-1 antagonist, or there may be certain a period over which both agents are administered simultaneously. The agents may be administered by the same or different manner of administration. According to the characteristics of the agents, a preparation containing the Allergin-1 antagonist and a preparation containing the other agent(s) may be provided as a kit. The dosage of the other agent(s) may be appropriately selected on the basis of the clinically used dose. The other agent(s) may be administered by combining any two or more agents at appropriate proportions. The other agent(s) encompasses existing agents as well as agents which will be discovered in future.

[0039] Examples of the anti-cancer drug which may be mainly exemplified as the other agent(s) include the anti-cancer drug described above.

[0040] The Allergin-1 antagonist according to the present invention is formulated as an injection or infusion and used. The injection or infusion may be in any form among an aqueous solution, a suspension or an emulsion or may be formulated as a solid agent to be used by addition of a solvent before use

to dissolve, suspend or emulsify the same. Examples of the solvent used for the injection or infusion include distilled water for injection, saline, dextrose solution and an isotonic solution (such as a solution of sodium chloride, potassium chloride, glycerine, mannitol, sorbitol, boric acid, borax or propylene glycol) and the like.

[0041] Examples of a pharmaceutically acceptable carrier which is used for an injection, an infusion or a solid agent to be used by addition of a solvent before use to dissolve, suspend or emulsify the same include a stabiliser, a solubilising agent, a suspending agent, an emulsifying agent, a soothing agent, a buffering agent, a preservative, an antiseptic, a pH controlling agent, an antioxidant and the like. Examples of the stabiliser which may be used include various amino acids, albumin, globulin, gelatine, mannitol, glucose, dextran, ethylene glycol, propylene glycol, polyethylene glycol, ascorbic acid, sodium hydrogen sulphite, sodium thiosulphate, sodium edetate, sodium citrate, dibutylhydroxytoluene and the like. Examples of the solubilising agent which may be used include an alcohol (such as ethanol), a polyalcohol (such as propylene glycol and polyethylene glycol), a nonionic surfactant (such as Polysorbate 80® and HCO-50) and the like. Examples of the suspending agent which may be used include glyceryl monostearate, aluminium monostearate, methylcellulose, carboxymethylcellulose, hydroxymethylcellulose, sodium lauryl

sulphate and the like. Examples of the emulsifying agent which may be used include gum arabic, sodium arginate, tragacanth and the like. Examples of the soothing agent which may be used include benzyl alcohol, chlorobutanol, sorbitol and the like. Examples of the buffering agent which may be used include phosphate buffer, acetate buffer, borate buffer, carbonate buffer, citrate buffer, Tris buffer, glutamate buffer, epsilon aminocapronate buffer and the like. Examples of the preservative which may be used include methyl para-oxybenzoate, ethyl para-oxybenzoate, propyl para-oxybenzoate, butyl para-oxybenzoate, chlorobutanol, benzyl alcohol, benzalkonium chloride, sodium dehydroacetate, sodium edetate, boric acid, borax and the like. Examples of the antiseptic which may be used include benzalkonium chloride, para-oxybenzoic acid, chlorobutanol and the like. Examples of the pH controlling agent which may be used include hydrochloric acid, sodium hydroxide, phosphoric acid, acetic acid and the like. Examples of the antioxidant which may be used include (1) a water-soluble antioxidant such as ascorbic acid, cysteine hydrochloride, sodium bisulphate, sodium metabisulphite and sodium sulphite, (2) an oil-soluble antioxidant such as ascorbyl palmitate, butylated hydroxy anisole, butylated hydroxytoluene, lecithin, propyl gallate and α-tocopherol and (3) a metal chelating agent such as citric acid, ethylenediamine tetraacetic acid, sorbitol, tartaric acid and phosphoric acid.

[0042] The injection or infusion may be produced by sterilising in the final process or by an aseptic procedure such as sterilizing by filtration through a filter and packing in a sterilised container. The injection or infusion may be used by dissolving aseptic powder (which may contain powder of a pharmaceutically acceptable carrier) obtained by vacuum drying or freeze drying in an appropriate solvent before use.

[0043] The present invention is more specifically described by way of Examples hereinbelow which do not limit the scope of the invention. It should be noted that a person skilled in the art can make various changes and modifications on the basis of the description of the present invention and such changes and modifications are also encompassed by the present invention.

[Examples]

[0044] Example 1: Preparation of Allergin-1KO mice

An Allergin-1 targeting vector was constructed. Specifically, the first exon including the initiation codon of Allergin-1 was substituted by a neomycin resistance gene cassette (Fig. 1A). ES cells derived from C57BL/6N mice were transfected with the linearized Allergin-1 targeting vector by electroporation. The cells were subjected to selection by the drug resistance screening and homologous recombined clones were selected by Southern blotting. With the positive clones, chimera mice were prepared by aggregation. Eight-cell stage embryos of the ICR were used as recipient embryos. The occurrence rate of chimera of the obtained chimera mice was

judged based on the coat color of the whole body. The obtained individual chimera mouse was crossed with a C57BL/6N mouse and the F1 offsprings were genetically analysed by Southern blotting to obtain F1 heterozygous individuals. The male and female of the F1 heterozygous individuals were crossed and it was verified that Alg1-KO mice were obtained by genetic analysis using Southern blotting (Fig. 1B).

[0045] As the Allergin-1KO mice did not show particularly apparent phenotype, it is expected that the side effect of the Allergin-1 antagonist may be minor.

[0046] Example 2: Tumor proliferation (MC38) in Allergin-1KO mice

To C57BL/6 mice (WT mice) and Alg1-KO mice, MC38 was subcutaneously transplanted at 2.0×10^5/mouse. The number of mice in one group was 15. The tumor volume of MC38 was measured on day 7, 10, 14, 17, 21 and 24 after transplantation. Fig. 2 shows the transitions of the tumor volume in median (Fig. 2, left panel) and mean ± standard error (Fig. 2, right panel) for each group. In the Allergin-1KO mice, tumor proliferation was significantly suppressed compared to the wild-type mice.

[0047] Example 3: Tumor proliferation (B16F10) in Allergin-1KO mice

To C57BL/6 mice (WT mice) and Alg1-KO mice, B16F10 was subcutaneously transplanted at 2.0×10^5/mouse. The number of

mice in one group was 10. The tumor volume of B16F10 in each group was measured on day 7, 11, 14, 18 and 21, provided that the day of transplantation was day 0. In the anti-mouse PD-1 antibody 4H2 (an antibody prepared according to the method disclosed in Example 12 in WO 2006/121168) administered group, 4H2 was intraperitoneally administered to the WT mice on the day of transplantation and day 6, 12 and 18. Fig. 3 shows the transitions of the tumor volume in median (Fig. 3, left panel) and average ± standard error (Fig. 3, right panel) for each group. As shown in Fig. 3, tumor proliferation of B16F10 was also significantly suppressed in the Allergin-1KO mice compared to the wild-type mice. Meanwhile, in the group of WT mice to which the anti-mouse PD-1 antibody 4H2 was administered, the median of the tumor volume on 21 days after transplantation was 1985.6 mm^3 (average: 2105.0 ± 418.4 mm^3). The median of the tumor volume on day 21 in the group of mice carrying tumor without administration was 2661.0 mm^3 (average: 2622.6 ± 377.1 mm^3).

[0048] From the results in Examples 2 and 3, it was demonstrated that tumor proliferation could be suppressed by inhibiting Allergin-1.

[0049] Example 4: Effect of anti-PD-1 antibody in Allergin-1KO mice

To C57BL/6 mice (WT mice) and Alg1-KO mice, MC38 was subcutaneously transplanted at 2.0×10^5 cells/mouse. The mIgG

and the anti-mouse PD-1 antibody 4H2 were intraperitoneally administered on the day of transplantation and day 6 and 12, provided that the day of transplantation was day 0. The dosage of 4H2 was 10 mg/kg (20 mg/kg only on the day 0 of transplantation). The number of mice in one group was 15 for the group of mice only carrying tumor (Fig. 4, left panel) and 10 for the groups of mice to which the antibodies were administered (Fig. 4, right panel). The tumor volume of MC38 was measured on day 7, 11, 14, 18, 21, 24 and 27 after transplantation. Fig. 4 shows the transition of the tumor volume in average ± standard error for each group. In the group of Allergin-1KO mice to which the 4H2 antibody was administered, tumor proliferation was further suppressed compared to the group of Allergin-1KO mice to which the control antibody was administered, namely tumor proliferation was not observed during the measurement period.

[0050] From the results in Examples 3 and 4, it was demonstrated that a synergistic effect was exhibited by Allergin-1 inhibition and PD-1 inhibition.

[0051] Example 5: Immunity enhancement for cancer in Allergin-1KO mice

To C57BL/6 mice (WT mice) and Alg1-KO mice, MC38 was subcutaneously transplanted at 2.0×10^5 cells/mouse. The number of mice in one group was 11 or 12. On 15 days after transplantation, tumor was removed from the mice and treated with collagenase to prepare tumor cells. The prepared cells

were subjected to antibody staining and the number of tumor-infiltrating CD8 positive T cells and the number of tumor antigen (p15E)-specific CD8 positive T cells were measured by FACS. Fig. 5 shows the number of infiltrating lymphocytes per 1 mg of tumor in average ± standard error. In the Allergin-1KO mice, the tumor-infiltrating CD8 cells ("$CD8^+$T cell" in Fig. 5) and the tumor-specific CD8 cells ("$CD8^+tetramer^+$" in Fig. 5) were significantly increased compared to the wild-type mice.

[0052] Example 6: Enhancement of IFNα production in Allergin-1KO mice

Various CpG oligonucleotides (CpG-ODNs) were mixed with a lipofection reagent DOTAP and administered to C57BL/6 mice (WT mice) and Allergin-1KO mice via the tail vein at 52 nmol/kg. At 2, 6 and 24 hours after administration, blood was collected from the tail vein and the blood IFNα was measured by ELISA. Fig. 6 shows the blood IFNα (pg/mL) in average ± standard error at each evaluation point for each group. In the Allergin-1KO mice, IFNα production was significantly increased compared to the wild-type mice.

[0053] From the results in Examples 5 and 6, it was demonstrated that Allergin-1 inhibition enhanced the immunity against tumor.

[0054] Example 7: Effect of anti-PD-1 antibody in Allergin-1KO mice

To C57BL/6 mice (WT mice) and Alg1-KO mice, MC38 was

subcutaneously transplanted at 2.0×10^5 cells/mouse. The control antibody mIgG and the anti-mouse PD-1 antibody 4H2 were intraperitoneally administered on the day of transplantation and day 6 and 12, provided that the day of transplantation was day 0. The dosage of 4H2 was 1 or 3 mg/kg. The number of mice in one group was 10. The tumor volume of MC38 was measured on day 7, 11, 13, 18, 21 and 24 after transplantation. Figs. 7 and 8 show the profiles of the tumor volume in average ± standard error for each group.

[0055] In the groups of Alg1-KO mice to which 1 and 3 mg/kg of 4H2 antibody was administered, the anti-tumor effect was observed at a similar level as that in Example 4. The number of animals in each group which showed tumor regression on day 32 is indicated below.

[Table 1]

Mouse	Antibody (1 mg/kg)	Number of animals with tumor regression	Mouse	Antibody (3 mg/kg)	Number of animals with tumor regression
WT	4H2	0/10	WT	4H2	0/10
Alg1-KO	mIgG	0/10	Alg1-KO	mIgG	0/10
Alg1-KO	4H2	5/10	Alg1-KO	4H2	9/10

[0056] Example 8: Effect of anti-CD4 antibody in Allergin-1KO mice

To C57BL/6 mice (WT mice) and Alg1-KO mice, MC38 or B16F10 was subcutaneously transplanted at 2.0×10^5 cells/mouse. The control antibody rat IgG_{2b} and the anti-mouse CD4 antibody GK1.5 (BioXcell) were intraperitoneally

administered on day 5, provided that the day of transplantation was day 0. The dosage of the antibodies was 5 mg/kg. The number of mice in one group was 10. The tumor volume of MC38 and B16F10 was measured on day 7, 11, 14, 18, 21, 25 and 28 after transplantation. When a half or more animals in a group died or were euthanized, the measurement immediately after the observation thereof was the last day of the tumor measurement. Figs. 9 and 10 show the transitions of the tumor volume in average ± standard error for each group. In the group of Alg1-KO mice to which GK1.5 was administered, tumor proliferation was further suppressed compared to the group of Alg1-KO mice to which the control antibody was administered.

[0057] Example 9: Production of type I IFN in Allergin-1KO mice after administration of polyuridine

To C57BL/6 mice (WT mice) and Alg1-KO mice, polyuridine was intravenously administered together with a liposome transfection reagent, DOTAP. The dosage was 50 μg/mouse. Serum IFNα and IFNβ were measured by ELISA at 2 and 6 hours after administration. Fig. 11 shows serum IFNα and IFNβ for each group. In the group of Alg1-KO mice to which polyuridine was administered, production of IFNα and IFNβ was increased compared to WT.

[0058] Example 10: Production of type I IFN after cGAMP stimulation on intraperitoneal macrophages derived from

Allergin-1KO mouse

To C57BL/6N mice and Alg1-KO mice, a 3% thioglycolate medium was intraperitoneally administered at 1 mL/body. After 3 days, 5 mL of 5 mM EDTA/PBS was injected for intraperitoneal lavage and the drain was collected. After haemolysis treatment, the proportion of $CD11b^+F4/80^+$ cells among intraperitoneal invasive cells was calculated on a flow cytometer.

[0059] The cells were seeded in a 96-well plate so that the $CD11b^+F4/80^+$ cells are 2×10^5 cells/well, the culture supernatant was discarded after 1 hour, the cells were washed once with the medium and the medium containing 3, 10 or 30 μM cyclic GMP-AMP (cGAMP), respectively was added. The culture supernatant was collected after 24 and 48 hours and the amount of IFN-β in the culture supernatants was measured. Fig. 12 shows the amount of IFNβ for each group. In the group of macrophages derived from Alg1-KO mice which were stimulated with cGAMP, the production of IFNβ was increased compared to WT.

[0060] Example 11: Effect of anti-PD-1 antibody in Allergin-1KO mice

To C57BL/6 mice (WT mice) and Alg-1KO mice, B16F10 was subcutaneously transplanted at 2.0×10^5 cells/mouse. The mIgG and the anti-mouse PD-1 antibody 4H2 were intraperitoneally transplanted on the day of plantation and day 6, 12 and 18,

provided that the day of transplantation was day 0. The dosage of 4H2 was 10 mg/kg (20 mg/kg only on day 0 of transplantation). The number of mice in one group was 10. The tumor volume of B16F10 was measured on day 7, 11, 14, 18 and 21 after transplantation. Fig. 13 shows the transition of the tumor volume in median for each group. In the group of Allergin-1KO mice to which the 4H2 antibody was administered, tumor proliferation was significantly suppressed compared to other groups.

[0061] Example 12: Effect of combined use of Allergin-1 deficiency and anti-PD-1 antibody in rechallenge test

To C57BL/6 mice (WT mice) and Allergin-1KO (Alg1-KO) mice, MC38 was subcutaneously transplanted at 2.0×10^5 cells/mouse. The anti-mouse PD-1 antibody 4H2 was intraperitoneally administered on the day of transplantation and day 6, 12 and 18. The dosage of 4H2 was 10 mg/kg (20 mg/kg only on day 0 of transplantation) for WT mice and 1 mg/kg or 3 mg/kg (2 mg/kg or 6 mg/kg only on day 0 of transplantation) for Alg1-KO mice. The number of mice in one transplantation group was 20 for WT mice and 10 for each dosage of the Alg1-KO mice. On day 32 of transplantation, 8 out of 20 WT mice and 14 out of 20 Alg1-KO mice showed complete remission (CR) of tumor.

[0062] To the WT mice and Alg1-KO mice which achieved CR, MC38 and B16F10 were subcutaneously transplanted on the right and left flanks, respectively, at 2.0×10^5/mouse on day 42

after the first transplantation. The tumor volume of MC38 and B16F10 was measured on day 7, 11, 14, 18, 21, 25, 28, 32, 35, 39 and 42 after transplantation. Fig. 14 shows the transition of the tumor volume in average ± standard error for each group. For MC38, 7 out of 8 WT mice and all 14 Alg1-KO mice showed tumor remission. For B16F10, 1 out of 8 WT mice and 11 out of 14 Alg1-KO mice showed tumor remission, namely in the group of Alg1-KO mice which achieved CR after 4H2 administration, more CR individuals were observed than the group of WT mice which achieved CR after 4H2 administration.

[0063] This indicates that in mice from which MC38 cancer cells were completely eliminated only by PD-1 inhibition, the immunological memory was already established against MC38 cancer cells to which the immune system of the mice had been encountered, while memory CD8T cells did not sufficiently functioned against B16F10 cancer cells to which the immune system had never been encountered. Meanwhile, when PD-1 inhibition coexisted with Allergin-1 inhibition, memory CD8T cells which were established against MC38 cancer cells to which the immune system of the mice had already encountered sufficiently functioned on B16F10 cancer cells to which the immune system had never been encountered, thereby completely eliminating the same. In this context, B16F10 may be regarded as recurrent cancer cells. Namely, the results indicate that the immune system in the environment where PD-1 inhibition coexists with Allergin-1 inhibition can memorise more various

cancer antigens than the cancer antigens which could be memorised by the immune system in the environment where only PD-1 inhibition exists. The spectrum of cancer antigens which are memorised by the immune system in the environment where PD-1 inhibition coexists with Allergin-1 inhibition covers cancer antigens with weak antigenicity. Therefore, it is believed that the antigens with weak antigenicity are not recognized as cancer antigens by the immune system in a normal environment and are hardly recognized as cancer antigens even in an environment only with PD-1 inhibition. Further, it is believed that if the environment with Allergin-1 inhibition is retained, cancer cells which could never be recognized by the immune system in a normal environment and could be hardly recognized in an environment only with PD-1 inhibition may be recognized as antigens and anti-tumor effect may be exhibited against new cancer cells or, in other words, recurrent cancer cells.

[0064] From the results in Examples 6, 9 and 10, it was demonstrated that Allergin-1 inhibition enhances the reactivity toward STING agonists and TLR ligands. It is believed that in an environment of Allergin-1 inhibition, the immune system recognizes cancer antigens on cancer cells having low antigenicity to activate CD8T cells and attack cancer cells, and then STING agonists and TLR ligands derived from killed cancer cells further enhance the immune reaction against cancer in an environment of Allergin-1 inhibition,

thereby resulting in a synergistic effect and leading to prevention of recurrence.

[Industrial Applicability]

[0065] The Allergin-1 antagonist according to the present invention is capable of enhancing the immunity for cancer and may be used for suppression of progress of, suppression of recurrence of and/or treatment of cancer.

CLAIMS

1. Use of an anti-Allergin-1 antibody in the manufacture of an immunity enhancing agent for the treatment of cancer wherein the anti-Allergin-1 antibody suppresses immunosuppressive intracellular signaling of Allergin-1.

2. The use according to claim 1, wherein the anti-Allergin-1 antibody is an anti-human Allergin-1 antibody.

3. The use according to claim 1 or claim 2, wherein the anti-Allergin-1 antibody is a monoclonal antibody.

4. The use according to claim 3, wherein the anti-Allergin-1 monoclonal antibody is of IgG_1 or IgG_4 isotype.

5. The use according to claim 3 or claim 4, wherein the anti-Allergin-1 monoclonal antibody is an antibody fragment selected from the group consisting of Fab, Fab', Fv, scFv and $(Fab')_2$ fragments.

6. The use according to any one of claims 3 to 5, wherein the anti-Allergin-1 monoclonal antibody is a humanized or human antibody.

7. The use according to claim 3, wherein the anti-Allergin-1 monoclonal antibody is a humanized or human anti-human Allergin-1 monoclonal IgG_1 or IgG_4 antibody.

8. The use according to claim 1 or claim 2, wherein the anti-Allergin-1 antibody is an Allergin-1 multispecific antibody recognizing two or more different epitopes present on one Allergin-1 molecule.

9. The use according to any one of claims 1 to 8, wherein the cancer is solid cancer or hematologic cancer.

10. The use according to claim 9, wherein the solid cancer is one or more selected from malignant melanoma, non-small cell lung cancer, small cell lung cancer, head and neck cancer, renal cell cancer, clear cell renal cell cancer, breast cancer, ovarian cancer, ovarian clear eel adenocarcinoma, bone and soft tissue sarcoma, glioblastoma, gliosarcoma, nasopharyngeal cancer,
uterine cancer, anal cancer, colorectal cancer, hepatocellular cancer, esophageal cancer, pancreatic cancer, stomach cancer, urothelial cancer, prostate cancer, fallopian tube cancer, primary peritoneal

cancer, pleural mesothelioma and myeloproliferative syndrome.

11. The use according to claim 9, wherein the hematologic cancer is one or more selected from multiple myeloma, non-Hodgkin lymphoma, Hodgkin lymphoma, acute myeloid leukemia and chronic myeloid leukemia.

12. The use according to any one of claims 1 to 11, which is to be administered to a cancer patient unresponsive to an anti-cancer drug.

13. The use according to claim 12, wherein the anti-cancer drug is a tumor immunotherapeutic agent.

14. The use according to claim 13, wherein the tumor immunotherapeutic agent is one or more selected from an anti-PD-1 antibody, an anti-PD-L1 antibody, an anti-PD-L2 antibody, a PD-L1 fusion protein, a PD-L2 fusion protein, an anti-CTLA-4 antibody, an anti-LAG-3 antibody, an anti-Tim3 antibody, an anti-KIR antibody, an anti-BTLA antibody, an anti-TIGIT antibody, an anti-VISTA antibody, an anti-CD137 antibody, an anti-OX40 antibody, an anti-HVEM antibody, an anti-CD27 antibody, an anti-GITR antibody, an anti-CD28 antibody, an anti-CCR4 antibody and an anti-CD4 antibody.

15. The use according to claim 14, wherein the anti-PD-1 antibody is Nivolumab, REGN-2810, Pembrolizumab, PDR-001, BGBA317, STI-A1110 or AMP-514.

16. The use according to claim 14, wherein the anti-PD-L1 antibody is Atezolizumab, Avelumab, Durvalumab or BMS-936559.

17. The use according to claim 14, wherein the anti-CTLA-4 antibody is Ipilimumab or Tremelimumab.

18. The use according to claim 14, wherein the PD-L2 fusion protein is AMP-224.

19. The use according to any one of claims 1 to 18, wherein one or more anti- cancer drugs are to be further administered.

20. The use according to claim 19, wherein the anti-Allergin-1 antibody and the anti-cancer drug in different preparations are to be administered.

21. The use according to claim 19, wherein the anti-Allergin-1 antibody and the anti-cancer drug in one preparation is to be administered.

22. The use according to any one of claims 19 to 21, wherein the anti-cancer drug is a tumor immunotherapeutic agent.

23. The use according to claim 22, wherein the tumor immunotherapeutic agent is one or more selected from an antiPD-1 antibody, an anti-PD-L1 antibody, an anti-PD-L2 anti-body, a PD-L1 fusion protein, a PD-L2 fusion protein, an anti-CTLA-4 antibody, an anti-LAG-3 antibody, an anti-Tim3 antibody, an anti-KIR antibody, an anti-BTLA antibody, an anti-TIGIT antibody, an anti-VISTA antibody, an anti-CD137 antibody, an anti-OX40 anti-body, an anti-HVEM antibody, an anti-CD27 antibody, an anti-GITR antibody, an anti-CD28 antibody, an anti-CCR4 antibody and an anti-CD4 antibody.

24. The use according to claim 23, wherein the anti-PD-1 antibody is Nivolumab, REGN-2810, Pembrolizumab, PDR-001, BGBA317, STI-A1110 or AMP-514.

25. The use according to claim 23, wherein the anti-PD-L1 antibody is Atezolizumab, Avelumab or Durvalumab.

26. The use according to claim 23, wherein the anti-CTLA-4 antibody is Tremelimumab.

27. The use according to claim 23, wherein the PD-L2 fusion protein is AMP-224.